

# 2011 IEEE CLOUD & ICWS & SCC & SERVICES

## ADVANCE PROGRAM

IEEE 4<sup>th</sup> International Conference on Cloud Computing (CLOUD 2011)

<http://thecloudcomputing.org/2011>

IEEE 9<sup>th</sup> International Conference on Web Services (ICWS2011)

<http://icws.org/>

IEEE 8<sup>th</sup> International Conference on Services Computing (SCC 2011)

<http://conferences.computer.org/scc/2011>

IEEE 7<sup>th</sup> World Congress on Services (SERVICES2011)

<http://www.servicescongress.org/2011>

Sponsored by **IEEE Technical Committee on Services Computing** (<http://tab.computer.org/tcsc>)



July 4-9, 2011

Washington Marriott

1221 22nd Street NW, Washington, DC 20037

Tel: 1-800-393-3053 or 1-202-872-1500 Fax: 1-202-872-1424

# Key Conference Organizers

## Honorary Chairs

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## General Chairs

<i>Ephraim Feig, IEEE Fellow, USA</i>	<i>Calton Pu, Georgia Tech, USA</i>	<i>Andrzej M Goscinski Deakin University, Australia</i>
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## Program Chairs

<b>CLOUD 2011</b>	<b>SERVICES 2011</b>
<i>Ling Liu, Georgia Institute of Technology, USA Manish Parashar, Rutgers University, USA</i>	<i>Dejan S. Milojicic, HP Lab, USA Markus Kirchberg, HP Labs, Singapore</i>
<b>ICWS 2011</b>	<b>SCC 2011</b>
<i>Ian Foster, The University of Chicago, Argonne National Laboratory, USA Louise Moser, University of California, Santa Barbara, USA Jia Zhang, Northern Illinois University, USA (Vice Chair)</i>	<i>Hans-Arno Jacobsen, University of Toronto, Canada  Yan Wang, Macquarie University, Australia  Patrick C. K. Hung, University of Ontario Institute of Technology, Canada (Vice Chair)</i>

## Applications and Industry Track Chairs

<b>CLOUD 2011</b>	<b>SERVICES 2011</b>
<i>Rong Chang, IBM T.J. Watson Research Center, USA</i>	<i>Min Luo, IBM Software Group, USA</i>
<b>ICWS 2011</b>	<b>SCC 2011</b>
<i>Wu Chou, Avaya Labs Research, USA Andreas Wombacher, University of Twente, Netherlands</i>	<i>Jian Yang, Macquarie University, Australia Ignacio Silva-Lepe, IBM T.J. Watson Research Center, USA</i>

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Carl K. Chang, Iowa State University, USA  
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Hemant Jain, University of Wisconsin at Milwaukee, USA  
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Calton Pu, Georgia Tech, USA  
Jeffrey Tsai, University of Illinois at Chicago, USA  
Liang-Jie Zhang (Chair), Kingdee International Software Group CO.,Ltd, China

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**July 4, 2011 (Monday)**

**2011 IEEE 4th International Conference on Cloud Computing (CLOUD 2011)  
 2011 IEEE 9th International Conference on Web Services (ICWS 2011)  
 2011 IEEE 8th International Conference on Services Computing (SCC 2011)  
 2011 IEEE 7th World Congress on Services (SERVICES 2011)**

7:00-8:00	Breakfast (outside Salon A-H)							
7:00-18:00	On-Site Registration (outside Salon A-H)							
8:00-18:00	IEEE Body of Knowledge on Services Computing Initiative (Presentation Recording)							
<i>Room</i>	<i>Salon A</i>	<i>Salon B</i>	<i>Salon C</i>	<i>Salon D</i>	<i>Salon E</i>	<i>Salon G</i>	<i>Salon H</i>	<i>Salon F</i>
10:00-11:30	Tutorial 1: A Practitioner's Respective of Cloud Roadmapping	Tutorial 2: Large Scale Text Analytics Using Hadoop/Hbase/Solr	Tutorial 3: Cloud and eGovernment: Challenges, Solutions and Experiences	SCC WIP Session 1	FM-S&C 2011 Workshop	WSHA 2011 Workshop	SWF 2011 Workshop	ICWS WIP Session 1
11:30-12:30	Lunch (not provided)							
12:30-14:00	Tutorial 1: A Practitioner's Respective of Cloud Roadmapping	Tutorial 2: Large Scale Text Analytics Using Hadoop/Hbase/Solr	Tutorial 3: Cloud and eGovernment: Challenges, Solutions and Experiences	SCC WIP Session 2	FM-S&C 2011 Workshop	CloudPerf 2011 Workshop	SWF 2011 Workshop	ICWS WIP Session 2
14:00-14:15	PM Break							
14:15-15:45	Tutorial 4: Cloud Development and Deployment	Tutorial 5: Knowledge Cloud: Harnessing knowledge on the Web	Tutorial 6: Platform as a Service	SCC WIP Session 3	SEASS 2011 Workshop	CloudPerf 2011 Workshop	SWF 2011 Workshop	ICWS WIP Session 3
15:45-16:30	PM Break (with refreshments)							
16:30-18:00	Tutorial 4: Cloud Development and Deployment	Tutorial 5: Knowledge Cloud: Harnessing knowledge on the Web	Tutorial 6: Platform as a Service	SCC WIP Session 4	SEASS 2011 Workshop	CloudPerf 2011 Workshop	SWF 2011 Workshop	ICWS WIP Session 4
18:00-21:00	No events planned for participants TSC Board Meeting (14:00-17:30, Logan: Invitation Only)							

**July 5, 2011 (Tuesday)**

**2011 IEEE 4th International Conference on Cloud Computing (CLOUD 2011)  
 2011 IEEE 9th International Conference on Web Services (ICWS 2011)  
 2011 IEEE 8th International Conference on Services Computing (SCC 2011)  
 2011 IEEE 7th World Congress on Services (SERVICES 2011)**

7:00-8:00	Breakfast (outside Salon A-H)							
7:00-18:00	On-Site Registration (outside Salon A-H)							
8:00-18:00	IEEE Body of Knowledge on Services Computing Initiative (Presentation Recording)							
Room	Salon A	Salon B	Salon C	Salon D	Salon E	Salon G	Salon H	Salon F
8:00-9:30	ICWS Research Session 1	ICWS Applications & Experiences Session 1	SCC Research Session 1	SCC Applications & Experiences Session 1	CLOUD Research Session 1	CLOUD Applications & Experiences Session 1	CLOUD WIP Session 1	ICWS WIP Session 5
9:30-10:00	AM Break (with refreshments)							
10:00-12:00	<p>Welcome from General Chairs, IEEE CLOUD/ICWS/SCC/SERVICES 2011                  Additional Greetings from Liang-Jie (LJ) Zhang, Steering Committee Chair                  Welcome Remarks: Sorel Reisman, IEEE Computer Society President, 2011                  Reports from PC Chairs, IEEE CLOUD/ICWS/SCC/SERVICES 2011                  Keynote 1: Data, Data, Data: The Core of Cloud/Services Computing!                  Peter Chen, Louisiana State Univ. &amp; Carnegie-Mellon Univ.                  Session Chair: Ephraim Feig                  (Salon A/B/C/D/E)</p>							
12:00-13:00	Lunch (not provided)							
13:00-14:30	ICWS Research Session 2	ICWS Industry Session 1	SCC Research Session 2	SCC Industry Session 1	CLOUD Research Session 2	CLOUD Industry Session 1	CLOUD WIP Session 2	Cloud Computing Industry Summit
14:30-14:45	PM Break							
14:45-16:15	ICWS Research Session 3	ICWS Applications & Experiences Session 2	SCC Research Session 3	SCC Applications & Experiences Session 2	CLOUD Research Session 3	CLOUD Applications & Experiences Session 2	CLOUD WIP Session 3	Social Networking
16:15-16:30	PM Break (with refreshments)							
16:30-18:00	<p>Panel 2 (Plenary): Science of Cloud Computing                  (Salon A/B/C/D/E)</p>							
18:00-18:30	PM Break							
18:30-21:00	<p>IEEE Plenary Poster and Innovation Showcase Session (with Refreshments)                  (Salon A/B/C/D/E)</p>							

**July 6, 2011 (Wednesday)**

**2011 IEEE 4th International Conference on Cloud Computing (CLOUD 2011)  
 2011 IEEE 9th International Conference on Web Services (ICWS 2011)  
 2011 IEEE 8th International Conference on Services Computing (SCC 2011)  
 2011 IEEE 7th World Congress on Services (SERVICES 2011)**

7:00-8:00	Breakfast (outside Salon A-H)							
7:00-18:00	On-Site Registration (outside Salon A-H)							
8:00-21:30	IEEE Body of Knowledge on Services Computing Initiative (Presentation Recording)							
Room	Salon A	Salon B	Salon C	Salon D	Salon E	Salon G	Salon H	Salon F
8:00-9:30	ICWS Research Session 4	ICWS Industry Session 2	SCC Research Session 4	SCC Industry Session 2	CLOUD Research Session 4	CLOUD Applications & Experiences Session 3	CLOUD Industry Session 2	SERVICES Research Session 1
9:30-9:50	AM Break (with refreshments)							
9:50-11:20	ICWS Applications & Experiences Session 3	ICWS Industry Session 3	SCC Applications & Experiences Session 3	SCC Industry Session 3	<b>Panel 4: Security in Cloud (Salon F/G/H)</b>			
11:20-11:50	AM Break							
11:50-13:20	<b>Panel 3 (Lunch Plenary Industry Panel): Enterprise Clouds vs. Commodity Clouds: Divergence or Convergence (Salon A/B/C/D/E)</b>							
13:20-13:50	PM Break							
13:50-15:20	ICWS Research Session 5	ICWS Applications & Experiences Session 4	SCC Research Session 5	SCC Applications & Experiences Session 4	CLOUD Research Session 5	CLOUD Applications & Experiences Session 4	CLOUD Industry Session 3	SERVICES Industry Session 1
15:20-15:30	PM Break							
15:30-17:00	ICWS Research Session 6	ICWS Industry Session 4	SCC Research Session 6	SCC Industry Session 4	CLOUD Research Session 6	CLOUD Applications & Experiences Session 5	CLOUD Industry Session 4	SERVICES WIP Session 1
17:00-17:15	PM Break (with refreshments)							
17:15-18:45	ICWS Research Session 7	ICWS Applications & Experiences Session 5	SCC Research Session 7	SCC Applications & Experiences Session 5	CLOUD Research Session 7	CLOUD Applications & Experiences Session 6	CLOUD Industry Session 5	Ph.D. Symposium Session 1
18:45-19:15	PM Break							
19:15-21:30	<b>IEEE Congress Banquet Banquet Address (Salon A/B/C/D/E)</b>							

**July 7, 2011 (Thursday)**

**2011 IEEE 4th International Conference on Cloud Computing (CLOUD 2011)  
 2011 IEEE 9th International Conference on Web Services (ICWS 2011)  
 2011 IEEE 8th International Conference on Services Computing (SCC 2011)  
 2011 IEEE 7th World Congress on Services (SERVICES 2011)**

7:00-8:00	Breakfast (outside Salon A-H)								
7:00-18:00	On-Site Registration (outside Salon A-H)								
8:00-18:00	IEEE Body of Knowledge on Services Computing Initiative (Presentation Recording)								
8:00-9:30	<p><b>Keynote 2: Clouds: From Both Sides, Now</b>  <b>Dan Reed, SrVP, Microsoft, USA</b>  <b>Session Chair: Louise Moser, UCSB</b>  <b>(Salon A/B/C/D/E)</b></p>								
9:30-10:00	AM Break (with refreshments)								
10:00-11:30	<p><b>Panel 1 (Plenary): The Federal Cloud</b>  <b>Simon Liu, Director of The National Agricultural Library (NAL), USA</b>  <b>(Salon A/B/C/D/E)</b></p>								
11:30-12:30	Lunch (not provided)								
Room	Salon A	Salon B	Salon C	Salon D	Salon E	Salon G	Salon H	Salon F	
12:30-14:00	ICWS Research Session 8	ICWS Industry Session 5	SCC Research Session 8	SCC Industry Session 5	CLOUD Research Session 8	CLOUD Applications & Experiences Session 7	CLOUD Industry Session 6	ICFP Session 1*	
14:00-14:15	PM Break								
14:15-15:45	ICWS Research Session 9	ICWS Applications & Experiences Session 6	SCC Research Session 9	SCC Industry Session 6	CLOUD Research Session 9	CLOUD Applications & Experiences Session 8	CLOUD Applications & Experiences Session 9	ICFP Session 2*	
15:45-16:30	PM Break (with refreshments)								
16:30-18:00	ICWS Research Session 10	ICWS Industry Session 6	SCC Applications & Experiences Session 6	SCC Industry Session 7	CLOUD Research Session 10	ICWS Applications & Experiences Session 9	ICWS Industry Session 8	ICFP Session 3*	
18:30-20:30	<p><b>No planned activities for conference participants</b>  <b>Organizing Committee Meeting (Invitation Only)</b></p>								

\*Details see Page 9

**July 8, 2011 (Friday)**

**2011 IEEE 4th International Conference on Cloud Computing (CLOUD 2011)  
2011 IEEE 9th International Conference on Web Services (ICWS 2011)  
2011 IEEE 8th International Conference on Services Computing (SCC 2011)  
2011 IEEE 7th World Congress on Services (SERVICES 2011)**

7:00-8:00	Breakfast (outside Salon A-H)							
7:00-18:00	On-Site Registration (outside Salon A-H)							
8:00-18:30	Services Cup Evaluation (Room 3015)							
<b>Room</b>	<b>Salon A</b>	<b>Salon B</b>	<b>Salon C</b>	<b>Salon D</b>	<b>Salon E</b>	<b>Salon G</b>	<b>Salon H</b>	<b>Salon F</b>
8:00-9:30	ICWS Research Session 11	ICWS Applications & Experiences Session 7	SCC Applications & Experiences Session 7	SCC Industry Session 8	<b>Panel 5: Opportunities of Services Business in Cloud Age (Salon F/G/H)</b>			
9:30-10:00	AM Break (with refreshments)							
10:00-11:30	<b>Keynote 3: Web Services in the Scientific Wilds</b> Carole Goble, University of Manchester, UK <b>Session Chair: Manish Parashar, Rutgers University, USA</b> <b>Salon A/B/C/D/E</b>							
11:30-12:30	Lunch (not provided)							
12:30-14:00	<b>Panel 6: Towards Omnificent Multimodal Situation-Aware Services (Salon A/B/C/D)</b>				CLOUD Research Session 11	CLOUD Applications & Experiences Session 10	SCC Applications & Experiences Session 12	ICFP Session 4*
14:00-14:15	PM Break							
14:15-15:45	ICWS Research Session 12	ICWS Industry Session 7	SCC Applications & Experiences Session 8	SCC Applications & Experiences Session 10	CLOUD Research Session 12	CLOUD Industry Session 8	SCC Applications & Experiences Session 13	ICFP Session 5*
15:45-16:30	PM Break (with refreshments)							
16:30-18:00	SCC Applications & Experiences Session 14	ICWS Applications & Experiences Session 8	SCC Applications & Experiences Session 9	SCC Applications & Experiences Session 11	CLOUD Industry Session 7	Planning Meeting for 2012		ICFP Session 6*
18:00-18:15	PM Break							
18:15-18:45	<b>"Services Cup" Awards Announcement</b> <b>Best Paper Awards Announcement</b> <b>Closing Remarks and 2012 Planning</b> (One time & one location. July 9-14, 2012, a nice place, USA) (CLOUD 2012, ICWS 2012, SCC 2012, SERVICES 2012)							
18:45-21:30	<b>No planned activities for conference participants</b>							

\*Details see Page 9

**July 9, 2011 (Saturday)**

**2011 IEEE 4th International Conference on Cloud Computing (CLOUD 2011)  
 2011 IEEE 9th International Conference on Web Services (ICWS 2011)  
 2011 IEEE 8th International Conference on Services Computing (SCC 2011)  
 2011 IEEE 7th World Congress on Services (SERVICES 2011)**

7:00-8:00	Breakfast (outside conference halls)					
7:00-14:00	On-Site Registration (outside Salon A-H)					
8:00-14:00	IEEE Body of Knowledge on Services Computing Initiative (Presentation Recording)					
<b>Room</b>	<b>Salon A</b>	<b>Salon B</b>	<b>Salon C</b>	<b>Salon D</b>	<b>Salon E</b>	<b>Salon F</b>
8:00-9:30	WS-CS-Testing 2011 Workshop	Discovery 2011 Workshop	Security&Privacy 2011 Workshop	FoSeC 2011 Workshop	MgmtCloud 2011 Workshop	ICFP Paper Session 1
9:30-10:00	AM Break (with refreshments)					
10:00-11:30	Composition 2011 Workshop	Discovery 2011 Workshop	Security&Privacy 2011 Workshop	FoSeC 2011 Workshop	MgmtCloud 2011 Workshop	ICFP Paper Session 2
11:30-12:30	Lunch (not provided)					
12:30-14:00	Composition 2011 Workshop	ITGRC 2011 Workshop	Security&Privacy 2011 Workshop	FoSeC 2011 Workshop	MgmtCloud 2011 Workshop	ICFP Paper Session 3
14:00 PM	<b>Have A Safe and Great Trip Back Home!</b> Check <a href="http://ServicesComputing.tv">ServicesComputing.tv</a> for recorded presentations!					

ICFP Session 1	ICFP Session 2
<b>BigDDM: New ways to look at Data Modeling in the Cloud</b> <i>(Jim Cannaliato, Technical Fellow &amp; VP, SAIC)</i>	<b>Threat Modeling in the Cloud: What You Don't Know Will Hurt You!</b> <i>(Scott Matsumoto, Principal Consultant at Cigital)</i>
<b>Cloud Driven Mobility: The Underlying Role of the Cloud within Secure Mobile Ecosystem</b> <i>(Hart Rossman, VP, CTO, SAIC)</i>	<i>Robert Bohn, NIST</i>
ICFP Session 3	ICFP Session 4
<i>Joseph Williams, Microsoft</i>	<i>John Viega</i> <i>James (Bret) Michael, Professor, Navel Postgraduate School</i>
ICFP Session 5	ICFP Session 6
<b>Portability and Interoperability in Cloud Computing</b> <i>(Lee Badger, NIST)</i> <i>Tim Grance, NIST</i> <i>Bill MacGregor, NIST</i>	<b>Cloud Computing: Hackers' Blue Sky</b> <i>(Anup Ghosh, George Mason University)</i> <i>Angelos Stavrou, George Mason University</i>

# ICWS/SCC/CLOUD/SERVICES 2011 Keynotes

## Opening Speech (SERVICES2011-5001)

Sorel Reisman, Ph.D., Professor  
IEEE Computer Society President, 2011



Dr. Sorel Reisman is Managing Director of the international, higher education consortium MERLOT.ORG, and Professor of Information Systems at California State University Fullerton. He has held senior management positions at IBM (Canada and US), Toshiba (US), and EMI (UK). He is a Senior IEEE member, was Vice President of the Computer Society Publications Board, and Vice President of the Electronic Products and Services Board. Dr. Reisman has presented/published 50+ articles and the books Multimedia Computing: Preparing for the 21st Century, and Electronic Learning Communities – Current Issues and Best Practices. Reisman received his PhD in Computer Applications from the University of Toronto.

## Keynote 1: Data, Data, Data: The Core of Cloud/Services Computing!

(SERVICES2011-5002)

Peter Chen, Ph.D., Fellow of IEEE, ACM & AAAS  
Louisiana State University (LSU) & Carnegie-Mellon University (CMU)



Dr. Peter Chen is the internationally renowned inventor of the ER Model, the top-ranked methodology for database design and the foundation of many data modeling and systems analysis methodologies, computer-aided software engineering tools, and repository systems. Dr. Chen's original paper on the ER model is one of the most cited papers in the field of computer science. Dr. Chen is a Fellow of IEEE, ACM, AAAS, and is a recipient of many international awards. He is Distinguished Chair Professor of Computer Science at Louisiana State University and Visiting Professor at Carnegie-Mellon University. Dr. Chen received his Ph.D. from Harvard and has also taught at Harvard, MIT, and UCLA.

## Keynote 2: Clouds: From Both Sides, Now (SERVICES2011-5003)

Dan Reed, Ph.D., Fellow of ACM, IEEE & AAAS  
Corporate Vice President, Microsoft



Dr. Dan Reed is Microsoft's Corporate Vice President for Technology Strategy and Policy and Extreme Computing. Previously, he was the Chancellor's Eminent Professor at UNC Chapel Hill, Chair and Professor of the Department of Computer Science at the University of Illinois at Urbana-Champaign (UIUC). Dr. Reed has served as a member of the U.S. President's Council of Advisors on Science and Technology (PCAST) and as a member of the President's Information Technology Advisory Committee (PITAC). He was also one of the PIs and chief architect for the NSF TeraGrid. He received his Ph.D. in computer science in 1983 from Purdue University.

## Keynote 3: Web Services in the Scientific Wilds (SERVICES2011-5004)

Carole Goble, Ph.D., Fellow of Royal Academy of Engineering  
Professor, University of Manchester, UK



Dr. Carole Goble is a Full Professor in the School of Computer Science. For the past 20 years she has applied technical advances in knowledge management technologies, workflow systems, and distributed and social computing to solve information management problems for Life Scientists and other scientific disciplines. She is the director of one of the most widely adopted open source scientific workflow systems (Taverna). She has also built several widely used crowd-sourced and community-curated data/model sharing platforms. These platforms are used as services (and are themselves web services) scientists in the field for Systems Biology (SEEK), social science data (MethodBox), workflows (myExperiment) and Web Services (BioCatalogue, with over 2000 life science services registered). In 2008 Carole was awarded the inaugural Microsoft Jim Gray award for outstanding contributions to e-Science and in 2011 was elected a Fellow of the Royal Academy of Engineering for her contributions to e-Science.

# ICWS/SCC/CLOUD/SERVICES 2011

## Panel Sessions

### Panel 1 (Plenary): The Federal Cloud (SERVICES2011-5005)

**Moderator:** Simon Liu, Director of The National Agricultural Library (NAL), USA

**Panelists:** Chris Smith, CIO of USDA, USA

Linda Cureton, CIO of NASA, USA

George Strawn, CIO of NSF, also Director of NITRD, USA

**ABSTRACT:** Cloud computing is fundamental to Obama Administration's technology strategy to improve IT efficiency and effectiveness, reduce IT costs, facilitate open access, and promote open government. While the transition to cloud computing seems inevitable in the federal government, many obstacles such as security, privacy, performance, reliability exist. Transition to the cloud in the federal government is a complex endeavor with many challenges. This panel assembles three top federal IT executives to share their views on the why, when, what, and how of their cloud journey. Attendees of the Federal Cloud Panel will leave with abundant ideas, examples, practices, tips, and lessons learned they can apply immediately to leveraging the cloud, helping them to improve performance, reduce cost, and increase the agility and scalability of their Enterprise IT capacities to support enterprise mission, business and operations.



**MODERATOR: Simon Liu** is the Director of the National Agricultural Library (NAL). Dr. Liu holds two Ph.D degrees, in Computer Science and Higher Education Administration, from George Washington University, a Master of Arts degree in Government from Johns Hopkins University, a Master of Business Administration (MBA) degree from the University of Maryland. He is the Editor-in-Chief of IEEE IT Professional magazine. Dr. Liu has published more than 60 book chapters, journal articles, and conference papers and has served as a speaker of numerous conferences, workshops, and seminars.

#### About the Panelists:



**Chris Smith** serves as the CIO for USDA with executive leadership responsibility for all USDA Information Technology Investments, Operations and Management. Mr. Smith provides leadership for USDA's IT Architecture, IT Policy, Cyber Security Operations and the Department's operational portfolio including Network, Enterprise Data Centers, International Technology Services, and Innovations group. Chris Smith received his Master of Public Administration Degree from the University of South Florida and a MS in MIS from George Washington University.



**Linda Y. Cureton** is the CIO for the National Aeronautics and Space Administration (NASA). She provides the requisite leadership to transform the management of IT capabilities and services to support and enable NASA's mission. She ensures that the Agency's information resource management (IRM) strategy is in alignment with NASA's vision, mission, and strategic goals. Ms. Cureton received a Master of Science Degree in Applied Mathematics and a Post-Master's Advanced Certificate in Applied Mathematics both from Johns Hopkins University.



**George O. Strawn** is the Director of the National Coordination Office (NCO) for the Federal government's multiagency Networking and Information Technology Research and Development (NITRD) Program. He also serves as the Co-Chair of the NITRD Subcommittee of the National Science and Technology Council. The NCO reports to the Office of Science and Technology Policy (OSTP) within the Executive Office of the President. Prior to coming to NSF, Dr. Strawn was Chair and Professor of the Computer Science Department at Iowa State University (ISU). Dr. Strawn received his Ph.D. in Mathematics from ISU.

### Panel 2 (Plenary): Science of Cloud Computing (SERVICES2011-5006)

**Co-Moderators:** Ling Liu, Georgia Institute of Technology, USA

Manish Parashar, Rutgers University, USA

**Panelists:** Geoffrey Charles Fox, Indiana University, USA

Robert Grossman, University of Chicago, USA

Jean-Francois Huard, CTO, Netuitive, Inc.

Vanish Talwar, HP Labs, USA

**ABSTRACT:** Cloud computing as one of the dominating disruptive technologies of the 21st century has penetrated the

heart of many enterprises in both business and government world-wide. The amount of investment in cloud computing has continued to grow at an astounding pace in different industry sectors (ranging from computing and IT industry to healthcare, communication, transportation, and retails) across multiple continents. This panel will explore the fundamental research issues underlying cloud computing, i.e., the Science of Cloud Computing. These issues go beyond technical aspects, and include social, legal and economic aspects. The panel will also describe not only how cloud computing is impacting business but also how it is changing the way that science and engineering is done. This panel will include both academic researchers and industry leaderships. Each panelist will bring their perspective in developing a research agenda for shaping the science of Cloud Computing and the impact of such an endeavor on our society, the growth of the IT industry as a whole and the speed of IT penetration in many fields of science and engineering worldwide in the next 10-20 years.

#### MODERATORS



**Ling Liu** is a Professor in the School of Computer Science at Georgia Institute of Technology. There she directs the research programs in Distributed Data Intensive Systems Lab (DiSL), examining various aspects of data-intensive systems with the focus on performance, availability, security, privacy, and energy efficiency. Prof. Liu has published over 300 International journal and conference articles in the areas of databases, distributed systems, and Internet Computing. She is a recipient of the best paper award of ICDCS 2003, WWW 2004, the 2005 Pat Goldberg Memorial Best Paper Award, and 2008 Int. conf. on Software Engineering and Data Engineering. Prof. Liu has served as general chair and PC chairs of numerous IEEE and ACM conferences and is a co-EIC of the 5 volume Encyclopedia of Database Systems (Springer). Her current research is primarily sponsored by NSF, IBM, and Intel.



**Manish Parashar** is a Professor of Electrical and Computer Engineering at Rutgers University. He is also the founding Director of the Center for Autonomic Computing and The Applied Software Systems Laboratory (TASSL), and Associate Director of the Rutgers Center for Information Assurance (RUCIA). He is currently serving as Program Director in the Office of Cyberinfrastructure (OCI) at the US NSF. Manish received his Ph.D. degree from Syracuse University. His research interests are in the broad area of Applied Parallel and Distributed Computing and Computational and Data-Enabled Science and Engineering. He is Fellow of IEEE and Senior Member of ACM.

#### About the Panelists:



**Geoffrey Charles Fox** received a Ph.D. in Theoretical Physics from Cambridge University and is now distinguished professor of Informatics and Computing, and Physics at Indiana University where he is director of the Digital Science Center and Associate Dean for Research and Graduate Studies at the School of Informatics and Computing. He has supervised 62 PhD students and published over 600 papers in physics and computer science. He currently works in applying computer science to Bioinformatics, Defense, Earthquake and Ice-sheet Science, Particle Physics and Chemical Informatics. He is PI of FutureGrid – a new facility to enable development of new approaches to computing.



**Robert Grossman** is a faculty member at the University of Chicago, where he is the Director of Informatics at the Institute for Genomics and Systems Biology, a Senior Fellow at the Computation Institute, and a Professor of Medicine in the Section of Genetic Medicine. His research group focuses on bioinformatics, data mining, cloud computing, data intensive computing, and related areas. He has published over 150 technical articles in these areas. He is the Founder and a Partner of Open Data Group, which provides strategic consulting and outsourced services in analytics and big data.



**Jean-Francois Huard** is CTO and VP of Research and Development at Netuitive, Inc., responsible for leading the company's vision and technology innovation effort. His research and product interest focuses on real-time analytics for large data sets, including, anomaly detection for application performance management, managing the virtual data center and closing the cloud control loop. Previously, Jean-François was Chief Network Architect and VP of Network Engineering at InvisibleHand Networks. He was awarded a Centennial Scholarship by the NSERC of Canada. He received Ph. D. (EE) from Columbia University, USA.



**Vanish Talwar** is a principal research scientist at HP Labs - Palo Alto, researching management systems for next generation data centers. His research interests include distributed systems, operating systems, and computer networks, with a focus on management technologies. He received his PhD degree in Computer Science from the University of Illinois at Urbana Champaign (UIUC). Dr. Talwar is a recipient of the David J Kuck Best Masters Thesis award from the Dept. of Computer Science, UIUC, and has numerous patents and papers including a book on utility computing.

### Panel 3 (Lunch Plenary Industry Panel) (SERVICES2011-5007)

## Enterprise Clouds vs. Commodity Clouds: Divergence or Convergence

**Moderator:** Tony Shan, Chief Cloudologist, Keane/NTT Data, USA

**Panelists:** Brian Stevens, CTO & VP Engineering at Red Hat  
Jason Hoffman, Chief Scientist and Founder at Joyent  
Jim Stikeleather, Chief Innovation Officer, Dell, USA  
Paul Chemmanoor, CTO at Corporate Executive Board

**ABSTRACT:** As Cloud Computing is gaining increasing traction in the complex heterogeneous enterprise environments, there is a battle between building private clouds and leveraging public clouds. More importantly, a key decision point is whether big organizations should construct enterprise clouds, which may be on premises or hosted on public providers' data centers, or large-size firms should migrate to commodity clouds that tend to be more cost effective economically. Are enterprise and commodity clouds moving towards separate directions? Or will they converge? Or will the path become hybrid routes? What are the key criteria and how to justify objectively? This panel will share the forward-thinking insights and practical forecasts from the industry gurus and field practitioners by anatomizing the potential outlook and predicting the tendency in the short term and long run.



**MODERATOR: Tony Shan** is a renowned thought leader and technology visionary with ¼ century of experience and guru-level expertise on cutting-edge enterprise computing. Specialized in innovative solutioning by leveraging converged complex technologies and cross-disciplinary practices, he has directed and advised the lifecycle design and buildout of large-scale award-winning distributed systems on diverse platforms in Fortune 50 companies and public sector organizations. He is a regular speaker and organizer in conferences, a book author, an editor of IT journals, and a founder of several user groups and forums.

### About the Panelists:



**Brian Stevens** has been a member of Red Hat's senior management team since 2001 and has been critical to the company's enterprise operating system, storage and virtualization strategies. As CTO and VP, Engineering, he manages Red Hat's research and development organizations for Linux, virtualization, security, messaging and systems management. Brian was a developer on the first commercial release of the X Windows System at DEC, and was responsible for the architecture and development of the UNIX and clustering product lines.



**Jason Hoffman** is the Founder and Chief Scientist at Joyent, and served as its CTO for the company's first 6 years. He is responsible for research and advanced development, technical outreach, evangelism, consultative efforts for partners and business units, and manages Joyent's intellectual property portfolio. He was once referred to as a "Renaissance engineer" by ZFS creator Jeff Bonwick. Jason taught at the university level for more than a decade, is a prolific speaker and author and a highly-regarded expert on scalable systems.



**Jim Stikeleather** serves as Chief Innovation Officer for Dell Services, the IT services arm of Dell. For more than 25 years, Jim has designed, developed and implemented information and communications technologies. Organizations worldwide rely on Jim for guidance on digital infrastructures, evaluation of emerging technologies, and strategic guidance on applications. He participates in IT standards bodies and has multiple book and industry articles. Previously, was a founder of the Technical Resource Connection (TRC).



**Paul Chemmanoor** is the Chief Technology Officer at Corporate Executive Board. At C.E.B. He is responsible for strategic IT decisions and leads teams responsible for architecture, security and web platform development. Before joining C.E.B, he worked at Capital One as Director of Application Architecture for Internet facing platforms. Paul has a Bachelor of Engineering in computer science from Karnatak University, a MS in Computers and Telecommunication from George Washington University and a M.B.A. from Darden, University of Virginia.

## Panel 4: Security in Cloud (SERVICES2011-5008)

**Moderator:** Billy Cox, Intel, USA

**Panelists:** Steve Orrin, Intel, USA  
Daniel Walsh, Red Hat, USA

Christopher Day, SVP, Terremark Worldwide, Inc., USA

Dennis Moreau, RSA, USA

Rear Admiral (USN, RET.) Elizabeth A. Hight, VP, Cybersecurity Practice, U.S. Public Sector, HP

**ABSTRACT:** Based on articles and surveys, we would assume that if there is a cloud, then there is a security problem. But is this really the case? Certainly, we have to match applications and usages to clouds. But, what does that really mean? This panel will explore the actual barriers to adoption from security, the challenges with audit and compliance, look at best practices and regulatory role for cloud security.



**MODERATOR:** Since 2007, **Billy Cox** has been leading the Cloud strategy efforts for the Intel Software and Services Group. He is also responsible for the Cloud Builders program. Prior to joining Intel, Billy was Director of Systems Engineering at HP. During his 14 years at HP, he was responsible for the development of all infrastructure management tools used to manage the various server and storage platforms. In his 30+ years of industry experience, Billy has led the design of compute, network, and storage solutions and actively participated in multiple standards efforts.

#### About the Panelists:



**Steve Orrin** is Director of Security Solutions, for SSG's SPI group at Intel, Corp. and is responsible for Security Strategy and Pathfinding. Prior to Intel, Steve was CSO of Sarvega, Inc; CTO of Sanctum; CTO and co-founder of LockStar, Inc.; CTO and chief architect of SynData Technologies, Inc. Steve was named one of InfoWorld's Top 25 CTO's of. Steve is a member of ISACA, CSI, IACR and is a co-Founder of WASC and a Co-Founder of the SafeSOA Taskforce. In 2009, Steve was named a fellow at the Center for Advanced Defense Studies.



Having worked in the computer security field for over 25 years, **Daniel Walsh** joined Red Hat in 2001. He has led the SELinux project, concentrating on the application space and policy development. Previously, Dan worked on Netect/Bindview on HackerShield and BVControl for Unix and Vulnerability Assessment Products; Digital Equipment Corporation on the Athena Project along with designing and developing the AltaVista Firewall and AltaVista Tunnel (VPN) Products. Dan has a MS in Computer Science from Worcester Polytechnic Institute.



**Christopher Day** joined Terremark Worldwide, Inc. in December 2005 as SVP, Secure Information Services. He is responsible for global information security services provided to Terremark customers both in the commercial and government sectors. Prior to Terremark, he was VP for SteelCloud. With over 14 years in the information security industry in the US, Latin America, Europe, the Middle East, Asia and Africa, Mr. Day has led numerous consulting projects in the areas of security audit, vulnerability assessment, computer forensics, and secure systems design.

**Dennis** of complex His primary solutions to configuration designing, and to RSA's Computer Science.



**Moreau** is a specialist in the application of leading edge technologies to the solution problems in the Information Systems and Utility Computing management domains. focus is in addressing advanced threats and developing enterprise/provider scale improve IT efficiency and effectiveness for service, systems, security and management/optimization. Dr. Moreau has over 35-year experience in evaluating, implementing complex systems and their management/security infrastructures. Prior CTO Office, he was a founder and CTO for Configuresoft. He holds a Ph.D in



**Navy Rear Adm. (Ret.) Elizabeth A. Hight** is VP of HP's Cybersecurity Practice, responsible to deliver strategic, end-to-end cybersecurity solutions to help HP clients anticipate, overcome and reduce security threats and vulnerabilities while achieving their missions. Previously, she served as the acting Director of Defense Information Systems Agency (DISA) and Commander of the Joint Task Force – Global Network Operations (JTF GNO). She has two master's degrees, one in telecommunications systems from Naval Post-graduate School, and one in information systems from George Washington University.

## Panel 5: Opportunities of Services Business in Cloud Age

(SERVICES2011-5009)

**Moderator:** Nianjun (Joe) Zhou, PIC Chair of Services Computing, IBM Watson Research Center, USA

**Panelists:** Ernesto Damiani, Professor, University of Milan, Italy

Steve Diamond, General Manager, Industry Standards Office, EMC Corporation, USA

Andrzej M Goscinski, Professor, Deakin University, Australia  
Dejan S. Milojicic, Director, HP Labs, USA  
Gregor von Laszewski, Indiana University, USA

**ABSTRACT:** Today, cloud technologies and their application to services business are advanced on every front of research and development – from low level base system technologies, operational support systems, to high level business support systems. Like all technology fields that are driven by immediate market needs, researchers have ample opportunities to provide cloud enabling technologies. However, there is not yet consensus on what cloud computing problems may be long-standing and require persistent attention of the research community. In this panel, we are looking for the ten most interesting problems in services and cloud computing that will shape the research focus in the next 10 years.



**MODERATOR: Nianjun Zhou (Joe)** is a research staff member at IBM T.J. Watson Research Center, where he is serving as PIC (Professional Interest Community) Chair of Services Computing. His current research areas mainly focus on services sciences and service computing to achieve IT and services solution optimization. He is leading research for resource estimation and optimization of IT solution and maintenance under global integration environment; and leading a solution framework development using standardized toolset, method, and assets to simplify service engagement.

#### About the Panelists:



**Ernesto Damiani** is currently a professor at the Università degli Studi di Milano and the director of PhD program in computer science. Prof. Damiani has done extensive research on advanced network infrastructure and distributed systems and protocols, taking part in the design and deployment of secure high-performance networking environments, both as chief scientist and in management positions. He is an Associate Editor of the IEEE Transaction on Services Computing. Prof. Damiani has published several books and about 200 papers and international patents. In 2008 he was nominated ACM Distinguished Scientist.



**Steve Diamond** has 30 years of management, marketing, and engineering experience in semiconductors, systems, standards, and software. He is General Manager of the Industry Standards Office and Global Standards Officer at EMC Corporation. Previously he was Director of Cloud Computing Product Operations at Cisco; President of the IEEE Computer Society; VP of Marketing at Equator Technologies; VP of Business Development at Tycho Networks; Director of Strategic Planning and Market Development at National Semiconductor; Director of SPARC Marketing at Sun; Director of Microprocessor Architecture and Applications Engineering at National Semiconductor; and General Manager of the Honeywell/Synertek microprocessor division. He has authored more than 20 technical publications. Steve is a recipient of the IEEE Third Millennium Medal and the Computer Society Golden Core Award.



**Andrzej A. Goscinski** has had a long-standing interest in distributed systems, parallel processing, virtualization, autonomic and service computing, and cloud computing. His major achievements include the concept of abroker that led to its use in clouds; the Resource Via Web Services (RVWS) framework that contains service's dynamic state and characteristics, and service publishing, selection and discovery; the contribution to level of cloud abstraction in the form of CaaS (Cluster as a Service); and comparative study of High Performance Computing clouds.



**Dejan Milojicic** is a senior researcher and director of Open Cirrus Cloud Computing testbed at HP Labs. He has more than 20-year experience in the areas of operating systems, distributed systems, and service management. He was program chair of IEEE ASA/MA'99. Dr. Milojicic published in many journals and conferences. He is an inaugural EIC of IEEE Computing Now. He serves on the IEEE CS Board of Governors (2011-2013). He has been engaged in various standardization bodies (OMG and Global Grid Forum). He is an ACM distinguished engineer, IEEE Fellow and member of USENIX. He received his PhD from University of Kaiserslautern. Prior to HP Labs, Dejan worked at Institute "Mihajlo Pupin", Belgrade (1993-1991) and at OSF Research Institute (1994-1998).



**Gregor von Laszewski** is assistant director at the Community Grids Lab at Indiana University. He is conducting work in Cloud computing as part of the Future Grid project. He was a scientist and a fellow of the Computation Institute at University of Chicago. He received a Ph.D. in 1996 from Syracuse University. Current research interests are in the areas of Grid & Cloud computing. He is best known for his efforts in making Grids usable and initiating the Java Commodity Grid Kit which provides a basis for many Grid related projects including the Globus toolkit.

## Panel 6: Towards Omnificent Multimodal Situation-Aware Services

(SERVICES2011-5010)

**Moderator:** Carl K. Chang, Chair and Professor, Department of Computer Science, Iowa State University, USA

**Panelists:** Stephen S. Yau, Arizona State University, USA

Peter Chen, Louisiana State University and Carnegie-Mellon University, USA

Cesar Gonzales, IBM Research, USA

Ying Cai, Iowa State University, USA

**ABSTRACT:** Current research in pervasive and mobile computing treats context and situation in an integrated fashion; however, it is unclear if there are universally accepted definitions of context and situation among computer science researchers. A large gap also exists between the conceptual models of situation as viewed by computer scientists versus that of the logicians and cognitive scientists. In this panel, each panelist will address different aspects of multimodal situation-aware services. They will attack the definitions of situation and context from individual perspectives, which enumerating practical and futuristic services based on multimodal and situation-aware information cues. The audience will be invited to challenge the views of our panelists and to debate future directions of the services-laden world of computing. Chair will summarize the discussions and share his perspective.



Carl K. Chang

**MODERATOR: Carl K. Chang** was 2004 IEEE Computer Society President. He served as EIC for IEEE Computer (2008-10) and IEEE Software (1991-94). Chang is Professor and Chair of the Department of Computer Science at Iowa State University. He received a PhD in computer science from Northwestern University. Prior to ISU, he was a faculty member of Auburn University and University of Illinois at Chicago, and worked for GTE Automatic Electric and Bell Laboratories. His research interests include requirements engineering, software architecture, and net-centric computing, and he has published extensively in these areas. He is a founding member of the IEEE RE, and general chair of ICRE'00 and RE'03. He is also the chair of the steering committee for SAINT, PC chair of SAINT'02 and general chair of SAINT'03. In 2005 he serves the general chair for ICWS and SCC. He is Fellow of both IEEE and AAAS. In 2006, he received the prestigious Marin Drinov Medal from the Bulgarian Academy of Sciences.

**About the Panelists:**



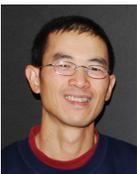
**Stephen S. Yau** is currently a professor of computer science and engineering and the Director of Information Assurance Center at Arizona State University (ASU). He served as the Chair of the Department of Computer Science and Engineering at ASU in 1994-2001. Previously, he was on the faculties of Northwestern University and University of Florida. He served as the President of IEEE Computer Society and on the IEEE Board of Directors and the Board of Directors of Computing Research Association. He also served as the EIC of IEEE COMPUTER, and organized many national and international major conferences. He founded and organized COMPSAC in 1977. He is the honorary chair and general chair of ICWS/SCC/CLOUD/SERVICES 2011 and 2010, respectively.



Dr. Peter Chen is the internationally renowned inventor of the ER Model, the top-ranked methodology for database design and the foundation of many data modeling and systems analysis methodologies, computer-aided software engineering tools, and repository systems. Dr. Chen's original paper on the ER model is one of the most cited papers in the field of computer science. Dr. Chen is a Fellow of IEEE, ACM, AAAS, and is a recipient of many international awards. He is Distinguished Chair Professor of Computer Science at Louisiana State University and Visiting Professor at Carnegie-Mellon University. Dr. Chen received his Ph.D. from Harvard and has also taught at Harvard, MIT, and UCLA.



**Cesar Gonzales** is an IBM Fellow and the research electronics industry executive, responsible for all interactions between IBM's worldwide research labs and our electronics industry executives and clients. He is an expert in image and video processing and compression. He is a co-inventor of various patented still-frame and motion video compression techniques that IBM contributed to the JPEG and MPEG international standards and the DVD patent pool. Cesar has received multiple external and internal awards, including a corporate-level award for his leadership in developing IBM's MPEG-based encoders and system-on-a-chip set top box products. Cesar is IBM Fellow and IEEE Fellow.



**Ying Cai** received his Ph.D. in Computer Science from the University of Central Florida. He is an associate professor at the Department of Computer Science of Iowa State University. His research interests include wireless networks, mobile computing, and multimedia systems. Dr. Cai chaired Mobilware'10 and has on numerous conference program committees. He is on the editorial board of Multimedia Tools and Applications.

# ICWS/SCC/CLOUD/SERVICES 2011

## Tutorials

### Tutorial 1: A Practitioner's Perspective of Cloud Roadmapping

(SERVICES2011-5011)

Tony Shan, Chief Cloudologist, Keane/NTT Data

**ABSTRACT:** This talk presents a methodical strategic planning approach, called Cloud Adoption Roadmapping Tool (CART), from the viewpoint of a practitioner. CART is a part of the implementation of the Cloud Adoption Lifecycle Framework (CALF) developed in previous work. The tool comprises 4 stages: 1) Discover: Baseline and identify pain areas and issues; 2) Investigate: Assess current state & explore cloud suitability; 3) Map: Establish target state vision and lay out transformation routes; and 4) Enable: Formulate multi-generation plan with priorities and measures of impacts. We will discuss a comprehensive process matrix, where the concept, objectives, inputs, activities, outputs, and checkpoints in each stage are defined. We will articulate the advanced cloud planning patterns and sophisticated techniques for hybrid roadmapping in complex IT environments, such as multi-attribute decision making and multi-player cooperative strategization. Working examples and case studies will be demonstrated.

### Tutorial 2: Large Scale Text Analytics Using Hadoop/Hbase/Solr

(SERVICES2011-5012)

David Buttler, Lawrence Livermore National Laboratory, USA

**ABSTRACT:** Google has pioneered a new paradigm in computing: large clusters of commodity hardware processing billions of documents a day, with analytics that make searching and finding relevant documents fast and efficient. Thanks to a large collection of open-source efforts, much of that power is available for the average researcher to assemble for very little cost. This provides an excellent platform to launch innovative research efforts that can have a significant impact, not only on the research community, but also on companies and governments from around the world.

This tutorial will take attendees through the process of setting up a cluster of machines to provide data storage and search capabilities. We will then add functionality for real-time ingest, and add advanced analytics to incoming data streams. The entire course will rely purely on open-source software, and attendees will have a chance to take home a CD with the software. The projects used in the course include Hadoop, HBase, Solr, and various academic packages.



**About the Speaker:** David Buttler finished his PhD in 2003 at the Georgia Institute of Technology. He is working in the Informatics group at LLNL. His research interests are in information management systems for distributed data. The main challenges he is working with are information discovery, update monitoring, and source selection. Dr. Buttler earned a B.Sc. in Computer Science from the University of Alberta in 1998, and he obtained his B.S. in Mathematics from Andrews University in 1995.

### Tutorial 3: Cloud and eGovernment: Challenges, Solutions and Experiences (SERVICES2011-5013)

Surya Nepal, Principal Research Scientist, CSIRO ICT Centre  
Mukaddim Pathan, Research Fellow, CSIRO ICT Centre

**ABSTRACT:** eGovernment has started to utilize Cloud computing to deliver government information and services to the citizens. However, Cloud computing raises new questions in terms of interoperability between services, compliance on data store, migration of legacy applications, and the issues of privacy, security and trust. The aim of this tutorial is to provide a comprehensive guide on new ideas, usage, experience, and results of Cloud computing in Government and enterprise domains. It will capture the state-of-the-art in Cloud technology in terms of design, architecture, and applications. This tutorial will also provide a coverage of trusted Cloud data storage system, Cloud service monitoring, application optimization, and Cloud-based CDNs.

#### About the Speakers:

**Surya Nepal** is a Principal Research Scientist working on Service and Cloud Computing at CSIRO ICT Centre. His main research interest is in the development of technologies in the area of SOA and Web Services. He received his PhD from RMIT University, Australia. He edited a book on "Managing Multimedia Semantics". He is also a pc member in international conferences including ICSOC, CLOUD, WISE, and SACMAT.

**Mukaddim Pathan** is a research fellow at CSIRO, also an adjunct lecturer at the Australian National University. He holds a PhD in Computer Science and Software Engineering from the University of Melbourne. His research interests include data management, resource allocation, load balancing, and coordination policies in wide-area distributed systems. He has authored and co-authored a number of research papers in internationally recognized journals and conferences.

## Tutorial 4: Cloud Development and Deployment (SERVICES2011-5014)

Steve Bobrowski, Senior Developer Evangelist, Salesforce.com

**ABSTRACT:** Designed for developers by developers, this workshop mixes presentations with hands-on coding exercises that teach you how to build a cloud app using the world's premier cloud platform, Force.com. This tutorial will provide you with a deeper understand of cloud computing and help you build a fully functional cloud app that you can extend on your own. Workbook included!

**About the Speaker: Steve Bobrowski** (@sbob909) is a Senior Developer Evangelist with salesforce.com. Previously, Steve worked as Director of SaaS Technology with BEA, SaaS CTO/architect with CSC, led a large database operations team at the EPA's National Computer Center, and worked for Oracle in many roles within the core Server Technologies group. He is an award-winning author of six books about database technology, writes for many publications, and speaks regularly at conferences and meet ups.

## Tutorial 5: Knowledge Cloud: Harnessing knowledge on the Web (SERVICES2011-5015)

Karthik Gomadam, Kunal Verma, Peter Yeh, Accenture Technology Labs  
Amit Sheth, and Prateek Jain, Wright State University, USA

**Abstract:** The amount of data on the web has been growing exponentially. An emerging theme in both industrial and academic settings is the ability to harness this content to create useful knowledge. We use the term "knowledge cloud" to refer to extractable knowledge present on the Web. In this tutorial, we will provide an overview of efforts across industry and academia that leverage the knowledge cloud. We will also share our experiences on designing and developing two applications that leverage the knowledge cloud: 1) contextually enhances information about objects by leveraging structured and unstructured sources of data on the Web; 2) uses existing models on the Web (like DBPedia) for ontology alignment.

### About the Speakers:

**Karthik Gomadam** is a senior research specialist at Accenture Technology Labs with research interests in data management and integration on the Web and their applications to healthcare and social computing. Before moving to Accenture, he was a research scientist in the Electrical Engineering Department at the University of Southern California. He holds a Ph.D in Computer Engineering from Wright State University.

**Kunal Verma** is a Research Manager at Accenture Technology Labs. He has published over 40 research papers in the areas of Semantic Web, Web Services, Software Engineering and Databases. He has organized a number of international workshops and acted as a reviewer for a number of international conferences and journals. He graduated with a Ph.D. in Computer Science from the University of Georgia.

**Peter Z. Yeh** is a researcher manager at Accenture Technology Labs where he defines and leads technology projects that apply AI and semantic technologies to address key business problems ranging from competitive intelligence to data and information management. . Yeh has published extensively on the topics of AI and semantic technologies; and regularly serves as pc members. Dr. Yeh received his PhD from The Department of Computer Science at The University of Texas at Austin.

**Amit Sheth** is the LexisNexis Ohio Eminent Scholar at Wright State University. He directs the Center of Excellence on Knowledge-enabled Human Centered Computing (Knucomp) which includes the Kno.e.sis Center. His recent work are in Semantic Web/Web3.0, including semantics-empowered Services/Cloud Computing, Sensor and Social computing over Web and mobile platforms. Prof. Sheth is an IEEE fellow, is among the highly-cited authors in computer science. He is EIC of the Intl. Journal of Semantic Web & Information Systems, and is joint-EIC of Distributed & Parallel Databases. By licensing his funded university research, he has also founded and managed two successful companies.

**Prateek Jain** is currently a Computer Science Ph.D student at the Kno.e.sis Center at Wright State University. His research interests are in the area of data management and integration, querying, and related Semantic Web technologies.

## Tutorial 6: Platform as a Service (SERVICES2011-5016)

Nianjun (Joe) Zhou, IBM T.J. Watson Research Center, USA



**About the Speaker:** Nianjun Zhou (Joe) is a research staff member at IBM T.J. Watson Research Center. He is serving as PIC (Professional Interest Community) Chair of Services Computing at IBM research. His current research areas mainly focus on services sciences and service computing to achieve IT and services solution optimization. He is leading research for resource estimation and optimization of IT solution and maintenance under global integration environment; and leading a solution framework development using standardized toolset, method, and assets to simplify service engagement.

# 2011 IEEE Fourth International Conference on Cloud Computing (CLOUD 2011)

## Research Track

### Research Track 1 – Cloud Analysis

Session Chair: Danilo Ardagna, Politecnico di Milano, Italy

#### **Cost-wait Trade-offs in Client-side Resource Provisioning with Elastic Clouds (CLOUD2011-1001)**

*Stéphane Genaud, Julien Gossa (Université de Strasbourg, CNRS; P'ole API Blvd S. Brant, Illkirch)*

From the user point of view, the cloud provides an inexhaustible supply of resources (e.g., IaaS), which can be dynamically claimed and released. This drastically changes the problem of resource provisioning and job scheduling. This article presents how billing models can be exploited by provisioning strategies to find a trade-off between fast/expensive computations and slow/cheap ones for independent sequential jobs. We study a dozen of strategies based on classic heuristics for online scheduling and bin-packing problems, with the double objective of minimizing the wait time (and hence the completion time) of jobs and the monetary cost of the rented resources. We simulate these strategies on real grid workloads in two cases: use the workloads as a whole; use the workloads extracted for each individual user. Our findings are reported.

#### **Analysis of Virtualization Technologies for High Performance Computing Environments (CLOUD2011-1002)**

*Andrew J. Younge, Robert Henschel, James T. Brown, Gregor von Laszewski, Judy Qiu, Geoffrey C. Fox (Indiana University, USA)*

Regarding virtualization, there are a large spread of different hypervisors, each with their own advantages and disadvantages. This paper provides an in-depth analysis of some of today's commonly accepted virtualization technologies from feature comparison to performance analysis, focusing on the applicability to High Performance Computing environments using FutureGrid resources. The results indicate virtualization sometimes introduces slight performance impacts depending on the hypervisor type, however the benefits of such technologies are profound and not all virtualization technologies are equal. We recommend KVM hypervisor.

#### **Evaluation of Network Topology Inference in Opaque Compute Clouds through End-to-End Measurements (CLOUD2011-1003)**

*Dominic Battre, Natalia Frejnik, Siddhant Goel, Odej Kao, Daniel Warneke (Technische Universität Berlin, Technische Universität München, Germany)*

The lack of network topology information, i.e. information on how the rented virtual machines are physically interconnected, can easily cause network bottlenecks as common techniques to exploit data locality cannot be applied. In this paper we study to what extent the underlying network topology of virtual machines inside an IaaS cloud can be inferred based on end-to-end measurements. Therefore, we experimentally evaluate the impact of hardware virtualization on the measurable link characteristics packet loss and delay using the popular open source hypervisors KVM and XEN. Afterwards, we compare the accuracy of different topology inference approaches and propose an extension to improve the inference accuracy for typical network structures in data centers. Our findings are reported.

### Research Track 2 – Business Intelligence in Cloud

Session Chair: Robert Grossman, University of Chicago, USA

#### **Strict SLAs for Operational Business Intelligence (CLOUD2011-1004)**

*Michael Seibold, Dean Jacobs, Alfons Kemper (Technische Universität München; SAP AG, Germany)*

SLAs for SaaS business applications usually lack stringent service level objectives and significant penalties. Moreover, Operational Business Intelligence features of modern business applications, like analytic dashboards, result in mixed workloads which make it even more difficult to predict execution times accurately due to resource contention. In contrast to traditional three-tier architecture, an architecture for SaaS business applications should combine application and database layer to allow for processing business transactions and queries according to a queuing approach which enables strict SLAs with stringent response time and throughput guarantees. With stricter SLAs it would be easier to compare different cloud offerings with on-premise solutions.

#### **Exploiting Cloud Utility Models for Profit and Ruin (CLOUD2011-1005)**

*Joseph Idziorek, Mark Tannian (Iowa State University, USA)*

This paper discusses an attack on the cloud computing model by which an attacker subtly exploits a fundamental vulnerability of current utility compute models over a sustained period of time. Internet-accessible cloud services expose resources that are metered for billing purposes. These resources are subject to fraudulent resource consumption that is intended to run up the operating expenses for public cloud service customers. The details and significance of this attack are discussed as well as two detection methodologies and their respective experimental results. This work investigates a potentially significant vulnerability of the cloud computing model that could be exploited from any Internet connected host.

#### **Efficient Bidding for Virtual Machine Instances in Clouds (CLOUD2011-1006)**

*Sharrukh Zaman, Daniel Grosu (Wayne State University, USA)*

Combinatorial auctions are efficient mechanisms for allocating VM instances to cloud computing users. Although in general these mechanisms lead to higher revenues than the currently employed fixed-price mechanisms, the cloud computing providers do not employ them to allocate their resources. One of the main reasons is the complexity faced by the users when determining the bid (i.e.,

the bundle of VM instances and the bid value). We address this issue by developing an efficient bidding strategy for users requesting VM instances. We design new metrics for evaluating bundles of VM instances based on the characteristics of the computing tasks. These metrics allow us to determine the valuation of the requested bundles and to design algorithms for selecting the best bundles to bid for.

### Research Track 3 – Cloud Performance

**Session Chair:** Geoffrey Charles Fox, Indiana University, USA

#### **Performance Modeling of Concurrent Live Migration Operations in Cloud Computing Systems using PRISM Probabilistic Model Checker (CLOUD2011-1007)**

*Shinji Kikuchi, Yasuhide Matsumoto (Fujitsu Laboratories Limited., Japan)*

Server virtualization technologies and their live migration function contribute to the utilization of the computing resources in cloud datacenters. However, many management operations for virtual machines (VMs) including live migrations can be evoked by many cloud users at anytime. The outburst of executions of live migration operations can deteriorate migration performance and make it difficult to provide required resources to users in a timely manner. Therefore, understanding the behaviors and the performance of simultaneous live migrations is very important to provide efficient and reliable cloud computing services. In this paper, we construct a performance model of concurrent live migrations in virtualized datacenters. We first collect performance data from an experimental virtualized system in which we execute simultaneous live migrations. Based on the data, we next construct a performance model representing the performance characteristics of live migration using PRISM, a probabilistic model checker.

#### **VirtPerf: A Performance Profiling Tool for Virtualized Environments (CLOUD2011-1008)**

*Prajakta Patil, Purushottam Kulkarni, Umesh Bellur (Indian Institute of Technology Bombay, India)*

Several applications in the “physical” world are being consolidated in “virtual” environments using different virtualization technologies. An important criterion for this exercise is to understand potential resource requirements and performance levels achieved in virtual environments. Empirical evidence of these can be gotten by benchmarking the application’s performance in a controlled manner in virtual environments. These measurements can be used for a variety of purposes from virtual machine capacity planning to build sophisticated performance models to predict performance for loads that cannot be practically tested. In this paper, we present *VirtPerf*, an integrated workload generator and measurement tool to capture resource utilization levels and performance metrics of applications executing under controlled circumstances in virtualized environments. The tool aims to provide comprehensive measurement-based analysis for applications in different virtualization settings. Additionally, a configurable workload generator can be used to stress and profile applications under different load conditions. We present the detailed design of *VirtPerf* and a comprehensive empirical study to demonstrate its correctness and capabilities.

#### **PCube: Improving Power Efficiency in Data Center Networks (CLOUD2011-1009)**

*Lei Huang, Shuang Yang, Qin Jia, Xin Wang, Baochun Li (Fudan University, China; Stanford University, USA; University of Toronto, Canada)*

To alleviate the growing concern of energy waste in networked devices, we present PCube, a server-centric data center structure that conserves energy by varying bandwidth availability based on traffic demand. PCube not only supports a low-power mode for existing data centers offering full bisection bandwidth without hardware modification or re-wiring, but also provides an alternative for new data centers at a lower construction cost. The bandwidth demand could be dynamic and scalable in the optimal way when considering conserving the energy waste. To further reduce the cost, we take advantage of traffic locality, and propose Hybrid PCube, to offer different bandwidth to different servers. We use samples of traffic from a real-world production data center with full bisection bandwidth across thousands of servers, and evaluate our proposed algorithm using these collected samples.

### Research Track 4 – Application Management in Cloud

**Session Chair:** Surya Nepal, Commonwealth Scientific and Industrial Research Organisation, Australia

#### **Variations in Performance and Scalability when Migrating n-Tier Applications to Different Clouds (CLOUD2011-1010)**

*Deepal Jayasinghe, Simon Malkowski, Qingyang Wang, Jack Li, Pengcheng Xiong, Calton Pu (Georgia Tech, USA)*

We aim to evaluate performance and scalability when an n-tier application is migrated from a traditional datacenter environment to an IaaS cloud. We used a representative n-tier macro-benchmark (RUBBoS) and compared its performance and scalability in three different testbeds: Amazon EC2, Open Cirrus (an open scientific research cloud), and Emulab (academic research testbed). Interestingly, we found that the best-performing configuration in Emulab can become the worst-performing configuration in EC2. Subsequently, we identified the bottleneck components, high context switch overhead and network driver processing overhead, to be at the system level. These overhead problems were confirmed at a finer granularity through micro-benchmark experiments that measure component performance directly. We describe concrete alternative approaches as practical solutions.

#### **Flexible Process-based Applications in Hybrid Clouds (CLOUD2011-1011)**

*Christoph Fehling, Ralf Konrad, Frank Leymann, Ralph Mietzner, Michael Pauly, David Schumm (University of Stuttgart; T-Systems International GmbH Frankfurt, Germany)*

Cloud applications target large customer groups to leverage economies of scale. To increase the number of customers, a flexible application design may enable customers to adjust the application to their individual needs in a self-service manner. In this paper, we classify the required variability of these flexible applications: data variability – changes to handled data structures; functional variability – changes to the processes that the application supports; user interface variability – changes to the appearance of the application; provisioning variability – the ability of the application to be deployed in different runtime environments. Existing and new technologies and tools are leveraged to realize these classes of variability. Further, we cover architectural principles to follow during the design of flexible cloud applications and we introduce an abstract architectural pattern to enable data variability.

## **Elastically Ruling the Cloud: Specifying Application’s Behavior in Federated Clouds (CLOUD2011-1012)**

*Daniel Morán, Luis M. Vaquero, Fermín Galán (Telefonica Investigacion y Desarrollo; HP Labs, Spain)*

Most IaaS clouds present limited capabilities to control how a service behaves at runtime, beyond basic low-level scalability rules for VMs. Higher-level approaches fail to provide mechanisms for a fine grained level of control of the service at runtime, being only focused on scaling. These scalability rules are based on an ad hoc “grammar” that is not expressive enough to reflect other desired control mechanisms at runtime (e.g., reconfigurations dynamic changes in the rules or in the components of the application, re-tiering, etc.). Here, we present an analysis on different alternatives for supporting such features. The Rule Interchange Format (RIF) emerges as a likely candidate to support the required flexibility and so it is proved in a typical use case. Also, a preliminary implementation of a mapping mechanism is offered to parse RIF rules to widespread rule engines such as Drools and Jess.

## **Research Track 5 – Data Distribution in Cloud**

**Session Chair:** Calton Pu, Georgia Tech, USA

## **Angels in the Cloud: A Peer-Assisted Bulk-Synchronous Content Distribution Service (CLOUD2011-1013)**

*Raymond Sweha, Vatche Ishakian, Azer Bestavros (Boston University, USA)*

Leveraging client upload capacity through peer assisted content distribution was shown to decrease the load on content providers, while also improving average distribution times. These benefits, however, are limited by the disparity between client upload and download speeds, especially in scenarios requiring a minimum distribution time (MDT) of a fresh piece of content to a set of clients. Achieving MDT is crucial for bulk-synchronous applications, when every client in a set must wait for all other clients in the set to finish their downloads before being able to make use of the downloaded content. In this paper, we propose the use of dedicated servers, which we call angels to accelerate peer-assisted content distribution in general, and to minimize MDT in particular. The only purpose of an angel is to enable a peer assisted content distribution scheme to approach the theoretical lower-bound for MDT. To overcome scalability issues inherent in an optimal MDT construction, we propose and evaluate a content exchange strategy involving angels, which we call Group Tree.

## **Distributed Semantic Web Data Management in HBase and MySQL Cluster (CLOUD2011-1014)**

*Craig Franke, Samuel Morin, Artem Chebotko, John Abraham, Pearl Brazier (University of Texas - Pan American, USA)*

Interconnected metadata constitutes the Semantic Web, whose volume can potentially grow the scale of the Web. Efficient management of Semantic Web data, expressed using the W3C’s Resource Description Framework (RDF), is crucial for supporting new data-intensive, semantics-enabled applications. In this work, we study and compare two approaches to distributed RDF data management based on emerging cloud computing technologies and traditional relational database clustering technologies. In particular, we design distributed RDF data storage and querying schemes for HBase and MySQL Cluster and conduct an empirical comparison of these approaches on a cluster of commodity machines using datasets and queries from the Third Provenance Challenge and Lehigh University Benchmark. Our study reveals interesting patterns in query evaluation.

## **Promoting Distributed Accountability in the Cloud (CLOUD2011-1015)**

*Smitha Sundareswaran, Anna Cinzia Squicciarini, Dan Lin, Shuo Huang (Penn State University; Missouri S&T, USA)*

A major feature of the cloud services is that users’ data is usually processed remotely in unknown machines that users do not own or operate. While enjoying the convenience brought by this new emerging technology, users’ fears of losing control of their own data (particularly financial and health data) can become a significant barrier to the wide adoption of cloud services. To address this problem, in this paper, we propose a novel highly decentralized information accountability framework to keep track of the actual usage of the users’ data in the cloud. In particular, we leverage the programmable capability of Java JAR files to enclose our logging mechanism together with users’ data and policies. Our approach ensures that any access to users’ data will trigger authentication and automated logging local to the JARs. To strengthen user’s control, we also provide distributed auditing mechanisms.

## **Research Track 6 –Cloud Security and Monitoring**

**Session Chair:** Keke Chen, Wright State University, USA

## **CertiCloud: a Novel TPM-based Approach to Ensure Cloud IaaS Security (CLOUD2011-1016)**

*Benoit Bertholon, Sébastien Varrette, Pascal Bouvry (University of Luxembourg, Luxembourg)*

The security issues raised by the Cloud paradigm are not always tackled from the user point of view. This paper fills this need by proposing CERTICLOUD, a novel approach for the protection of IaaS platforms that relies on the concepts developed in the Trusted Computing Group (TCG) together with hardware elements, i.e., Trusted Platform Module (TPM) to offer a secured and reassuring environment. Those aspects are guaranteed by two protocols: TCRR and VerifyMyVM. When the first one asserts the integrity of a remote resource and permits to exchange a private symmetric key, the second authorizes the user to detect trustfully and on demand any tampering attempt on its running VM. We take seriously analysis of our protocols against known cryptanalytic attacks, through validation by AVISPA and Scyther, two reference tools for the automatic verification of security protocols. The CERTICLOUD proposal is then detailed: relying on the above protocols.

## **Secure Locking for Untrusted Clouds (CLOUD2011-1017)**

*Chiu Tan, Qin Liu, Jie Wu (Temple University, USA; Central South University, China)*

Migrating applications with strong consistency requirements to public cloud platforms remains risky since the *data owner* cannot verify the correctness of the public cloud’s locking algorithm. In this paper, we identify new attacks that an untrusted *cloud provider* can launch via control of the locking mechanism, and propose an extension to existing locking scheme to address such attacks. Our

solution modifies the locks to include a short history to allow *data users* to determine correctness, and can also prevent the cloud from re-ordering operations for financial gain.

### **Affinity-Aware Modeling of CPU Usage for Provisioning Virtualized Applications (CLOUD2011-1018)**

*Sujesha Sudevalayam, Purushottam Kulkarni (Indian Institute of Technology Bombay, India)*

VM migration-enabled consolidation and dynamic resource provisioning remain challenging. Mutually communicating VMs, as part of migration and consolidation strategies, may get colocated on the same physical machine or placed on different machines. In this work, we argue the need for network affinity-awareness not only in placement but also in resource provisioning for virtual machines. First, we empirically quantify the resource savings due to collocation of communicating virtual machines. Next, we build models based on different resource-usage micro-benchmarks to predict the resource usages when transitioning from non-colocated placements to colocated placements and vice-versa. These resource usage prediction models are usable along-with consolidation and migration procedures to determine requirements of VMs in colocated and non colocated scenarios.

### **Research Track 7 – Workload Management in Cloud**

**Session Chair:** Stephen S. Yau, Arizona State University, USA

### **Markovian Workload Characterization for QoS Prediction in the Cloud (CLOUD2011-1019)**

*Sergio Pacheco-Sanchez, Giuliano Casale, Bryan Scotney, Sally McClean, Gerard Parr, Stephen Dawson (SAP Research Center Belfast; Imperial College London; University of Ulster, UK)*

Resource allocation in the cloud is usually driven by performance predictions. In this paper, we investigate the Markovian Arrival Processes (MAP) and the related MAP/MAP/1 queueing model as a tool for performance prediction of servers deployed in the cloud. MAPs are a special class of Markov models used as a compact description of the time-varying characteristics of workloads. In addition, MAPs can fit heavy-tail distributions, which are common in HTTP traffic, and can be easily integrated within analytical queueing models to efficiently predict system performance without simulating. By comparison with tracedriven simulation, we observe that existing techniques for MAP parameterization from HTTP log files often lead to inaccurate performance predictions. We then define a maximum likelihood method for fitting MAP parameters based on data commonly available in Apache log files, and a new technique to cope with batch arrivals.

### **Towards Optimal Resource Provisioning for Running MapReduce Programs in Public Clouds (CLOUD2011-1020)**

*Fengguang Tian, Keke Chen (Wright State University, USA)*

Running MapReduce programs in the public cloud introduces the important problem: how to optimize resource provisioning to minimize the financial charge for a specific job? In this paper, we study the whole process of MapReduce processing and build up a cost function that explicitly models the relationship between the amount of input data, the available system resources (Map and Reduce slots), and the complexity of the Reduce function for the target MapReduce job. The model parameters can be learned from test runs with a small number of nodes. Based on this cost model, we can solve a number of decision problems, such as the optimal amount of resources that can minimize the financial cost with a time deadline or minimize the time under certain financial budget.

### **Flexible Distributed Capacity Allocation and Load Redirect Algorithms for Cloud Systems (CLOUD2011-1021)**

*Daniilo Ardagna, Sara Casolari, Barbara Panicucci (Universit`a di Modena e Reggio Emilia, Politecnico di Milano)*

In Cloud computing systems, resource management is one of the main issues. In this paper we propose capacity allocation techniques able to coordinate multiple distributed resource controllers working in geographically distributed cloud sites. Furthermore, capacity allocation solutions are integrated with a load redirection mechanism which forwards incoming requests between different domains. The overall goal is to minimize the costs of the allocated virtual machine instances, while guaranteeing QoS constraints expressed as a threshold on the average response time. We compare multiple heuristics which integrate workload prediction and distributed non-linear optimization techniques. Experimental results show positive results without introducing significant QoS violations.

### **Research Track 8 – Data Scalability in Cloud**

**Session Chair:** Kenneth Hopkinson, Air Force Institute of Technology, USA

### **Deadline Queries: Leveraging the Cloud to Produce On-Time Results (CLOUD2011-1022)**

*David Alves, Pedro Bizarro, Paulo Marques (University of Coimbra, Portugal)*

Support for MapReduce tasks in cloud environments has been provided but it is left to users to make best guesses on the number of nodes needed for a task to complete within acceptable time. Previous research addressed this problem by establishing time constraints for query execution and, when needed, reduce the accuracy of queries using result approximation and/or sampling. However, in many situations reduced accuracy is not tolerable. In this paper we present FloodDQ, a MapReduce system that implements deadline queries—queries that must finish before a deadline, never discarding data or reducing accuracy. FloodDQ produces timely, accurate results by adaptively increasing or decreasing computing power, at runtime, towards completing execution within the specified deadline. In FloodDQ, users only specify a deadline and the input data. The system monitors the progress of the task and extrapolates whether it will complete on time.

### **A Local-Optimisation based Strategy for Cost-Effective Datasets Storage of Scientific Applications in the Cloud (CLOUD2011-1023)**

*Dong Yuan, Yun Yang, Xiao Liu, Jinjun Chen (Swinburne University of Technology, Australia)*

Massive computation power and storage capacity of cloud computing systems allow scientists to deploy computation and data

intensive applications without infrastructure investment, where large application datasets can be stored in the cloud. However, due to the pay-as-you-go model, the datasets should be strategically stored in order to reduce the overall application cost. In this paper, by utilizing Data Dependency Graph (DDG) from data provenances in scientific applications, deleted datasets can be regenerated, and as such we develop a novel cost-effective datasets storage strategy that can automatically store appropriate datasets in the cloud. This strategy achieves a localised optimal trade-off between computation and storage.

### **Scalable Complex Query Processing Over Large Semantic Web Data Using Cloud (CLOUD2011-1024)**

*Mohammad Farhan Husain, James McGlothlin, Latifur Khan, Bhavani Thuraisingham (University of Texas at Dallas, USA)*

While cloud computing becomes more popular, Semantic web is another domain of rapid growth in both research and industry. RDF datasets are becoming increasingly large and complex and existing solutions do not scale adequately. In this paper, we will detail a scalable semantic web framework built using cloud computing technologies. We define solutions for generating and executing optimal query plans. We handle not only queries with Basic Graph Patterns (BGP) but also complex queries with optional blocks. We have devised a novel algorithm to handle framework to process our query plan. We will show that our these complex queries. Our algorithm minimizes binding triple patterns and joins between them by identifying common blocks by algorithms to find subgraph isomorphism and building a query plan utilizing that information.

### **Research Track 9 – Elastic Cloud**

**Session Chair:** Ernesto Damiani, University of Milan, Italy

### **Elastic Stream Computing with Clouds (CLOUD2011-1025)**

*Atsushi Ishii, Toyotaro Suzumura (Tokyo Institute of Technology, Japan)*

Stream computing, also known as data stream processing, has emerged as a new processing paradigm that environment as required in response to the changes of the data rate in the input data stream. Since a trade-off exists between application's latency and the economic costs when using the Cloud environment, we treat it as an optimization problem that minimizes the economic cost of using the Cloud. We implemented a prototype system using Amazon EC2 and an IBM System S stream computing system to evaluate the effectiveness of our approach. Our experimental results show that our approach reduces the costs by 80% while keeping the application's response latency low.

### **Cost-effective Partial Migration of VoD Services to Content Clouds (CLOUD2011-1026)**

*Haitao Li, Lili Zhong, Jiangchuan Liu, Bo Li, Ke Xu (Simon Fraser University, Canada; Hong Kong University of Science & Technology, China; Tsinghua University, China)*

Since user demand for a Video-on-demand (VoD) service varies with time in one-day period, provisioning self-owned servers for the peak load it must sustain a few hours per day leads to bandwidth underutilization at other times. Content clouds, e.g. Amazon CloudFront and Azure CDN, let VoD providers pay by bytes for bandwidth resources, potentially leading to cost savings even if the unit rate to rent a machine from a cloud provider is higher than the rate to own one. In this paper, based on long-term traces from two large-scale VoD systems and temporal development model of content clouds, we tackle challenges, design and potential benefits in migrating VoD services into the hybrid cloud-assisted deployment, where the user requests are partly served by the self-owned servers and partly served by the cloud. Our measurements show that the popularity of the most popular videos decays so quickly.

### **A Scalable Communication Runtime for Clouds (CLOUD2011-1027)**

*Jaliya Ekanayake, Atilla Soner Balkir, Jared Jackson, Wei Lu, Roger Barga (Microsoft Research, University of Chicago, USA)*

Implementing communication and synchronization between cooperating processes and efficiently exchanging arbitrary size messages remains a challenge for application developers. We envision a solution to this problem that leverages scalable storage services, queues, and direct socket based communication. Publish/subscribe (pub/sub) is a well-known communication pattern that can achieve the above capabilities in a loosely coupled fashion, which is highly desirable in cloud environments where most services are asynchronous. In this paper, we describe the architecture of a pub/sub library implemented on a commercial cloud computing platform, which can be used to develop various parallel applications. We also present an evaluation of our implementation using both micro benchmarks and a real world application.

### **Research Track 10 – Cloud Applications**

**Session Chair:** Christophe Cérin, University of Paris 13, France

### **DACAR Platform for eHealth Services Cloud (CLOUD2011-1028)**

*L. Fan, W. Buchanan, C. Thiimmler, O. Lo, A. Khedim, O. Uthmani, A. Lawson, D. Bell (Edinburgh Napier University; Imperial College London, UK)*

Concerns over service integration, large scale deployment, and security, integrity and confidentiality of sensitive medical data still need to be addressed. This paper presents a solution proposed by the Data Capture and Auto Identification Reference (DACAR) project to overcoming these challenges. The key contributions of this paper include a Single Point of Contact (SPoC), a novel rule based information sharing policy syntax, and Data Buckets hosted by a scalable and cost-effective Cloud infrastructure. These key components and other system services constitute DACAR's eHealth platform, which allows the secure capture, storage and consumption of sensitive health care data. Currently, a prototype of the DACAR platform has been implemented. To assess the viability and performance of the platform, a demonstration application, namely the EarlyWarningScore (EWS), has been developed and deployed within a private Cloud infrastructure at Edinburgh Napier University.

### **A User Experience-based Cloud Service Redeployment Mechanism (CLOUD2011-1029)**

*Yu Kang, Yangfan Zhou, Zibin Zheng, Michael R. Lyu (National University of Defence Technology, China)*

Optimizing user experience is usually required for cloud service deployment. However, it is a challenging task to know the user

experience of end users, since there is generally no proactive connection between a user to the machine that will host the service instance. To attack this challenge, in this paper, we first propose a framework to model cloud features and capture user experience. Then based on the collected user connection information, we formulate the redeployment of service instances as *k-median* and *max k-cover* problems. We proposed several approximation algorithms to efficiently solve these problems. Comprehensive experiments are conducted by employing a real-world QoS dataset of service invocation. The experimental results show the effectiveness of our proposed redeployment approaches.

### **Leveraging Service Clouds for Power and QoS Management for Mobile Devices (CLOUD2011-1030)**

*Yunqi Ye, Liangliang Xiao, I-Ling Yen, Farokh Bastani (University of Texas at Dallas, USA)*

We propose a QoS and power management (QPM) framework for mobile devices making use of the service cloud. Several techniques for the realization of the QPM framework have been developed. First, we develop a function pool based prediction model to predict the power and QoS behaviors of the task activated by a mobile device. Based on the prediction, we design the cost function and the decision algorithm for selecting the best platforms for executing the services/applications in order to achieve optimal energy saving while satisfying QoS requirements. Several service and data migration policies have been designed for a service to be migrated and executed on a mobile device to achieve power and QoS gains. We apply the QPM framework and associated techniques to a facial recognition case study system to validate our approach.

## **Research Track 11 – Energy Efficiency in Cloud**

**Session Chair:** Andrzej M Goscinski, Deakin University, Australia

### **Energy-efficient Management of Virtual Machines in Eucalyptus (CLOUD2011-1031)**

*Pablo Graubner, Matthias Schmidt, Bernd Freisleben (University of Marburg, Germany)*

In this paper, an approach for improving the energy efficiency of infrastructure-as-a-service clouds is presented. The approach is based on performing live migrations of virtual machines to save energy. In contrast to related work, the energy costs of live migrations including their pre- and post-processing phases are taken into account, and the approach has been implemented in the Eucalyptus open-source cloud computing system by efficiently combining a multi-layered file system and distributed replication block devices. To evaluate the proposed approach, several short- and long-term tests based on virtualmachine workloads produced with common operating system benchmarks, web-server emulations as well as different MapReduce applications have been conducted.

### **Exploiting Spatio-Temporal Tradeoffs for Energy-aware MapReduce in the Cloud (CLOUD2011-1032)**

*Michael Cardoso, Aameek Singh, Himabindu Pucha, Abhishek Chandra (University of Minnesota; IBM Research, Almaden, USA)*

MapReduce is a distributed computing paradigm widely used for building large-scale data processing applications. When used in cloud environments, MapReduce clusters are dynamically created using virtual machines (VMs) and managed by the cloud provider. In this paper, we study the energy efficiency problem for such MapReduce clusters in private cloud environments, that are characterized by repeated, batch execution of jobs. We describe a unique spatio-temporal tradeoff that includes *efficient spatial fitting* of VMs on servers to achieve high utilization of machine resources, as well as *balanced temporal fitting* of servers with VMs having similar runtimes to ensure a server runs at a high utilization throughout its uptime. We propose VM placement algorithms that explicitly incorporate these tradeoffs. Our algorithms achieve energy savings over existing placement techniques.

### **Low Carbon Virtual Private Clouds (CLOUD2011-1033)**

*Ferydoun Farrahi Moghaddam, Mohamed Cheriet, Kim Khoa Nguyen (Ecole de technologie superieure, Canada)*

With the introduction of live WAN VM migration, however, the challenge of energy efficiency extends from a single data center to a network of data centers. In this paper, intelligent live migration of VMs within a WAN is used as a reallocation tool to minimize the overall carbon footprint of the network. We provide a formulation to calculate carbon footprint and energy consumption for the whole network and its components, which will be helpful for customers of a provider of cleaner energy cloud services. Simulation results show that using the proposed Genetic Algorithm (GA)-based method for live VM migration can significantly reduce the carbon footprint of a cloud network compared to the consolidation of individual datacenter servers. In addition, the WAN data center consolidation results show that an optimum solution for carbon reduction is not necessarily optimal for energy consumption, and vice versa. Also, the simulation platform was tested under heavy and light VMloads, the results showing the levels of improvement in carbon reduction under different loads.

## **Research Track 12 – VM Management**

**Session Chair:** Fermín Galán, Telefonica Investigacion y Desarrollo, Spain

### **Live Migration of Multiple Virtual Machines with Resource Reservation in Cloud Computing Environments (CLOUD2011-1034)**

*Kejiang Ye, Xiaohong Jiang, Dawei Huang, Jianhai Chen, Bei Wang (Zhejiang University, China)*

Most of the previous work concentrated on the implementation of migration technology itself while didn't consider the impact of resource reservation strategy on migration efficiency. This paper focuses on the live migration strategy of multiple virtual machines with different resource reservation methods. We first describe the live migration framework of multiple virtual machines with resource reservation technology. Then we perform a series of experiments to investigate the impacts of different resource reservation methods on the performance of live migration in both source machine and target machine. Additionally, we analyze the efficiency of parallel migration strategy and workload-aware migration strategy. The metrics such as downtime, total migration time, and workload performance overheads are measured. Experiments reveal some new discovery of live migration of multiple virtual machines. Based on the observed results, we present corresponding optimization methods to improve the migration efficiency.

## **On Theory of VM Placement: Anomalies in Existing Methodologies and Their Mitigation Using a Novel Vector Based Approach (CLOUD2011-1035)**

*Mayank Mishra, Anirudha Sahoo (Indian Institute of Technology Bombay, India)*

In this paper, we present the methodologies used in existing literature for Virtual Machine (VM) placement, load balancing and server consolidation in a data center environment. While the methodologies may seem fine on the surface, certain drawbacks and anomalies can be uncovered when they are analyzed deeper. We point out those anomalies and drawbacks in the existing literature and explain what are the root causes of such anomalies. Then we propose a novel methodology based on vector arithmetic which not only addresses those anomalies but also leads to some interesting theories and algorithms to tackle the above mentioned three functionalities required in managing resources of data centers.

## **Identification and Evaluation of Sharing Memory Covert Timing Channel in Xen Virtual Machines (CLOUD2011-1036)**

*Jingzheng Wu, Liping Ding, Yongji Wang, Wei Han (The Chinese Academy of Science, China)*

Isolation guarantees security between virtual machines. However, covert channel breaks the isolation and leaks sensitive message covertly. In this paper, we formally model the isolation into *noninterference*, and define that all the transmission channels violating. With this definition, we present an identification method based on information flow. This method first compiles the source code into a more structured equivalent code with LLVM. And then a search algorithm is proposed to obtain the shared resources and the operational processes in the equivalent code. A new covert channel termed sharing memory covert timing channel (SMCTC) is identified from Xen source code. We construct channel scenario for evaluating SMCTC.

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# **Applications and Experiences Track**

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## **Applications and Experiences Track 1 – Integrity in Cloud**

**Session Chair:** Sandip Agarwala, IBM Almaden Research Center, USA

### **Space-Efficient Bloom Filters for Enforcing Integrity of Outsourced Data in Cloud Environments (CLOUD2011-1037)**

*Telidevara Aditya, Pallav Kumar Baruah, Ravi Mukkamala (Prashanti Nilayam, A.P., India; Old Dominion University, USA)*

Evidence of data integrity---being tamper-evident and up-to-date, seems to be of immediate concern. While several integrity techniques currently exist, most result in significant storage overhead at the data owner site. For clients with large data sets, these are not viable solutions. In this paper, we propose a space-efficient alternative---data integrity using Bloom filters. We propose the basic method and discuss different alternatives to implement the scheme based on the trust/threat model and processing/storage capacity at the server and the client. For one of these alternatives, we present a detailed analysis and experimental results. These results are compared with the traditional security hash functions such as SHA-1 and MD5. The Bloom filter implementations are shown to be highly space-efficient at the expense of additional computational overhead. To overcome this bottleneck, we have implemented the schemes on multiprocessor systems. The multicore implementations have significantly reduced the execution time.

### **VIAF: Verification-Based Integrity Assurance Framework for Mapreduce (CLOUD2011-1038)**

*Yongzhi Wang, Jinpeng Wei (Florida International University, USA)*

MapReduce suffers from the integrity assurance vulnerability: it takes merely one malicious worker to render the overall computation result useless. Existing solutions are effective in defeating the malicious behavior of non-collusive workers, but are futile in detecting collusive workers. In this paper, we focus on the mappers, which typically constitute the majority of workers, and propose the Verification-based Integrity Assurance Framework (VIAF) to detect both non-collusive and collusive mappers. The basic idea of VIAF is to combine task replication with non-deterministic verification, in which consistent but malicious results from collusive mappers can be detected by a trusted verifier. We have implemented VIAF in Hadoop, an open source MapReduce implementation.

### **DIaaS: Data Integrity as a Service in the Cloud (CLOUD2011-1039)**

*Surya Nepal, Shiping Chen, Jinhui Yao, Danan Thilakanathan (CSIRO ICT Centre, Australia)*

In this paper, we propose a secure cloud storage service architecture with the focus on *Data Integrity as aService* (DIaaS) based on the principles of SOA and Web services. Our approach not only releases the burdens of data integrity management from a storage service by handling it through an independent thirdparty data Integrity Management Service (IMS), but also reduces the security risk of the data stored in the storageservices by checking the data integrity with the help of IMS. We define data integrity protocols for a number of different scenarios, and demonstrate the feasibility of the proposed architecture, service and protocols by implementing them on a public cloud, Amazon S3. We also study the impact of our proposed protocols on the performance of the storage service.

## **Applications and Experiences Track 2 – SLA Management in Cloud**

**Session Chair:** Odej Kao, Technische Universität Berlin (TU Berlin), Germany

### **MADMAC: Multiple Attribute Decision Methodology for Adoption of Clouds (CLOUD2011-1040)**

*Prasad Saripalli, Gopal Pingali (IBM T.J. Watson Research, USA)*

Cloud Adoption decisions tend to involve multiple, conflicting criteria (attributes) with incommensurable units of measurements. Multi-attribute Decision Making (MADM) has been shown to provide a rational basis to aid decision making in such scenarios. We present a MADMAC framework for cloud adoption, consisting of 3 Decision Areas (DA) referred to as the Cloud Switch, Cloud Type and Vendor Choice. We also present a taxonomy organized in a two level hierarchy. DSS presented showing algorithms derived from MADMAC can compute and optimize CA decisions separately for the three stages. A modified Wide-band Delphi method is proposed for assessing the relative weights for each attribute, by workload. Relative ranks are calculated using these weights, and the Simple Additive Weighting (SAW) method is used to generate value functions for all the alternatives, and rank the alternatives by their value

to finally choose the best alternative.

### **Multi-Dimensional SLA-Based Resource Allocation for Multi-Tier Cloud Computing Systems (CLOUD2011-1041)**

*Hadi Goudarzi, Massoud Pedram (University of Southern California, USA)*

With increasing demand for computing and memory, distributed computing systems have attracted a lot of attention. Resource allocation is one of the most important challenges in the distributed systems specially when the clients have SLAs and the total profit in the system depends on how the system can meet these SLAs. In this paper, an SLA-based resource allocation problem for multi-tier applications in the cloud computing is considered. An upper bound on the total profit is provided and an algorithm based on force-directed search is proposed to solve the problem. The processing, memory requirement, and communication resources are considered as three dimensions in which optimization is performed. Simulation results demonstrate the effectiveness of the proposed algorithm.

### **Modelling Contract Management for Cloud Services (CLOUD2011-1042)**

*Mario A. Bochicchio, Antonella Longo (University of Salento, Italy)*

Contracts for the Cloud must combine international legal, financial, technical and operational aspects in a concise and expressive form, able to drive the business, but also to minimize any controversy in case of problems. Moreover, it must cover a wide range of scenarios: from well-known standard situations to highly customized ones (Government, large companies and strategic customers may have very specific requests which also affect contracts). In all cases software support is essential, during the whole contract lifecycle, from formation to execution, up to the conclusion. In this scenario we propose a process model and an information model as the foundation to build a tool for Cloud Services' Contract Management (CM). The validation of both models is carried out.

## **Applications and Experiences Track 3 – Streaming Computing in Cloud**

**Session Chair:** Mikio Aoyama, Nanzan University, Japan

### **Videoconference Capacity Leasing on Hybrid Clouds (CLOUD2011-1043)**

*Javier Cerviño, Fernando Escribano, Pedro Rodríguez, Irena Trajkovska, Joaquín Salvachúa (Universidad Politécnica de Madrid, Madrid)*

This paper proposes a new methodology focused on implementing cost effective architectures on Cloud Computing systems. The paper presents some disadvantages of systems that are based on single Cloud architectures and gives some advices for taking into account in the development of hybrid systems. The work also includes a validation of these ideas implemented in a complete videoconference service developed with our research group. This service allows a great number of users per conference, multiple simultaneous conferences, different client software (requiring transcoding of audio and video flows) and provides a service like automatic recording. Furthermore it offers different kinds of connectivity including SIP clients and a client based on Web 2.0.

### **Esc: Towards an Elastic Stream Computing Platform for the Cloud (CLOUD2011-1044)**

*Benjamin Satzger, Waldemar Hummer, Philipp Leitner, and Schahram Dustdar (Vienna University of Technology, Austria)*

Today, most tools for processing big data are batch-oriented. However, many scenarios require continuous, online processing of data streams and events. We present ESC, a new stream computing engine. It is designed for computations with real-time demands, such as online data mining. It offers a simple programming model in which programs are specified by directed acyclic graphs (DAGs). The DAG defines the data flow of a program, vertices represent operations applied to the data. The data which are streaming through the graph are expressed as key/value pairs. ESC allows programmers to focus on the problem at hand and deals with distribution and fault tolerance. Furthermore, it is able to adapt to changing computational demands. In the cloud, ESC can dynamically attach and release machines to adjust the computational capacities to the current needs. This is crucial for stream computing since the amount of data fed into the system is not under the platform's control. We substantiate the concepts we propose in this paper with an evaluation.

### **Testing a Cloud Provider Network for Hybrid P2P and Cloud Streaming Architectures (CLOUD2011-1045)**

*Javier Cerviño, Pedro Rodríguez, Irena Trajkovska, Alberto Mozo, Joaquín Salvachúa (Universidad Politécnica de Madrid, Spain)*

This paper contains the experimental results of streaming distribution in a hybrid architecture that consist of mixed connections among P2P and Cloud nodes that can interoperate together. We have chosen to represent the P2P nodes as PlanetLab machines over the world and the cloud nodes using a Cloud provider's network. First we present an experimental validation of the Cloud infrastructure's ability to distribute streaming sessions with respect to some key streaming QoS parameters: jitter, throughput and packet losses. Next we show the results obtained from different test scenarios, when a hybrid distribution network is used. The scenarios measure the improvement of the multimedia QoS parameters, when nodes in the streaming distribution network (located in different continents) are gradually moved into the Cloud provider infrastructure. The overall conclusion is that the QoS of a streaming service can be efficiently improved, unlike in traditional P2P systems and CDN, by deploying a hybrid streaming architecture. This enhancement can be obtained by strategic placing of certain distribution network nodes into the Cloud provider infrastructure.

## **Applications and Experiences Track 4 – Cloud Security**

**Session Chair:** Xiaoqing (Frank) Liu, Missouri University of Science and Technology, USA

### **Collaboration-Based Cloud Computing Security Management Framework (CLOUD2011-1046)**

*Mohemed Almorsy, John Grundy, Amani S. Ibrahim (Swinburne University of Technology, Australia)*

Obtaining a security certificate such as ISO 27000 or NIST-FISMA would help cloud providers improve consumers trust in their cloud platforms' security. However, such standards are still far from covering the full complexity of the cloud computing model. We introduce a new cloud security management framework based on aligning the FISMA standard to fit with the cloud computing model, enabling cloud providers and consumers to be security certified. Our framework is based on improving collaboration between cloud providers, service providers and service consumers in managing the security of the cloud platform and the hosted services. It is built

on top of a number of security standards that assist in automating the security management process. We have developed a proof of concept of our framework using .NET and deployed it on a testbed cloud platform. We evaluated the framework by managing the security of a multitenant SaaS application exemplar.

### **Governance Life Cycle Framework for Managing Security in Public Cloud: From User Perspective (CLOUD2011-1047)**

*Rizwan Ahmad, Lech Janczewski (University of Auckland, New Zealand)*

Public Cloud Computing (PCC) delivers technology "As a Service". It is widely accepted by consumers, enterprises and, even governments because it reduces financial budget for acquiring Information technology (IT) infrastructure. The major deterrence against its adoption is security and governance risks. These risks are associated with three facets; geographical location of cloud provider, change of governance level within cloud service layers and inadequacy of existing international security standards to maintain security. In this paper, these three domains are researched to formulate governance life cycle framework for managing user data security in PCC.

### **Design and Deployment of a Trusted Eucalyptus Cloud (CLOUD2011-1048)**

*Imran Khan, Habib-Ur Rehman, Zahid Anwar (FAST-NUCES NUST; SEecs, Pakistan)*

Before clouds can reach their full potential and be wholeheartedly adopted there is a need to address the concern of privacy. Eucalyptus is an open source cloud computing software framework that implements the Cloud Service Model commonly known as Infrastructure as a Service (IaaS). The IaaS model allows users to run and control entire virtual machines on cloud Infrastructure. However one of the main privacy issues in cloud Infrastructure such as Eucalyptus is to ensure the integrity and confidentiality of user data and computation. In this paper we describe the design and deployment of a Trusted Eucalyptus cloud architecture based on remote attestation via Trusted Platform Modules (TPM). Trusted Eucalyptus guarantees users that their virtual machines execute only on cloud nodes, whose integrity is valid. Our experimental results show that Trusted Eucalyptus cloud is practical.

## **Applications and Experiences Track 5 – Migration to Cloud**

**Session Chair:** Jun Shen, University of Wollongong, Australia

### **A Pattern-Based Approach to Cloud Transformation (CLOUD2011-1049)**

*Yi-Min Chee, Nianjun Zhou, Fan Jing Meng, Peide Zhong, Saeed Bagheri (Arizona State University, USA)*

One problem clients face in migrating to cloud is a lack of experience and knowledge as to how best to accomplish this transformation. We propose a Cloud Transformation Advisor (CTA) which helps users to select appropriate enablement patterns from a knowledge base of best practices when performing transformation planning. This knowledge base uses a structured representation to capture application information, cloud platform capability information, and enablement pattern information in order to facilitate pattern selection. We describe this representation and a mathematical model which leverages it to choose the "best" combination of patterns for a given transformation problem. We present an example which illustrates the approach, and describe the usage of the CTA.

### **A SaaSify Tool for Converting Traditional Web-Based Applications to SaaS Application (CLOUD2011-1050)**

*Jie Song, Feng Han, Zhenxing Yan, Guoqi Liu, Zhiliang Zhu (Northeastern University, China)*

SaaS is increasingly used by web-based applications. It is significant if service providers can automatically convert traditional applications into SaaS mode, a *SaaSify* tool is needed urgently. In this paper, we analyze and conclude the new challenges of automatically *SaaSify* webbased application, propose several key technologies for *SaaSifying*, and further propose *SaaSify* Flow Language (SFL) to model and implement *SaaSify* process; finally, we use a case study to show the effects of proposed tool, and the performance experiments prove that the proposed approach is efficient and effective.

### **Migrating Service-Oriented System to Cloud Computing: An Experience Report (CLOUD2011-1051)**

*Muhammad Aufeef Chauhan, Muhammad Ali Babar (Mälardalen University, Sweden; IT University of Copenhagen, Denmark)*

Since cloud-oriented migration projects are likely to encounter several kinds of challenges, it is important to identify and share the process and logistical requirements of migration projects in order to build a body of knowledge of appropriate process, methods, and tools. This paper purports to contribute to the growing knowledge of how to migrate existing systems to cloud computing by reporting our effort aimed at migrating an Open Source Software (OSS) framework, Hackystat, to cloud computing. We report the main steps followed, the process and technical challenges faced, and some of the strategies that helped us to address those challenges. We expect the reported experiences can provide readers with useful insights into the process and technical aspects that should be considered when migrating existing software systems to cloud computing infrastructures.

## **Applications and Experiences Track 6 – Cloud Scheduling**

**Session Chair:** Dejan S. Milojicic, HP Laboratories, USA

### **Multi-Objective Scheduling of BPEL Workflows in Geographically Distributed Clouds (CLOUD2011-1052)**

*Ernst Juhnke, Tim Dörnemann, David Böck, Bernd Freisleben (University of Marburg, Germany)*

In this paper, a novel scheduling algorithm for Cloud-based workflow applications is presented. If the constituent workflow tasks are geographically distributed – hosted by different Cloud providers or data centers of the same provider – data transmission can be the main bottleneck. The algorithm therefore takes data dependencies between workflow steps into account and assigns them to Cloud resources based on the two conflicting objectives of cost and execution time according to the preferences of the user. Our implementation is based on BPEL, an industry standard for workflow modeling, and does not require any changes to the standard. It is based on, but not limited to, the ActiveBPEL engine and Amazon's Elastic Compute Cloud. To automatically adapt the scheduling

decisions to network-related changes, the data transmission speed between the available resources is monitored continuously. Experimental results for a real-life workflow from a medical domain are reported.

### **Optimal Algorithms for Cross-Rack Communication Optimization in MapReduce Framework** (CLOUD2011-1053)

*Li-Yung Ho, Jan-Jan Wu, Pangfeng Liu (National Taiwan University; Academia Sinica, Taiwan)*

MapReduce is a widely used data-parallel programming model for large-scale data analysis. However, research has shown that there is room for performance improvement of the MapReduce framework. One of the main performance bottlenecks is caused by the all-to-all communication between mappers and reducers, which may saturate the top-of-rack switch and inflate job execution time. Reducing cross-rack communication will improve job performance. In current MapReduce implementation, the task assignment is based on the pull-model, in which cross-rack traffic is difficult to control. In contrast, the MapReduce framework allows more flexibility in assigning reducers to the computing nodes. In this paper, we investigate the reducer placement problem (RPP), which considers the placement of reducers to minimize cross-rack traffic. We devise two optimal algorithms to solve RPP and implement the algorithms in the Hadoop system. We also propose an analytical solution for this problem. Our experiment results are reported.

### **Reserved or On-Demand Instances? A Revenue Maximization Model for Cloud Providers** (CLOUD2011-1054)

*Michele Mazzucco, Marlon Dumas (University of Tartu, Estonia)*

We examine the problem of managing a server farm in a way that attempts to maximize the net revenue earned by a cloud provider by renting servers to customers according to a typical PaaS model. The Cloud provider offers its resources to two classes of customers: 'premium' and 'basic'. Premium customers pay upfront fees to reserve servers for a specified period of time (e.g. a year). Premium customers can submit jobs for their reserved servers at any time and pay a fee for the server-hours they use. The provider is liable to pay a penalty every time a 'premium' job can not be executed due to lack of resources. On the other hand, 'basic' customers are served on a best-effort basis, and pay a server-hour fee that may be higher than the one paid by premium customers. The provider incurs energy costs when running servers. Hence, it has an incentive to turn off idle servers. The question of how to choose the number of servers to allocate to each pool (basic and premium) is answered by analyzing a suitable queuing model and maximizing a revenue function. Experimental results are reported.

## **Applications and Experiences Track 7 – Storage Cloud**

**Session Chair:** Rong Chang, IBM T.J. Watson Research Center, USA

### **ICostale: Adaptive Cost Optimization for Storage Clouds** (CLOUD2011-1055)

*Sandip Agarwala, Divyesh Jadav, Luis Bathen (IBM Almaden Research Center; University of California, USA)*

The unprecedented volume of data generated by contemporary business users and consumers has created enormous data storage and management challenges. In order to control data storage cost, many users are moving their data to online storage clouds, and applying capacity usage reducing data transformation techniques like de-duplication, compression, and transcoding. These give rise to several challenges, such as which cloud to choose, and what data transformation techniques to apply for optimizing cost. This paper presents an integrated storage service called iCostale that reduces the overall cost of data storage through automatic selection and placement of users data into one of many storage clouds. Further, it intelligently transforms data based on its type, access frequency, transformation overhead, and the cost model of the storage cloud providers. We demonstrate the efficacy of iCostale through a series of micro- and application-level benchmarks. Our experimental results are reported.

### **BFTCloud: A Byzantine Fault Tolerance Framework for Voluntary-Resource Cloud Computing** (CLOUD2011-1056)

*Yilei Zhang, Zibin Zheng, Michael R. Lyu (The Chinese University of Hong Kong; National University of Defense Technology, China)*

Cloud computing is becoming a popular and important solution for building highly reliable applications on distributed resources. However, it is a critical challenge to guarantee the system reliability of applications especially in voluntary-resource cloud due to the highly dynamic environment. In this paper, we present BFTCloud (Byzantine Fault Tolerant Cloud), a Byzantine fault tolerance framework for building robust systems in voluntary-resource cloud environments. BFTCloud guarantees robustness of systems. BFTCloud is evaluated in a large-scale real-world experiment.

### **Metastorage: A Federated Cloud Storage System to Manage Consistency-Latency Tradeoffs** (CLOUD2011-1057)

*David Bermbach, Markus Klems, Michael Menzel, Stefan Tai (Karlsruhe Institute of Technology (KIT); Forschungszentrum Informatik (FZI), Germany)*

Selecting a single storage service provider limits availability and scalability to the selected provider and may further cause a vendor lock-in effect. In this paper, we present MetaStorage, a federated Cloud storage system that can integrate diverse Cloud storage providers. It is a highly available and scalable distributed hashtable that replicates data on top of diverse storage services. MetaStorage reuses mechanisms from Amazon's Dynamo for cross-provider replication and hence introduces a novel approach to manage consistency-latency tradeoffs by extending the traditional quorum (N;R;W) configurations to an (NP; R;W) scheme that includes different providers as an additional dimension. With MetaStorage, new means to control consistency-latency tradeoffs are introduced.

## **Applications and Experiences Track 8 – Cloud Application Deployment**

**Session Chair:** Zhen Kong, Wayne State University, USA

### **Toward Optimal Deployment of Communication-Intensive Cloud Applications** (CLOUD2011-1058)

*Pei Fan, Ji Wang, Zibin Zheng, Michael R. Lyu (National University of Defense Technology; The Chinese University of Hong Kong, China)*

When deploying a cloud application to the cloud environment, cloud node ranking is one of the most important approaches for selecting optimal cloud nodes for the cloud application. Traditional ranking methods usually rank the cloud nodes based on their QoS values, without considering the communication performance between cloud nodes. However, such kind of node relationship is very important for the communication-intensive cloud applications, which have a lot of communications between the selected cloud nodes. In this paper, we propose a novel clustering-based method for selecting optimal cloud nodes for deploying communication-intensive applications to the cloud environment. Our method not only takes into account the cloud node qualities, but also the communication performance between different nodes. We deploy several well-known MPI programs on a real-world cloud and compare our method with other methods. The experimental results show the effectiveness of our cluster-based method.

### **Scaling Non-Elastic Applications using Virtual Machines (CLOUD2011-1059)**

*Thomas Knauth, Christof Fetzer (TU Dresden)*

Virtualization also guarantees high levels of isolation (performance and security wise) between virtual machines running on the same physical hardware. Besides enabling consolidation of workloads, virtual machine (VM) technology also offers an application independent way of shifting workloads between physical machines. Live migration, i.e., shifting workloads without explicitly stopping the virtual machine, is particularly attractive because of the minimal impact on virtual machine and hence service availability. We explore the use of live migration to scale non-elastic (i.e., static runtime configuration) applications dynamically. Virtual machines thus provide an application agnostic way to dynamic scalability, and open new venues for minimizing the physical resource usage in a data center. We will show that virtualization technology in connection with the live migration capabilities of modern hypervisors can be used to scale non-elastic applications in a generic way. Some problems still present in current virtualization techniques.

### **STRATUS: Assembling Virtual Platforms from Device Clouds (CLOUD2011-1060)**

*Minsung Jang, Karsten Schwan (Georgia Tech, USA)*

By exploiting the virtualization technologies that have begun to pervade even the mobile domain, these devices' hardware components, such as displays, input devices, disks, or processors, can be decoupled from the physical platforms on which they reside to form a *resource pool* or *device cloud*. By drawing on the composite resources of device clouds, applications can leverage the heterogeneity present in the cloud to exploit hardware/device differences in terms of power consumption, computational speeds, display sizes, or the presence of certain accelerators, and can take advantage of software diversity in terms of the different operating environments and applications that efficiently operate on individual devices. This paper implements and evaluates the concept of device clouds, in which virtual execution platforms dynamically composed from sets of devices are built for applications, using automated methods that are based on simple policies. Experimental results identify the basic overheads associated with device clouds and their use, and demonstrate the advantages of dynamically constructed virtual platforms rather than individual machines, both in terms of improvements in system properties like power usage and improvements in user experiences for media delivery and playout.

## **Applications and Experiences Track 9 – Performance Modeling in Cloud**

**Session Chair:** Dawn Jutla, Saint Mary's University, Canada

### **What Are You Paying for? Performance Benchmarking for Infrastructure-as-a-Service Offerings (CLOUD2011-1061)**

*Alexander Lenk, Michael Menzel, Johannes Lipsky, Stefan Tai, Philipp Offermann (FZI Forschungszentrum Informatik; Deutsche Telekom Laboratories, Germany)*

Performance specifications for virtual machines provided by providers are not coherent and sometimes insufficient to predict the actual performance of a deployment. To measure hardware performance, hardware benchmarks are available. For measuring the performance of virtual machines in IaaS offerings, these benchmarks are not sufficient, as they don't take into account the IaaS provisioning model. We have designed a new performance measuring method for Infrastructure-as-a-Service offerings. The method takes into account the type of service running in a virtual machine. By using the method, the actual performance of the virtual machines running a specific IaaS service is measured. This measurement can be used to better compare prices between different providers, but also to evaluate the performance actually available on a certain IaaS platform. We have evaluated the method on several Cloud infrastructure offerings of the Amazon EC2, Flexiscale and Rackspace platforms.

### **Efficient Autoscaling in the Cloud Using Predictive Models for Workload Forecasting (CLOUD2011-1062)**

*Nilabja Roy, Abhishek Dubey, Aniruddha Gokhale (Vanderbilt University, USA)*

In the context of Cloud computing, autoscaling mechanisms hold the promise of assuring QoS properties to the applications while simultaneously making efficient use of resources and keeping operational costs low for the service providers. Despite the perceived advantages of autoscaling, realizing the full potential of autoscaling is hard due to multiple challenges stemming from the need to precisely estimate resource usage in the face of significant variability in client workload patterns. This paper makes three contributions to overcome the general lack of effective techniques for workload forecasting and optimal resource allocation. First, it discusses the challenges involved in autoscaling in the cloud. Second, it develops a model-predictive algorithm for workload forecasting that is used for resource autoscaling. Finally, empirical results are provided.

### **Performance Modeling of Virtual Machine Live Migration (CLOUD2011-1063)**

*Yangyang Wu, Ming Zhao (Florida International University, USA)*

Therefore, it is key to understand the performance of live VM migration under different levels of resource availability. This paper addresses this need by creating performance models for live migration which can be used to predict a VM's migration time given its application's behavior and the resources available to the migration. A series of experiments were conducted on Xen to profile the time for migrating a DomU VM running different resource-intensive applications while Dom0 is allocated different CPU shares for processing the migration. Regression methods are then used to create the performance model based on profiling data. The results show

that VM's migration time indeed substantially impacted by Dom0's CPU allocation whereas the performance model can accurately capture this relationship with the coefficient of determination generally higher than 90%.

## Applications and Experiences Track 10 – Cloud Provenance and Management

**Session Chair:** Michael R. Lyu, The Chinese University of Hong Kong

### Private Cloud Configuration with Metaconfig (CLOUD2011-1064)

*Thomas Damgaard Nielsen, Christian Iversen, Philippe Bonnet (Cirego ApS; IT University of Copenhagen, Denmark)*

Today, even if tools exist to automate system configuration, there is no solution that seamlessly integrate the administration and configuration of virtual as well as physical machines. In this paper, we present MetaConfig, a system that supports (a) convergent as well as congruent configuration management, (b) full bootstrapping of blank physical and virtual machines and (c) automatic allocation of virtual machines onto physical machines based on their resource requirements. We describe our design and explain how MetaConfig differs from existing systems such as Cfengine and Puppet.

### Large-Scale Distributed Storage System for Business Provenance (CLOUD2011-1065)

*Szabolcs Rozsnyai, Aleksander Slominski, Yurdaer Doganata (IBM Research Center, USA)*

Monitoring and analyzing artifacts enables access to critical process information to improve the effectiveness of business operations. Tracking, capturing storing and processing such large volumes of data, however, is difficult and resource intensive with current relational database technologies. Hence, designers are forced to make trade-offs in deciding the type and the granularity level of the data to be captured. Nevertheless, the amount of historical data that carries important insight about the business processes that need to be captured is growing. A solution that is capable of handling massive business provenance data is necessary. In this paper, using cloud as opposed to relational databases to manage this massive amount of business provenance data is proposed and a cloud-based business provenance architecture based on HBase/Hadoop technology is introduced.

### Usage Management in Cloud Computing (CLOUD2011-1066)

*Pramod A. Jamkhedkar, Christopher C. Lamb, Gregory L. Heileman (University of New Mexico, Albuquerque, USA)*

User concerns regarding data handling within the cloud will gain increasing importance as cloud computing becomes more pervasive. Existing service level agreement (SLA) frameworks are not designed for flexibly handling even relatively straightforward usage policies. This paper introduces the notion and importance of usage management in cloud computing. It provides an analysis of features and challenges involved in deploying a usage management framework over a distributed cloud environment to enable automated and actionable interpretation, reasoning and enforcement of usage policies. Finally, a preliminary architecture for such a framework is proposed.

### Cloud#: A Specification Language for Modeling Cloud (CLOUD2011-1067)

*Dongxi Liu, John Zic (CSIRO ICT Centre, Australia)*

We present a specification language [Cloud] for modeling the internal organisation of cloud. By reasoning about cloud models, clients understand more on how services are delivered inside cloud. In this sense, cloud models make cloud services more transparent to clients. The transparency of cloud services are expected to increase the confidence of clients to move their business-critical applications to cloud. The expressiveness of [Cloud] is evaluated by giving four cloud models, which demonstrate basic features of cloud computing, such as resource virtualization and fair scheduling. We describe an application of [Cloud] by building an architecture, in which [Cloud] models are combined with remote attestation to deliver trusted services.

## Industry Track

### Industry Track 1 – Case Study in Cloud

**Session Chair:** David Buttlar, Lawrence Livermore National Laboratory, USA

### Decision Support Tools for Cloud Migration in the Enterprise (CLOUD2011-1068)

*Ali Khajeh-Hosseini, Ian Sommerville, Jurgen Bogaerts, Pradeep Teregowda (University of St Andrews, UK; Economics & Management Faculty HUBrussel, Belgium; Uni. of Pennsylvania, USA)*

This paper describes two tools that aim to support decision making during the migration of IT systems to the cloud. The first is a modeling tool that produces cost estimates of using public IaaS clouds. The tool enables IT architects to model their applications, data and infrastructure requirements in addition to their computational resource usage patterns. The tool can be used to compare the cost of different cloud providers, deployment options and usage scenarios. The second tool is a spreadsheet that outlines the benefits and risks of using IaaS clouds from an enterprise perspective; this tool provides a starting point for risk assessment. Two case studies were used to evaluate the tools.

### A Home Healthcare System in the Cloud – Addressing Security and Privacy Challenges (CLOUD2011-1069)

*Mina Deng, Milan Petkovic, Marco Nalin, Ilaria Baroni (Philips Research Europe, The Netherlands; Scientific Institute Hospital San Raffaele, Italy)*

This paper focuses on a home healthcare system based on cloud computing. It introduces several use cases and draws an architecture based on the cloud. A comprehensive methodology is used to integrate security and privacy engineering process into the software development lifecycle. In particular, security and privacy challenges are identified in the proposed cloud-based home healthcare system. Moreover, a functional infrastructure plan is provided to demonstrate the integration between the proposed application architecture with the cloud infrastructure. Finally, the paper discusses several mitigation techniques putting the focus on patient-centric control and policy enforcement via cryptographic technologies, and consequently on digital rights management and attribute

based encryption technologies.

### **Content Server System Architecture for Providing Differentiated Levels of Service in a Digital Preservation Cloud (CLOUD2011-1070)**

*Quyen L. Nguyen, Alla Lake (University of Maryland, College Park, USA)*

The growing use of digital records in organizations creates a challenge of preservation and archival of these records. The entities dealing with the care and keeping of digital records include governmental organizations at the local and national. Archiving and preserving digital records requires IT infrastructure and personnel to run the infrastructure. Recently, Cloud Computing has gained momentum in the IT world as one of the options for dealing with the challenges of electronic record management, thanks to the maturity of network protocol infrastructure, virtualization technology and a price-based Service Level Agreement structure. This paper discusses the characteristics and challenges of long term digital preservation that motivate the concept of a specialized Digital Preservation Cloud Service. A scalable and evolvable Content Server System Architecture is proposed here, which can constitute the core of a Digital Preservation Cloud.

### **Industry Track 2 – Security in Cloud**

**Session Chair:** Antonella Longo, University of Salento, Italy

### **Security Prospects through Cloud Computing by Adopting Multiple Clouds (CLOUD2011-1071)**

*Jens-Matthias Bohli, Meiko Jensen, Nils Gruschka, Luigi Lo Iacono, Jörg Schwenk (Ruhr-University Bochum; NEC Lab Europe Heidelberg ;European University of Applied Sciences Brühl, Germany)*

Clouds impose new security challenges, which are amongst the biggest obstacles when considering the usage of cloud services. This triggered a lot of research activities in this direction, resulting in a quantity of proposals targeting the various security threats. Besides the security issues coming with the cloud paradigm, it can also provide a new set of unique features which open the path towards novel security approaches, techniques and architectures. This paper initiates this discussion by contributing a concept which achieves security merits by making use of multiple distinct clouds at the same time.

### **Tackling the Loss of Control: Standards-based Conjoint Management of Security Requirements for Cloud Service (CLOUD2011-1072)**

*Ingo Mueller, Jun Han, Jean-Guy Schneider, Steven Versteeg (Faculty of Information and Communication Technologies; CA Technologies (Pacific), Australia)*

Service consumers typically have no insights which controls protect their information assets and how effectively. To tackle this challenge, we propose an approach where service providers and consumers conjointly manage security requirements for a Cloud service following the ISO 27001 standard for information security management. We have developed a security management platform that provides tool support for service providers and consumers (i) to specify and consolidate security requirements and (ii) to collect, measure, analyze and report information about the effectiveness of implemented controls. By involving service consumers in management activities following an international standard, our approach helps service providers to increase transparency and traceability of their security measures whereas service consumers gain much-needed insights in the protection of their information assets. The applicability of our approach is demonstrated.

### **An Analysis of Security and Privacy Issues in Smart Grid Software Architectures on Clouds (CLOUD2011-1073)**

*Yogesh Simmhan, Alok Gautam Kumbhare, Baohua Cao, Viktor K. Prasanna (University of Southern California, USA)*

Power utilities globally are increasingly upgrading to Smart Grids that use bi-directional communication with the consumer to enable an information-driven approach to distributed energy management. Clouds offer features well suited for Smart Grid software platforms and applications. However, these security and privacy concerns inherent in an information-rich Smart Grid environment are further exacerbated by their deployment on Clouds. Here, we present an analysis of security and privacy issues in a Smart Grids software architecture operating on different Cloud environments, in the form of a taxonomy. We use the Los Angeles Smart Grid Project underway in the largest U.S. municipal utility to drive the analysis.

### **Industry Track 3 – Cloud Applications**

**Session Chair:** Steve Bobrowski, Salesforce.com, USA

### **A Commodity-Focused Multi-Cloud Marketplace Exemplar Application (CLOUD2011-1074)**

*Peter Wright, Terence Harmer, John Hawkins, Yih Leong Sun (Queen's University of Belfast, UK)*

We have been developing and managing a large multi-provider cloud in field deployment for broadcasting applications with an active user community for several years that uses owned resources and resources bought from commercial providers. With the availability of large-scale resources from the increasing number of utility providers, mechanisms are required to enable resources to be added to and removed from clouds in an automated and application-centric way. We use a resource commodity market approach to managing resources within our cloud that is used to define which resources should be used and for how long they should be used and that monitors the performance of resources in an attempt to optimize cloud costs. This model is application-centric because how the cost of a resource is calculated is specified by the application. Our cloud interface approach has some similarity with existing intercloud work however it is distinct in that providers remain unaware of and uncooperative with each other: they form a marketplace through which users can exploit price variation to maximize their profit for their current workload.

### **Implementation of a Scalable Next Generation Sequencing Business Cloud Platform- An Experience Report (CLOUD2011-1075)**

*Shyam Kumar Doddavula, Madhavi Rani, Santonu Sarkar, Harsh Rajesh Vachhani, Akansha Jain, Anirban Ghosh (Infosys Labs, India ; Infosys Consulting Inc., USA)*

Life science industry is looking towards new and cost-effective ways to manage and analyze huge amount of genomic data for faster innovation in drug or biologics discovery. In order to make the development, and management of data and applications cost-effective, a secure cloud computing based platforms are being considered. In this paper we describe an experience report of building such a collaborative platform on Amazon cloud platform. In order to build a scalable genome sequence alignment solution, we have adopted the well-known BLAST framework on Hadoop platform. A major challenge here is that the BLAST executable requires to be ported as it is, and yet the execution needs to scale, as the number of jobs increases, by elastically growing the Hadoop infrastructure. In this paper we proposed a BLAST database partitioning solution to achieve optimal scalability. Our controlled experiment is encouraging; the empirical result shows that the job execution scales with the number of jobs, if the partition sizes are chosen appropriately.

#### **Open911: Experiences with the Mobile Plus Cloud Paradigm (CLOUD2011-1076)**

*Jaime Seguel, Maniel Sotomayor, Juan Aleman, Jose Rivera, Melvin Greer (University of Puerto Rico, Mayagüez; Lockheed Martin Corporation)*

Private, public or hybrid clouds will host many (if not most) of the online services consumed by mobile devices. Hence, cloud researchers and engineers must develop appropriate architectures and design patterns to ensure that clouds provide responsive, efficient, and feature-rich services to both native and web-based applications running on mobile to both native and web-based applications running on mobile devices, desktop or laptop computers. In this paper, we present Open911 as reference architecture for the development of cloud-based applications that feed mobile devices through either native or web applications. Open911 is built on top of cloud services that run on a hybrid cloud that includes Google services and custom-built services deployed on a private cloud powered by Ubuntu Enterprise Cloud. We discuss the elements of our architecture, the rationale behind our design choices, the strengths of the cloud systems, and the drawbacks or limitations that we found during our implementation effort.

#### **Industry Track 4 – Elastic Resource Provisioning**

**Session Chair:** Wu Chou, Avaya Labs Research, USA

#### **Mechanism Design for Stochastic Virtual Resource Allocation in Non-Cooperative Cloud Systems (CLOUD2011-1077)**

*Zhen Kong, Cheng-Zhong Xu, Minyi Guo (Wayne State University, USA; Shanghai Jiao Tong University, China)*

A selfish VM may strategically compete for resource with other VMs to maximize its own benefit while at the cost of overall system performance. This problem poses new challenges to cloud providers, who must thwart non-cooperative behavior as well as allocating resource among selfish VMs efficiently. In this paper, we propose to utilize mechanism design to allocate resource among selfish VMs in a non-cooperative cloud environment. Because the accurate relationship between VM's valuation function and allocated resource may not be available in practice and the valuation function parameters may not noise-free, we also propose to apply stochastic approximation methods to get stochastic solution for allocation and payment outcomes. We show through theoretical analysis and simulations that the proposed stochastic mechanism is efficient and incentive compatible. That is, the incorporation of mechanism design for virtualized resource allocation is able to enforce cooperation and achieve efficient resource utilization among selfish VMs in non-cooperative cloud systems.

#### **Real Time Elastic Cloud Management for Limited Resources (CLOUD2011-1078)**

*Sijin He, Li Guo, Yike Guo (Imperial College London, UK)*

An IaaS provider is usually assumed to own a large data center with significant computational resources. For a small or medium sized Internet Data Centre (IDC), offering cloud computing service is a nature of business model but there are technical barriers which need to be resolved. One key issue is ineffective resource management given such an IDC usually has only limited resource. In this paper, we propose an efficient resource management solution specially designed for helping small and medium sized IaaS cloud providers to better utilize their hardware resources with minimum operational cost. Such an optimized resource utilization is achieved by a well-designed underlying hardware infrastructure, an efficient resource scheduling algorithm and a set of migrating operations of VMs.

#### **SLA Based Dynamic Virtualized Resources Provisioning for Shared Cloud Data Centers (CLOUD2011-1079)**

*Zhiliang Zhu, Jing Bi, Haitao Yuan, Ying Chen (Northeastern University; IBM Research-China)*

Cloud computing focuses on delivery of reliable, secure, sustainable, dynamic and scalable resources provisioning for hosting virtualized application services in shared cloud data centers. For an appropriate provisioning mechanism, we developed a novel cloud data center architecture based on virtualization mechanisms for multitier applications, so as to reduce provisioning overheads. Meanwhile, we proposed a novel dynamic provisioning technique and employed a flexible hybrid queuing model to determine the virtualized resources to provision to each tier of the virtualized application services. We further developed meta-heuristic solutions, which is according to different performance requirements of users from different levels. Simulation experiments are reported.

#### **Industry Track 5 – Engineering Cloud Applications**

**Session Chair:** Rui Zhang, IBM Research – Almaden, USA

#### **Automotive Cloud Service Systems Based on Service-Oriented Architecture and its Evaluation (CLOUD2011-1080)**

*Akihito Iwai, Mikio Aoyama (DENSO CORPORATION; Nanzan University, Japan)*

This article reports our concept and experiences on ACSS (Automotive Cloud Service System) based on SOA (Service-Oriented Architecture) for the next-generation automotive software platform. Along with rapid deployment of cloud computing, we expect, automotive software is evolving to ACSS where vehicles are collaborating with outside cloud computing and a variety of social networks. We propose an ACSS based on SOA named DARWIN, and demonstrate the validity of DARWIN with case studies running on a prototype electric vehicle. This article contributes to reveal key aspects of new software architecture for the next generation

automotive software of integrating software in a vehicle and cloud services out of vehicles seamlessly.

### **A Cloud-based Accessible Architecture for Large-scale ADL Analysis Services (CLOUD2011-1081)**

*Yu-Chiao Huang, Yu-Chieh Ho, Ching-Hu Lu, Li-Chen Fu (National Taiwan University, Taiwan)*

Recognizing Activities of Daily Living (ADL) plays an important role in healthcare. However, it is often impractical and sometimes impossible for a person to collect those useful data manually, not to mention constant long-term data maintenance and analysis. To address the above-mentioned challenges, we propose an architecture, in which many health-care applications and services can easily build upon, for collective long-term ADL pattern analysis that leverages several prominent advantages inherent in cloud computing. The core of the proposed infrastructure includes a module to perform MapReduce-assisted Bayesian activity recognition based on all collected ADL data. Better yet, the resultant data analysis can be delivered as a service from a service station which serves as a readily accessible interface to 3rd party service providers and endusers.

### **Optimal Multitenant Designs for Cloud Apps (CLOUD2011-1082)**

*Steve Bobrowski (Salesforce.com, USA)*

Often overlooked by application architects, multitenancy is the core technology of a cloud that controls how it shares computing resources among applications. Two basic approaches formultitenancy will be discussed, virtual and organic multitenancy, along with thebenefits and disadvantages of each approach. Then you willdiscover why the database that supports a cloud app is acritical consideration, and learn about emerging clouddatabase options that promise to simplify the development andmanagement of apps executing in the cloud. We draw conclusions about which types of solutions best fit particular application scenarios.

## **Industry Track 6 – Governance in Cloud**

**Session Chair:** Kevin Mills, NIST, USA

### **Profiling Applications for Virtual Machine Placement in Clouds (CLOUD2011-1083)**

*Anh Vu Do, Junliang Chen, Chen Wang, Young Choon Lee, Albert Y. Zomaya, Bing Bing Zhou (The University of Sydney; CSIRO ICT Centre; National ICT Australia Limited, Australia)*

With the advent of cloud computing as a multitenant virtualized platform, diverse applications are increasingly deployed onto the cloud and they more than often share physical resources. The background load (other applications running on the same physical machine) is therefore an important factor for profiling an application in this cloud computing scenario. In this paper, we present a novel application profiling technique using the canonical correlation analysis (CCA) method, which identifies the relationship between application performance and resource usage. We further devise a performance prediction model based on application profiles generated using CCA. Clearly, our profiling technique with this prediction model has a lot of potentials particularly in virtual machine (VM) placement with performance awareness. Our experimental results demonstrate the capability of our profiling technique and the accuracy of our prediction model.

### **Self-Configuration of Distributed Applications in the Cloud (CLOUD2011-1084)**

*Xavier Etchevers, Thierry Coupaye, Fabienne Boyer, Noel de Palma (Orange Labs; LIG Labs, France)*

In the field of cloud computing, current solutions dedicated to PaaS are only partially automated. This limitation is due to the lack of an architectural model for describing a distributed application in terms of its software stacks (operating system, middleware, application), their instantiation as virtual machines, and their configuration interdependencies. This article puts forward (i) a component-based application model for defining any kind of distributed applications composed of a set of interconnected virtual machines, (ii) an automated line for deploying such a distributed application in the cloud, which includes a decentralized protocol for self-configuring the virtual application machines, (iii) a first performance evaluation demonstrating the viability of the solution.

### **Delivering High Resilience in Designing Platform-as-a-Service Clouds (CLOUD2011-1085)**

*Qianhui Liang, Bu-Sung Lee (HP Labs; Nanyang Technological University, Singapore)*

One issue in designing PaaS is how to make development process deliver applications resilient to potential changes of the constraints. The first type of dynamic constraints we need to consider is the compatibility between possible components of the application. PaaS must only engage compatible components to collaborate with each other in the same instance of applications. Other constraints include the environment that the application is running and the preferences of the users. We present a data-flow based approach, for PaaS clouds, to designing cloud-based applications that are resilient to failures due to dynamic constraints on resources and on component compatibility. The uniqueness of our approach is the following: The procedure of building cloud-based applications is time-stamped. We have designed a graph structure called Instance Dependency Graphs (IDGs), and have used time-based IDGs to capture, analysis and optimize the resilience of the application. A case study is also reported.

## **Industry Track 7 – Data Storage Management**

**Session Chair:** Hong Cai, IBM China

### **Phoenix A Relational Storage Component for the Cloud (CLOUD2011-1086)**

*Davi E. M. Arnaut, Rebeca Schroeder, Carmem S. Hara (Universidade Federal do Paraná, Brazil)*

This paper describes the design and architecture of a cloud-based relational database system. The system's core component is a storage engine, which is responsible for mapping the logical schema, based on relations, to a physical storage, based on a distributed key-value datastore. The proposed stratified architecture provides physical data independence, by allowing different approaches for data mapping and partitioning, while the distributed datastore is responsible for providing scalability, availability, data replication and ACID properties. A prototype of the system, named Phoenix, has been developed based on the proposed architecture using a transactional key-value store. Experimental studies on a cluster of commodity servers show that Phoenix preserves the desired properties of key-value stores, while providing relational database functionality at a very low overhead.

## Database-Agnostic Transaction Support for Cloud Infrastructures (CLOUD2011-1087)

*Navraj Chohan, Chris Bunch, Chandra Krantz, Yoshihide Nomura (University of California, Santa Barbara; Fujitsu Labs Ltd., Japan)*

In this paper, we present and empirically evaluate the performance of database-agnostic transaction (DAT) support for the cloud. Our design and implementation of DAT is scalable, fault-tolerant, and requires only that the datastore provide atomic, row-level access. Our approach enables applications to employ a single transactional datastore API that can be used with a wide range of cloud datastore technologies. We implement DAT in AppScale, an open-source implementation of the Google App Engine cloud platform, and use it to evaluate DAT's performance and the performance of a number of popular key-value stores.

## IO Tetris: Deep Storage Consolidation for the Cloud via Fine-grained Workload Analysis (CLOUD2011-1088)

*Rui Zhang, Ramani Routray, David M. Eyers, David Chambliss, Prasenjit Sarkar, Douglas Willcocks, Peter Pietzuch (IBM Research – Almaden, USA; University of Otago, New Zealand; Imperial College London, UK)*

Intelligent workload consolidation in storage systems leads to better Return On Investment (ROI), in terms of more efficient use of data center resources, better Quality of Service (QoS), and lower power consumption. This is particularly significant yet challenging in a cloud environment, in which a large set of different workloads multiplex on a shared, heterogeneous infrastructure. However, the increasing availability of finegrained workload logging facilities allows better insights to be gained from workload profiles. As a consequence, consolidation can be done more deeply, according to a detailed understanding of how well given workloads mix. We describe IO Tetris, which takes a first look at fine-grained consolidation in large-scale storage systems by leveraging temporal patterns found in real-world I/O traces gathered from enterprise storage environments. The core functionality of IO Tetris consists of two stages. A grouping stage performs hierarchical grouping of storage workloads to find complementary groupings that consolidate well together over time and conflicting ones that do not. After that, a migration stage examines the discovered groupings to determine how to maximize resource utilization efficiency while minimizing migration costs. Experiments based on customer I/O traces from a high-end enterprise class IBM storage controller show that a non-trivial number of IO Tetris groupings exist in real-world storage workloads, and that these groupings can be leveraged to achieve better storage consolidation in a cloud setting.

## Industry Track 8 – Cloud Analysis

**Session Chair:** Umesh Bellur, Indian Institute of Technology Bombay, India

## A Performance Evaluation of X-ray Crystallography Scientific Workflow using SciCumulus (CLOUD2011-1089)

*Daniel de Oliveira, Kary Ocaña, Eduardo Ogasawara, Jonas Dias, Fernanda Baião, MartaMattoso (COPPE/UFRJ; NP2Tec/UNIRIO; CEFET/RJ)*

X-ray crystallography is an important field due to its role in drug discovery and its relevance in bioinformatics experiments of comparative genomics, phylogenomics, evolutionary analysis, ortholog detection, and three-dimensional structure determination. Managing these experiments is a challenging task due to the orchestration of legacy tools and the management of several variations of the same experiment. Workflows can model a coherent flow of activities that are managed by scientific workflow management systems (SWfMS). Due to the huge amount of variations of the workflow to be explored (parameters, input data) it is often necessary to execute X-ray crystallography experiments HPC environments. Cloud computing is well known for its scalable and elastic HPC model. In this paper, we present a performance evaluation for the X-ray crystallography workflow defined by the PC4 (Provenance Challenge series). The workflow was executed using the SciCumulus middleware at the Amazon EC2 cloud environment. SciCumulus is a layer for SWfMS that offers support for the parallel execution of scientific workflows in cloud environments with provenance mechanisms. Experimental results are reported.

## Exploring Alternative Approaches to Implement an Elasticity Policy (CLOUD2011-1090)

*Hamoun Ghanbari, Bradley Simmons, Marin Litoiu, Gabriel Işzlai (York University; IBM Toronto Lab, Canada)*

An elasticity policy governs how and when resources (e.g., application server instances at the PaaS layer) are added to and/or removed from a cloud environment. The elasticity policy can be implemented as a conventional control loop or as a set of heuristic rules. In the control-theoretic approach, complex constructs such as tracking filters, estimators, regulators, and controllers are utilized. In the heuristic, rule-based approach, various alerts (e.g., events) are defined on instance metrics (e.g., CPU utilization), which are then aggregated at a global scale in order to make provisioning decisions for a given application tier. This work provides an overview of our experiences designing and working with both approaches to construct an autoscaler for simple applications. We enumerate different criteria such as design complexity, ease of comprehension, and maintenance upon which we form an informal comparison between the different methods. We conclude with a brief discussion of how these approaches can be used in the governance of resources to better meet a high-level goal over time.

## An Efficient Sensitivity Analysis Method for Large Cloud Simulations (CLOUD2011-1091)

*Kevin Mills, James Filliben, Chris Dabrowski (NIST, USA)*

Simulations of large distributed systems, such as infrastructure clouds, usually entail a large space of parameters and responses that prove impractical to explore. To reduce the space of inputs, experimenters, guided by domain knowledge and ad hoc methods, typically select a subset of parameters and values to simulate. Similarly, experimenters typically use ad hoc methods to reduce the number of responses to analyze. Such ad hoc methods can result in experiment designs that miss significant parameter combinations and important responses, or that overweight selected parameters and responses. When this occurs, the experiment results and subsequent analyses can be misleading. In this paper, we apply an efficient sensitivity analysis method to demonstrate how relevant parameter combinations and behaviors can be identified for an infrastructure Cloud simulator that is intended to compare resource allocation algorithms. Researchers can use the techniques we demonstrate here to design experiments for large Cloud simulations, leading to improved quality in derived research results and findings.

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## Work-in-Progress Track

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### Work-in-Progress Track 1 – Performance in Cloud

Session Chair: Yogesh Simmhan, University of Southern California, USA

#### **Tuning Adaptive Computations for Performance Improvement of Autonomic Middleware in PaaS Cloud (CLOUD2011-1092)**

*Ying Zhang, Gang Huang, Xuanzhe Liu, Hong Mei (Peking University China)*

An autonomic middleware can perform adaptive computations for self-management of the system. However, these adaptive computations consume resources such as CPU and memory, and can interfere with each other and also with normal business functions of the system due to resource competition, especially when the system is under heavy load. As a result, the adaptive computations should be tuned from the perspective of resource management. Here we propose an approach to tuning the autonomic levels and thus controlling the resource costs of the adaptive computations in an autonomic middleware of PaaS cloud.

#### **MN-GEMS: A Timing-aware Simulator for a Cloud Node with Manycore, DRAM, and Non-Volatile Memories (CLOUD2011-1093)**

*Woomin Hwang, Ki-Woong Park, Kyu Ho Park (Computer Engineering Research Laboratory, KAIST)*

In this paper, we describe a part of our ongoing research project aimed at the management of manycore and Hybrid Main Memory with DRAM and Non-Volatile RAMs (NVRAMs). By the needs of simulation and through investigation of the requirements for the target management system, we found that the simulation platform requires support for manycore, a timing-aware simulation of hybrid memory with DRAM and NVRAM, and a Performance Monitoring Unit (PMU). Therefore, we built MN-GEMS, a full-system simulator for the consolidated VMs of a cloud node satisfying all these requirements.

#### **Energy-Aware Virtual Machine Dynamic Provision and Scheduling for Cloud Computing (CLOUD2011-1094)**

*Ching-Chi Lin, Pangfeng Liu, Jan-Jan Wu (Academia Sinica; National Taiwan University, Taiwan)*

Server consolidation is a NP-hard problem. In this paper, a new algorithm Dynamic Round-Robin (DRR), is proposed for energy-aware virtual machine scheduling and consolidation. We compare this strategy with the GREEDY, ROUNDROBIN and POWERSAVE scheduling strategies implemented in the Eucalyptus Cloud system. Our experiment results show that the Dynamic Round-Robin algorithm reduce a significant amount of power consumption compared with the three strategies in Eucalyptus.

#### **Real Time Collaborative Video Annotation using Google App Engine and XMPP Protocol (CLOUD2011-1095)**

*Abbas Attarwala, Deepak Jagdish, Ute Fischer (University of Toronto, Canada; Nokia Research Center; Georgia Tech, USA)*

This WIP paper reports the status of a Windows based tool, 'Event Coding and Visualization of Data' (ECOVRD) that allows real time collaborative video annotation using Google App Engine (GAE) and XMPP protocol. ECOVRD facilitates classification of live or video recorded individual and team behavior. It is designed with the dual purpose of advancing behavioral (observational) research and of supporting applied uses such as performance assessment and feedback during professional coaching. Users of ECOVRD can initiate a shared real-time video annotation with their social network (Google Buzz) via XMPP protocol. The custom-built publish/subscribe architecture wrapped around GAE's channel service, pushes data from the cloud to subscribed clients resulting in real-time collaborative experience.

#### **Soft-Union: An Overlay based Efficient Software P2P Distribution Scheme (CLOUD2011-1096)**

*Liang Zhong, Chunming Hu, Tianyu Wo, Jianxin Li, Weiji Zeng (Beihang University, China)*

Recent years, SaaS (Software as a Service) has become an innovative software delivery model. The traditional centralized software distribution model failed to meet the rapid deployment requirement of distribute software in large scale environment. In this paper, we present Soft-Union: a novel peer-to-peer based software distribution scheme. Soft-Union organizes the nodes sharing the same software into an overlay to reduce the query time. Furthermore, it incorporates a distributed mechanism for meta-information placement mechanism, and a search protocol to balance the query load and shorter the query time of the block meta-information. The experimental results validate that Soft-Union significantly reduces the block query time comparing with flooding and BTlike software distribution solutions.

#### **Performance Issues in Cloud Computing for Cyber-physical Applications (CLOUD2011-1097)**

*Michael Olson, K. Mani Chandy (California Institute of Technology, USA)*

A focus of the paper is on the performance of cloud computing servers in cyber-physical systems (CPS) applications that aggregate data over large spatial regions over long spans of time. Examples of such CPS applications include those that: sense and respond to change in the environment such as forest fires or mud slides; help utilities such as water management districts monitor water quality and flow; and traffic management systems. This paper evaluates the benefits of architectures based on Cloud computing systems for such CPS applications. We use earthquake detection as a concrete example for this application class. The focus of the paper is on the performance of Platform-as-a-Service systems. The paper described the relative advantages of different types of services in the next few sections.

### Work-in-Progress 2 – Management in Cloud

Session Chair: Yike Guo, Imperial College London, UK

#### **The KOALA Cloud Manage - Cloud Service Management the Easy Way (CLOUD2011-1098)**

*Christian Baum, Marcel Kunze, Viktor Mauch (Karlsruhe Institute of Technology, Germany)*

The key advantages of cloud computing are flexibility, scalability (elasticity) and usability and these features originate in the combination of virtualization technologies with web services. However, in contrast to the elasticity and flexibility of cloud services the traditional management methods and tools seem inappropriate because they usually require local software installation with continuous updates and patches. Furthermore, the solutions are often proprietary and only conform to the cloud service offerings of specific service providers, making it difficult to work with cloud services of different providers. A vendor agnostic generic cloud based software service would bear many advantages in this area. This paper describes the design of a better management solution – the KOALA cloud management service – for cloud services and its implementation.

### **Scheduling Scientific Workflows Elastically for Cloud Computing (CLOUD2011-1099)**

*Cui Lin, Shiyong Lu (California State University, Fresno; Wayne State University, USA)*

Most existing workflow scheduling algorithms only consider a computing environment in which the number of compute resources is bounded. Compute resources in such an environment usually cannot be provisioned or released on demand of the size of a workflow, and these resources are not released to the environment until an execution of the workflow completes. To address the problem, we firstly formalize a model of a Cloud environment and a workflow graph representation for such an environment. Then, we propose the SHEFT workflow scheduling algorithm to schedule a workflow elastically on a Cloud computing environment. Our preliminary experiments show that SHEFT not only outperforms several representative workflow scheduling algorithms in optimizing workflow execution time, but also enables resources to scale elastically at runtime.

### **Defining Customizable Business Processes without Compromising the Maintainability in Multi-Tenant SaaS Applications (CLOUD2011-1100)**

*Malinda Kapuruge, Alan Colman, Jun Han (Swinburne University of Technology, Australia)*

In Software-as-a-Service (SaaS) delivery model a vendor maintains a single application instance, which is used by multiple tenants. However, due to changing business requirements tenants expect customizations. Providing such customizations is trivial to retain tenants but a challenge to the vendor due to multi-tenancy. In this paper we present an approach to define such customizable business processes in multi-tenant SaaS applications without unnecessary and hard to maintain duplication of process definitions and deployments.

### **Legacy Application Migration to Cloud (CLOUD2011-1101)**

*Meng Xin, Shi Jingwei, Liu Xiaowei, Liu Hui Feng, Wang Lian (NEC Laboratories China, China)*

Along with the increasing popularity of cloud computing, the requirement to efficiently migrate enterprises' legacy applications to cloud has become extremely intensive. Existing solutions have many limitations in use, such as the source code of legacy application is always required, or the migrated application cannot be customized or mashed up. What's more, it always overbalances the budget to perform these solutions. In this paper, we proposed a brand new Application Migration Solution (AMS) to efficiently migrate legacy applications to web applications by GUI recognition and reconstruction technology. The core technologies are presented and evaluation results are given for technology validation. Based on AMS, enterprises can deploy their legacy applications to cloud easily. This solution also fulfills advanced enterprise requirements, including application customization requirement or mashup with other applications to compose more integrated and powerful applications.

### **My Private Cloud Overview (CLOUD2011-1102)**

*David W Chadwick, Stijn F Lievens, Jerry I den Hartog, Andreas Pashalidis, Joseph Alhadef (University of Kent, UK; Technische Universiteit Eindhoven, NL; Kasteelpark Arenberg 1 Leuven, Belgium; Oracle, USA)*

Based on the assumption that cloud providers can be trusted (to a certain extent) we define a trust, security and privacy preserving infrastructure that relies on trusted cloud providers to operate properly. Working in tandem with legal agreements, our open source software supports: trust and reputation management, sticky policies with fine grained access controls, privacy preserving delegation of authority, federated identity management, different levels of assurance and configurable audit trails. Armed with these tools, cloud service providers are then able to offer a reliable privacy preserving infrastructure-as-a-service to their clients.

### **Multi-Level Autonomic Architecture for the Management of Virtualized Application Environments in Cloud Platforms (CLOUD2011-1103)**

*Omar Abdul-Rahman, Masaharu Munetomo, Kiyoshi Akama (Hokkaido University, Japan)*

resource management in cloud platforms becomes an increasingly complex and daunting task surrounded by various challenges of stringent QoS requirements, service availability guaranteeing and escalating overhead of the infrastructure that resulted from operation costs and ecological effects. Virtualization adds a greater flexibility to the resource manager in addressing such challenges. However, it imposes a further challenge of added management complexity. So, in this brief paper, we attempt to address still an open question of how to employ virtualization techniques effectively to realize a resource manager that intelligently adapts cloud platforms resource usage to satisfy the conflicting objectives of running applications and underlying cloud infrastructures by proposing a novel multi-level architecture which relays on a hybrid virtualization framework. We describe its functional components and dataflow and highlight the next steps that we will adopt in order to realize it and evaluate its feasibility and effectiveness.

## **Work-in-Progress Track 3 – Security and Scalability in Cloud**

**Session Chair:** Karthik Gomadam, Accenture Technology Labs, USA

### **Secure Sharing of Item-level Data in the Cloud (CLOUD2011-1104)**

*Florian Kerschbaum, Leonardo Weiss Ferreira Chaves (SAP AG, SAP Research Center Karlsruhe, Germany)*

Companies can optimize their supply chain if they exchange item-level data, i.e. specific data about each item gathered with the help of Radio Frequency Identification or 2D bar codes. However, business critical information might be inferred from this data, e.g. strategic relations or best practices. Therefore, companies are reluctant to share item-level data. In this paper we discuss requirements for an encryption scheme for exchanging item-level data by storing it in a cloud based data repository. We envision a system that allows the data owner to enforce access control on an item-level. And data should remain confidential even against the cloud service

## **Towards Multi-User Private Keyword Search for Cloud Computing (CLOUD2011-1105)**

*Yanjiang Yang (Institute for Infocomm Research, Singapore)*

Storage-as-a-service is an essential component of the cloud computing infrastructure, which allows the customers to outsource their databases to the regime of a cloud. Towards enabling private keyword search, we propose an efficient multi-user searchable encryption scheme.

## **Flexible Authorization by Generating Public Re-decryption Trapdoor in Outsourced Scenarios (CLOUD2011-1106)**

*Yang Zhang, Jun-Liang Chen (Beijing University of Posts & Telecommunications, China)*

Service and data outsourcing has become a practical and useful computing paradigm. Combined use of access control and cryptography was proposed by many researchers to protect sensitive information in this outsourcing scenario. However, the rigid combination in existing approaches has difficulty in satisfying the flexibility requirement of access control for diverse applications. In this paper, we propose a flexible authorization by generating public re-decryption trapdoor. The features of our solution are as follows: simple key management without the need of key derivation for users to decrypt ciphertexts; grouping users during authorization to reduce management workload; composing conditions for accessing new resources without generating new keys if the re-encryption keys for atomic conditions have been produced.

## **Security Management Areas in the Inter-Cloud (CLOUD2011-1107)**

*Michael Kretzschmar, Mario Golling, Sebastian Hanigk (Universität der Bundeswehr München; Institut für Technische Informatik, Germany)*

Within the context of Cloud Computing, one of the most important security challenges is to manage and assure a secure usage over multi-provider Inter-Cloud environments with dedicated communication infrastructures, security mechanisms, processes and policies. The aim of Security controls in Cloud computing is, for the most part, no different than security controls in any IT environment from a functional security management perspective. The adaption and reuse of existing traditional security management areas that have to be enhanced for specific Cloud computing requirements (e.g., dynamic reconfiguration, distributed services, etc.), is proposed. Based on the collection of various Inter-Cloud use cases and scenarios within the private and public sector like DMTF (Distributed Management Task Force), NIST (National Institute of Standards and Technology), GICTF (Global Inter- Cloud Technology Forum) and ENISA (European Network and Information Security Agency) we analyzed and summarized the range of requirements for security management. As these requirements are not yet fulfilled by current security management approaches, we derived a set of security management areas that describe all identified functional aspects. This set will serve as a foundation of our future development towards a security management architecture for the Inter-Cloud.

## **Cloud User Roles - Establishing Standards for Describing Core Tasks of Cloud Creators, Providers, and Consumers (CLOUD2011-1108)**

*Birgit Schmidt-Wesche, Terry Bleizeffer, Jeff Calcaterra, Deepa Nair, Randy Rendahl, Peter Sohn (IBM, USA)*

In order to design, build, and provide cloud based solutions that best meet customers' needs, it is essential to understand the skills, goals, primary tasks, and responsibilities of the people or organizations involved throughout the cloud service lifecycle. At IBM®, we developed a set of user roles that are used to describe the tasks of the people who interact with a cloud based Information Technology system. The three core roles of Cloud Service Creator, Cloud Service Provider, and Cloud Service Consumer create the base for reflecting the close interaction between developers, providers, and consumers in order to achieve the optimum service flow. The development of a single role and the entire taxonomy of roles is guided by a framework of well-defined principles.

## **Scalable Service Oriented Replication in the Cloud (CLOUD2011-1109)**

*Tao Chen, Rami Bahsoon (University of Birmingham, UK)*

In this paper, we present Scalable Service Oriented Replication (SSOR), a middleware solution that satisfies application's requirements in service replication. We propose the notions of region and the relevant service oriented requirements policies, by which trading between consistency and scalability can be handled. We solve atomic broadcast as a sub-problem by demonstrating Multi-fixed Sequencers Protocol (MSP). We also apply a Region based Election Protocol (REP) that elastically balances the workload amongst sequencers. Preliminary experiments are reported.

# **2011 IEEE Ninth International Conference on Web Services (ICWS 2011) Research Tracks**

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## **Research Track 1 – Multicast and Mobile Wireless Communication**

**Session Chair:** Munindar P. Singh, North Carolina State University, USA

## **Differential SOAP Multicasting (ICWS2011-2001)**

*Joe Tekli, Ernesto Damiani, Richard Chbeir (Università Degli Studi Di Milano, Italy; University of Bourgogne, France)*

SOAP has been widely adopted as a simple, robust and extensible XML-based protocol for the exchange of messages among web services. Unfortunately, SOAP communications have two major performance-related drawbacks: i) *verbosity*, related to XML, that leads to increased network traffic, and ii) *high computational burden* of XML parsing and processing, that leads to high latency. In this paper, we address these two issues and introduce a novel framework for Differential SOAP Multicasting (DSM). The main idea

consists in identifying the common pattern and differences between SOAP messages, modeled as trees, so as to multicast similar messages together. Our method is based on the well known concept of Tree Edit Distance, built upon a novel *filter-differencing* architecture to reduce message aggregation time, identifying only those messages which are relevant (i.e., similar enough) for similarity evaluation. In addition, our technique exploits a dedicated differencing output format specifically designed to carry the minimum amount of *diff* information, in the multicast message, so as to minimize the multicast message size, and therefore reducing the network traffic. The battery of simulation experiments conducted to evaluate our approach shows the relevance of our method in comparison with traditional and dedicated multicasting techniques.

### **Enhancing the Caching of Web Service Responses on Wireless Clients (ICWS2011-2002)**

*Apostolos Papageorgiou, Marius Schatke, Stefan Schulte, Ralf Steinmetz (Technische Universität Darmstadt, Germany)*

Contrary to simple Web content, standard Web services do not offer their clients the possibility to use cached information without the risk that it may be out-of-date. This feature has not been worth its costs in realistic Web service usage scenarios until now. However, its absence may pose restrictions and impede possible benefits in a future scenario, where mediators are both willing and able to effectively minimize the amount of wirelessly transmitted data in the Internet of Services. This paper describes how developments in the Internet of Services start to motivate the automatic enablement of safe (i.e., always up-to-date) client-side caching for Web services. It presents our solution for generically adding this feature to any Web service, and, based on new experiments, reveals the limits beyond which the approach can offer significant benefits.

### **Opportunistic Composition of Sequentially-Connected Services in Mobile Computing Environments (ICWS2011-2003)**

*Christin Groba, Siobhan Clarke (Trinity College Dublin, Ireland)*

Dynamic service composition has emerged as a promising approach to build complex runtime-adaptable applications as it allows for binding service providers only shortly before service execution. However, the dynamic and ad hoc nature of mobile computing environments poses a significant challenge for dynamic service composition. In particular, the lack of central control and the potential volatility of service providers increase the complexity and failure probability of the composition process. Although, current research has led to decentralised composition algorithms and failure recovery strategies, the key question of how to reduce the failure probability of a composition still remains. We address this question and propose opportunistic service composition, an optimized execution model for complex service requests. The model merges the execution phase into the dynamic binding phase and supports the immediate fulfillment of partially composed service requests. We evaluated our model in mobile ad hoc network simulations. The results show an improvement over a baseline approach regarding composition success, responsetime, and communication effort.

## **Research Track 2 – Security, Privacy and Trust**

**Session Chair:** John A. Miller, University of Georgia, USA

### **Defending Web Services against Denial of Service Attacks Using Client Puzzles (ICWS2011-2004)**

*Suriadi Suriadi, Douglas Stebila, Andrew Clark, Hua Liu (Queensland University of Technology, Australia)*

The interoperable and loosely-coupled web services architecture, while beneficial, can be resource-intensive, and is thus susceptible to denial of service (DoS) attacks in which an attacker can use a relatively insignificant amount of resources to exhaust the computational resources of a web service. We investigate the effectiveness of defending web services from DoS attacks using client puzzles, cryptographic, countermeasure which provides a form of gradual authentication by requiring the client to solve some computationally difficult problems before access is granted. In particular, we describe a mechanism for integrating a hash-based puzzle into existing web services frameworks and analyze the effectiveness of the countermeasure using a variety of scenarios on a network testbed. Client puzzles are an effective defense against flooding attacks. They can also mitigate certain types of semantic-based attacks, although they may not be the optimal solution.

### **A Privacy-Preserving Service Selection in Business Oriented Web Service Composition (ICWS2011-2005)**

*Anna Cinzia Squicciarini, Barbara Carminati, Sushama Karumanchi (Fudan University; Shanghai University of Electric Power; East China Normal University, China)*

With the convenient connection to network, more and more individual information including sensitive information, such as contact list in Mobile Phone or PDA, can be delegated to the professional third service provider to manage and maintain. The benefit of this paradigm is, on one hand to avoid the sensitive information leakage when individual devices failed or lost, on the other hand to make only the authorized users access and share the delegated information online anytime and anywhere. However, in this paradigm the critical problems to be resolved are to guarantee both the privacy of delegated individual information and the privacy of authorized users, and what is more important to afford the owners of communication devices to have high level of control and power to create their own particular access control policies. In this paper, we present an approach to implement the personalized access control at third service provider in a privacy preserving way. Our approach implements the critical problems above in this paradigm by using selective encryption, blind signature and the combination of role based access control and discretionary access control.

### **Finding $K$ Optimal Social Trust Paths for the Selection of Trustworthy Service Providers in Complex Social Networks (ICWS2011-2006)**

*Guanfeng Liu, Yan Wang, Mehmet A. Orgun (Macquarie University, Australia)*

In a service-oriented online social network consisting of service providers and consumers as participants, a service consumer can search trustworthy service providers via the social network between them. This requires the evaluation of the trustworthiness of a service provider along a potentially very large number of social trust paths from the service consumer to the service provider. Thus, a challenging problem is how to identify  $K$  optimal social trust paths that can yield the  $K$  most trustworthy evaluation results based on service consumers' evaluation criteria. In this paper, we first present a complex social network structure and a concept, Quality of Trust (QoT). We then model the  $K$  optimal social trust paths selection with multiple end-to-end QoT constraints as the Multiple

Constrained K Optimal Paths (MCOP-K) selection problem, which is NP-Complete. For solving this challenging problem, based on Dijkstra's shortest path algorithm and our optimization strategies, we propose a heuristic algorithm H-OSTP-K with the time complexity of  $O(m+Kn \log n)$ .

### Research Track 3 – Service Evolution

Session Chair: Ephraim Feig, USA

#### An Empirical Study on Web Service Evolution (ICWS2011-2007)

*Marios Fokaefs, Rimon Mikhael, Nikolaos Tsantalos, Eleni Stroulia, Alex Lau (University of Alberta; IBM Toronto Lab, Canada)*

The service-oriented architecture paradigm prescribes the development of systems through the composition of services, i.e., network-accessible components, specified by (and invoked through) their WSDL interface descriptions. Systems thus developed need to be aware of changes in, and evolve with, their constituent services. Therefore, accurate recognition of changes in the WSDL specification of a service is an essential functionality in the context of the software lifecycle of service-oriented systems. In this work, we present the results of an empirical study on WSDL evolution analysis. In the first part, we empirically study whether VTracker, our algorithm for XML differencing, can precisely recognize changes in WSDL documents by applying it to the task of comparing 18 versions of the Amazon EC2 webservice. Second, we analyze the changes that occurred between the subsequent versions of various web-services and discuss their potential effects on the maintainability of service systems relying on them.

#### LoST: Local State Transfer – An Architectural Style for the Distributed Enactment of Business Protocols (ICWS2011-2008)

*Mumindar P. Singh (North Carolina State University, USA)*

Local State Transfer (LoST) is a simple, declarative approach for enacting communication protocols. LoST is perfectly distributed and relies only upon the local knowledge of each business partner. It involves a novel treatment of the information bases of protocols, especially in terms of how their parameters are specified. As a result, LoST can capture subtle patterns of interaction that more complex approaches cannot handle well. Further, LoST lends itself to implementations that are robust against unordered and lossy message transmission.

#### Towards Privacy-Preserving XML Transformation (ICWS2011-2009)

*Meiko Jensen, Florian Kerschbaum (Ruhr University Bochum; SAP Research Center Karlsruhe, Germany)*

In composite web services one can only either hide the identities of the participants or provide end-to-end confidentiality via encryption. For a designer of interorganizational business processes this implies that she either needs to reveal her suppliers or force her customers to reveal their information. In this paper we present a solution to the encrypted data modification problem and reconcile this apparent conflict. Using a generic sender-transformer-recipient example scenario, we illustrate the steps required for applying XML transformations to encrypted data, present the cryptographic building blocks, and give discussions. The transformer is then able to offer composite services without itself learning the content of the messages.

### Research Track 4 – Automatic Service Composition

Session Chair: Ernesto Damiani, University of Milan, Italy

#### Dynamic Composition of Pervasive Process Fragments (ICWS2011-2010)

*Adina Sirbu, Annapaola Marconi, Marco Pistore, Hanna Eberle, Frank Leymann, Tobias Unge (Fondazione Bruno Kessler, Italy; Institute of Architecture of Application Systems, Germany)*

A critical aspect for pervasive computing is the possibility to discover and use process knowledge at run time depending on the specific context. This can be achieved by using an underlying service-based application and dynamic service discovery, selection, and composition. Pervasive process fragments represent a service-based tool that allows to model incomplete and contextual knowledge. We provide a solution to automatically compose such fragments into complete processes, according to a specific context and specific goals. We compute the solution by encoding process knowledge, domain knowledge and goals into an AI planning problem. We evaluate our approach on different scenarios stressing the main characteristics of pervasive process fragments.

#### Automatic Web Service Composition with a Heuristic-Based Search Algorithm (ICWS2011-2011)

*Pablo Rodriguez-Mier, Manuel Mucientes, Manuel Lama (Universidad de Santiago de Compostela, Spain)*

Algorithms finding proper web services must deal with different issues like performance, semantics or user restrictions. In this paper we present an A\* algorithm which solves the problem of semantic input-output message structure matching for web service composition. Given a request, a service dependency graph with a subset of the original services from an external repository is dynamically generated. Then, the A\* search algorithm is used to find a minimal composition that satisfies the user request. Moreover, to improve the performance, a set of dynamic optimization techniques has been implemented over the search process. Experimental validation is reported.

#### QoS-aware Automatic Service Composition by Applying Functional Clustering (ICWS2011-2012)

*Florian Wagner, Fuyuki Ishikawa, Shinichi Honiden (University of Tokyo; National Institute of Informatics, Japan)*

With the steadily growing number of service providers the competition becomes more and more intense. In order to find a distinctive edge over other competitors, automatic service composition can be applied to further adapt to the requirements of the users. Most of the current composition approaches can be categorized as either planning or selection algorithms. The former automatically create workflows and tend to neglect Quality-of-Service (QoS) concerns, drawing compositions useless if user constraints are violated. Selection algorithms on the other hand optimize the QoS but provide no functional flexibility. In this paper we show how the strengths of both approaches can be combined by leveraging common characteristics of service registries. Therefore we utilize a data structure which arranges functionally similar services in clusters and compute the QoS of each cluster. Our planning tool composes workflows

consisting of these clusters, taking the QoS of the clusters into account. This way, the utility in general and the reliability of the composed workflows are significantly increased.

## Research Track 5 – Service Selection and Negotiation

**Session Chair:** Xiaoqing (Frank) Liu, Missouri University of Science and Technology, USA

### Service Selection with Combinational Use of Functionally-Equivalent Services (ICWS2011-2013)

*Nobuaki Hiratsuka, Fuyuki Ishikawa, Shinichi Honiden (University of Tokyo; National Institute of Informatics, Japan)*

Due to the increase in Web services, many recent studies have been addressing the service selection problem based on non-functional or quality aspects. Our study incorporates combinational use of functionally-equivalent services into the problem to compose an application of higher quality or with additional value. However, when such combinational use is introduced, computational cost for the service selection becomes much higher. In this work, we propose a set of methods that reduce the additional cost for the QoS-based service selection considering combinational use. This approach achieves low cost by considering only effective combinations. The experimental results show that it can reduce computational cost regardless of the number of services and whatever their QoS values are while keeping the effectiveness of combinational use.

### Webneg: A Genetic Algorithm Based Approach for Service Negotiation (ICWS2011-2014)

*Khayyam Hashmi, Amal Alhosban, Zaki Malik, Brahim Medjahed (Wayne State University; The University of Michigan, USA)*

Automated negotiation among Web services not only provides an effective way for the services to bargain for their optimal customizations, but also allows the discovery of overlooked potential solutions. A number of negotiation supporting techniques have been used to find solutions that are acceptable to all parties in the negotiation. However, employing these solutions for automated negotiations among Web services has its own challenges. In this paper, we present the design of a Negotiation Web service that would be used by both the consumers and providers of Web services for conducting negotiations. This negotiation service uses a genetic algorithm (GA) based approach for finding acceptable solutions in multi-party and multi-objective negotiations. In addition to the traditional genetic operators of crossover and mutation, the search is enhanced using a new operator called the Norm. Norm operator represents the cumulative knowledge of all the parties involved in the negotiation process. GA performance with the new Norm operator is compared to the traditional GA, hill-climber and random search techniques. Experimental results indicate the practicality of our approach in facilitating the negotiations involved in a Web service composition process. Specifically, the proposed GA with Norm operator performs better than other approaches.

### Combining Configuration and Query Rewriting for Web Service Composition (ICWS2011-2015)

*Amin Mesmoudi, Michael Mrissa, Mohand-Said Hacid (Universit'e de Lyon, CNRS, France)*

In this paper, we investigate the combination of configuration and query rewriting for semantic Web service composition. Given a user query and a set of service descriptions, we rely on query rewriting to find services that implement the functionalities expressed in the user query (discovery stage). Then, we use configuration to capture dependencies between services, and to generate a set of composed Web services described as a directed acyclic graph, while maintaining validity with respect to business rules (orchestration stage). Finally, we propose a semantic ranking algorithm to rank results according to user preferences (classification stage). The techniques used in our approach take into account the semantics of concepts utilized to describe the elements (services, business rules, query and user preferences) involved in the composition process. We provide a formal approach and its implementation, together with experiments on Web services from different application domains.

## Research Track 6 – Business Process Management

**Session Chair:** Andreas Wombacher, University of Twente, Netherlands

### A Multi-tenant Architecture for Business Process Executions (ICWS2011-2016)

*Milinda Pathirage, Srinath Perera, Indika Kumara, Sanjiva Weerawarana (WSO2 Inc., USA)*

To enable economic pay-as-you-go services, we need Cloud middleware that maximizes sharing and support near-zero costs for unused applications. Multi-tenancy, which lets multiple tenants (user) to share a single application instance securely, is a key enabler for building such a middleware. On the other hand, business processes capture Business logic of organizations in an abstract and reusable manner, and hence play a key role in most organizations. This paper presents the design and architecture of a Multi-tenant Workflow engine while discussing in detail potential use cases of such architecture. Primary contributions of this paper are motivating workflow multi-tenancy, and the design and implementation of multi-tenant workflow engine that enables multiple tenants to run their workflows securely within the same workflow engine instance without modifications to the workflows.

### Refactoring and Publishing WS-BPEL Processes to Obtain More Partners (ICWS2011-2017)

*Wei Song, Xiaoxing Ma, S. C. Cheung, Hao Hu, Qiliang Yang, Jian Lu (Nanjing University of Science and Technology; Nanjing University; HKUST, China)*

Abstract WS-BPEL processes can facilitate service discovery when the services have multiple interfaces in certain order. Current approaches derive the abstract WS-BPEL processes directly from the corresponding executable ones by hiding or omitting the internal activities. However, these simple approaches may prevent the services from being found by valuable potential partners at service discovery stage. To address this problem, we propose a novel approach to refactoring the executable and abstract WS-BPEL processes for service discovery. We show the application of our approach through a typical travel agency service.

### Modeling and Executing Business Processes with Annotated Security Requirements in the Cloud (ICWS2011-2018)

*Julio Cesar Damasceno, Fernando Antonio Aires Lins, Robson Wagner Albuquerque de Medeiros, Bruno Leonardo Barros Silva, Andre Ricardo da Silva Souza, David Levy Lucena Alves Araçao, Paulo Romero Martins Maciel, Nelson Souto Rosa, Bryan Stephenson, Jun Li (Federal University of Pernambuco, Brazil; HP Labs, USA)*

The design, deployment and execution of business process models and their associated security models is expensive and time consuming. This is because these activities usually involve multiple stakeholders that include business domain experts, security experts, web service developers and IT operations teams, and there is no streamlined development environment to allow these stakeholders to work collaboratively on a business process. We have developed a cloud-based model-driven development and execution environment called SSC4Cloud to provide a shared business process modeling workspace and a business process execution environment. More specifically, with the shared modeling workspace, business process models can be developed, refined and shared. Within the shared execution environment, a business process model is translated into a WS-BPEL based executable model, which is then assigned for execution in a virtual machine container from a shared machine cluster. The common model execution environment supports both business process execution and enforcement of the security requirements attached to the business process models.

## Research Track 7 – Service Evaluation and Analysis

Session Chair: Srinath Perera, WSO2 Inc., USA

### A QoS-Aware Service Evaluation Method for Co-Selecting a Shared Service (ICWS2011-2019)

*Dou Wanchun, Lv Chao, Zhang Xuyun, Jinjun Chen (Nanjing University, China; Swinburne University of Technology; University of Technology, Australia)*

In service selection, an end user often has his or her personal preferences imposing on a candidate service's non-functional properties. For a service selection process promoted by a group of users, candidate services are often evaluated by a group of end users who may have different preferences or priorities. In this situation, it is often a challenging effort to make a tradeoff among various preferences or priorities of the users. In view of this challenge, a multi-criteria decision-making method, named AHP (Analytic Hierarchy Process), is introduced to transform both qualitative personal preferences and users' priorities into numeric weights. Furthermore, a QoS-aware service evaluation method is presented for a shared service's co-selection taking advantage of AHP theory. At last, a case study is presented to demonstrate the feasibility of the method.

### Timed Web Services Analysis after Removing Complex Implicit Transitions (ICWS2011-2020)

*Emad Elabd, Emmanuel Coquery, Mohand-Said Hacid (Université Claude Bernard, Lyon 1, France)*

Time is an important parameter in modeling and analyzing Web services. A Web service can be presented by its behavior which can be described by a business protocol representing the possible sequences of message exchanges. Automated analyses of timed Web services such as compatibility checking are very difficult and in some cases are not possible with the presence of implicit transitions (internal transitions) based on time constraints. The semantics of the implicit transitions is the source of this difficulty because most of well known modeling tools do not express this semantics (e.g., epsilon transition on the timed automata has a different semantics). This paper presents an approach for removing complex implicit transitions of the timed business protocols before performing the interoperability analysis without changing the semantics of the protocols.

### Runtime Monitoring of Data-centric Temporal Properties for Web Services (ICWS2011-2021)

*Guoquan Wu, Jun Wei, Chunyang Ye, Xiaozhe Shao, Hua Zhong, Tao Huang (Chinese Academy of Sciences., China)*

Existing runtime monitoring solutions consider only the constraints on the sequence of messages exchanged between partner services and ignore the actual data contents inside the messages. As a result, it is difficult to monitor some dynamic properties. To address this issue, we propose an efficient, non-intrusive online monitoring approach to dynamically analyze data-centric properties for service oriented applications involving multiple participants. By introducing *Par-BCL* - a Parametric Behavior Constraint Language for web services - to define monitoring parameters, various data-centric temporal behavior properties for Web services can be specified and monitored. This approach broadens the monitored patterns to include not only message exchange orders, but also the data contents bound to the parameters. To reduce runtime overhead, we statically analyze the monitored properties to generate parameter state machine from the event pattern automata to optimize monitoring. The experiments show that our solution is efficient and promising.

## Research Track 8 – Service Interoperability

Session Chair: Andrzej M Goscinski, Deakin University, Australia

### Has WS-I's Work Resulted in Web Services Interoperability? (ICWS2011-2022)

*Andreas Schoenberger, Johannes Schwalb, Guido Wirtz (University of Bamberg; Senacor Technologies AG, Germany)*

Recently, the Web Services Interoperability Organization (WS-I) has announced to have completed its interoperability standards work. The latest deliverables include the so-called "Basic Security Profile" and the "Reliable Secure Profile". This gives rise to the question whether or not Web Services adopters can rely on interoperability of Web Services stacks, in particular in terms of security and reliability features. To answer this question, we thoroughly analyze two important Web Services stacks for interoperability of WS-Security and WS-Reliable Messaging features. Our analysis shows that security and reliability features are far from being implemented in an interoperable manner. Additionally, we reveal that some of those interoperability problems are not even covered by WS-I profiles and therefore conclude that WS-I's work has not yet resulted in Web Services interoperability.

### Retrieving Compatible Web Services (ICWS2011-2023)

*Vasilios Andrikopoulos, Pierluigi Plebani (Tilburg University, Netherlands; Politecnico di Milano, Italy)*

Service retrieval holds a central role during the development of Web services and Service-Based Applications (SBAs). The higher the number of available services, the more complex it becomes to locate the service closer to the developer needs. The complexity increases further with the number of available service versions that could also be suitable for this purpose. Existing approaches on service retrieval use a similarity measure between service interfaces to identify potentially relevant services. In this work we focus on introducing information about the compatibility of services while calculating their similarity as the means for providing more suitable results. For this purpose we update and extend an existing Web services matchmaker called UDDI Registry By Example (URBE).

### DIEGO: A Tool for Deriving Choreography-Conforming Web Service Systems (ICWS2011-2024)

*Pablo Rabanal, Ismael Rodriguez, Gregorio Diaz (Universidad Complutense de Madrid (UCM); Universidad de Castilla-La Mancha (UCLM), Spain)*

We present a tool to automatically derive choreography-conforming web services systems. The user provides a specification that describes peer-to-peer collaborations of the observable behavior of parties from a global viewpoint, in our case WS-CDL documents, and the tool automatically extracts the particular behavior of each participant, more concretely, WS-BPEL documents defining the behavior from a local viewpoint. We implement two automatic methods (centralized and decentralized) that derive conforming systems even in cases where projecting the choreography into each service would lead to a non-conforming system. This issue is addressed by adding control messages that make services interact as required by the choreography. Experiments are discussed.

## **Research Track 9 – Service Ranking and Recommendation**

**Session Chair:** Mauricio Cortes, Bell Laboratories, Alcatel-Lucent, USA

### **Collaborative Filtering Based Service Ranking Using Invocation Histories (ICWS2011-2025)**

*Qiong Zhang, Chen Ding, Chi-Hung Chi (Ryerson University, Canada; Tsinghua University, China)*

Collaborative filtering based recommender systems are very successful in dealing with the information overload problem and providing personalized recommendations to users. When more and more web services are published online, this technique can also help recommend and select services which satisfy users' particular Quality of Service (QoS) requirements and preferences. In this paper, we propose a novel collaborative filtering based service ranking mechanism, in which the invocation and query histories are used to infer the user behavior, and user similarity is calculated based on similar invocations and queries. To overcome some of the inherent problems with the collaborative filtering systems such as the cold start and data sparsity problem, the final ranking score is a combination of the QoS-based matching score and the collaborative filtering based score. The experiment using a simulated dataset proves the effectiveness of the algorithm.

### **A QoS-based Fuzzy Model for Ranking Real World Web Services (ICWS2011-2026)**

*Mohamed Almulla, Kawthar Almatori, Hamdi Yahyaoui (Kuwait University, Kuwait)*

With the increasing popularity of using Web services, Quality of Service (QoS) is becoming a significant concern for both service consumers and providers. Several models for considering functional and non-functional QoS requirements for the purpose of Web service discovery and selection have been proposed. We present in this paper a new Web services selection model based on fuzzy logic. In this model, the non-functional QoS requirements are taken into account for the appropriate selection of required services. Our model can handle consumers' imprecise preferences with fuzzy sets. Moreover, a new fuzzy ranking algorithm that is based on the dependencies between quality attributes is proposed. The experimental results obtained from real world Web service domains revealed better performance of our algorithm compared to Entropy-based ranking algorithms.

### **An Effective Web Service Recommendation Method based on Personalized Collaborative Filtering (ICWS2011-2027)**

*Yechun Jiang, Jianxun Liu, Mingdong Tang, Xiaoqing (Frank) Liu (Hunan University of Science and Technology, China; Missouri University of Science & Technology, USA)*

Collaborative filtering is one widely used Web service recommendation technique. Existing Web service selection and recommendation methods seldom consider personalized influence of users and services. In this paper, we present an effective personalized collaborative filtering method for Web service recommendation. A key component is computation of similarity measurement of Web services. Different from the Pearson Correlation Coefficient (PCC) similarity measurement, we consider the personalized influence of services when computing similarity measurement between users and personalized influence of services. We also developed an effective Personalized Hybrid Collaborative Filtering (PHCF) technique by integrating personalized user-based algorithm and personalized item-based algorithm. We conduct series of experiments.

## **Research Track 10 – Efficient Service Composition**

**Session Chair:** Daniela Barreiro Claro, Federal University of Bahia, Brazil

### **Semi-Empirical Service Composition: A Clustering Based Approach (ICWS2011-2028)**

*Xianzhi Wang, Zhongjie Wang, Xiaofei Xu (Harbin Institute of Technology, China)*

Service composition suffers from dramatic decrease on the efficiency of determining the best composition solution when large scale candidate services are available. Most current approaches greatly depend on the adopted algorithms. To eliminate such deficiency, this paper proposes a semi-empirical composition approach which incorporates two stages, i.e., periodical clustering and real-time composition. The former partitions the candidate services and historical requirements into clusters based on similarity measurement, and then the probabilistic correspondences between service clusters and requirement clusters are identified by statistical analysis. The latter deals with a new requirement by firstly finding its most similar requirement cluster and the corresponding service clusters by leveraging Bayesian inference, then a set of concrete services are optimally selected from such reduced solution space and constitute the final composition solution. Instead of relying on solely historical data exploration or on pure real-time computation, our approach distinguishes from traditional methods by combining the two perspectives together. Experiments demonstrate the advantages of this approach.

### **Efficient Multi-Granularity Service Composition (ICWS2011-2029)**

*Lina Barakat, Simon Miles, Iman Poernomo, Michael Luck (King's College London, UK)*

Dynamic composition of services copes with a large variety of complex requirements that cannot be met by individual service alone. However, the best combination of services becomes very complex. In response, this paper addresses the challenges of service selection, and makes a twofold contribution. First, a rich representation of compositional planning knowledge is provided, allowing the expression of multiple decompositions of tasks at arbitrary levels of granularity. Second, two distinct search space reduction techniques are introduced, the application of which, prior to performing service selection, results in significant improvement in

selection performance in terms of execution time, which is demonstrated via experimental results.

### **On the Optimal Petri Net Representation for Service Composition (ICWS2011-2030)**

*Yin Wang, Ahmed Nazeem, Ram Swaminathan (HP Labs, CA; Georgia Tech, GA)*

The problem of representation of the composition outcome has been largely ignored. Ad-hoc workflows are often employed. In this paper, we show how *theory of regions*, which was originally developed to derive *Petri nets* from finite state automata, can be applied to find the optimal representation of composition. We first propose an automaton-based composition framework that incorporates most existing composition techniques without changing the service semantics or its description language. Then based on the special requirements of the composition representation, we develop our own Petri nets synthesis algorithm that combines the benefits of two well known algorithms from the theory of regions. We demonstrate that AND/OR workflow nets can limit the concurrency even for simple input/output based service composition. Experimental evaluations are reported.

### **Research Track 11 – Semantic Services**

**Session Chair:** Cesar Gonzales, IBM T.J. Watson Research Center, USA

### **Composing Data-Driven Service Mashups with Tag-based Semantic Annotations (ICWS2011-2031)**

*Xuanzhe Liu, Qi Zhao, Gang Huang, Hong Mei, Teng Teng (Peking University; Kingdee Middleware Company Ltd., China)*

Mashups usually address solving situational problems and require quick and iterative development lifecycle. In this paper, we propose an approach to composing data driven mashups, based on tag-based semantics. The core principle is deriving semantic annotations from popular tags, and associating them with programmatic inputs and outputs data. Tag-based semantics promise a quick and simple comprehension of data capabilities. Mashup developers including end-users can intuitively search desired services with tags, and combine several services by means of data flows. Our approach takes a planning technique to retrieving the potentially relevant composition opportunities.

### **A Learning Ontology Method for RESTful Semantic Web Services (ICWS2011-2032)**

*Yong-Ju Lee, Chang-Su Kim (Kyungpook National University; Yeungnam University, Korea)*

The growing number of RESTful web services available on the web raises a challenging search problem as to how the desired web services should be located. Traditional keyword searching is inaccurate, and its limitations have been noted for several years. We propose a combination method of WADL and a learning ontology mechanism to enable RESTful semantic web services. These syntactic and semantic descriptions allow search engines to support a similarity search for RESTful web services. We describe an experimental study on a collection of 168 RESTful web services. The experimental results show that our method has higher performance in terms both of the rate of recall and precision compared to existing methods.

### **Personalizing Access to Semantic Web Services (ICWS2011-2033)**

*Freddy Lecue (The University of Manchester, UK)*

Existing approaches, largely syntactic content-based, fail to provide robust, accurate and useful personalized services to its users. The semantic web provides technologies to annotate and match services' descriptions with users' features, interests and preferences, thus allowing for more efficient access to services and more generally information. The aim of our work, part of service personalization, is on automated instantiation of services which is crucial for advanced usability. To this end, we exploit Description Logics reasoning through semantic matching to (i) identify useful parts of a user profile that satisfy services requirements (i.e., input parameters) and (ii) compute the description required by a service to be executed but not provided by the user profile. Our approach, part of the EC funded project SOA4All, was evaluated on its applicability.

### **Research Track 12 – Service Composition Planning and Testing**

**Session Chair:** Freddy Lecue, The University of Manchester, UK

### **Identifying Optimal Composite Services by Decomposing the Service Composition Problem (ICWS2011-2034)**

*Zachary J. Oster, Ganesh Ram Santhanam, Samik Basu (Iowa State University, USA)*

Several recent techniques have been developed and deployed to identify a composite service that conforms to the functional requirements and is optimal w.r.t. the user-defined preferences over non-functional properties. However, they are limited to using one formalism for specifying the required functionality; in short, the existing techniques cannot identify optimal (w.r.t. non-functional properties) composite services that are required to satisfy functional requirements described in multiple formalisms. We have previously proposed a meta-framework for service composition that involves decomposing the required functionality into a boolean combination of atomic requirements, which are expressed using different formalisms. This meta-framework supports the use of multiple formalisms and their corresponding composition algorithms within a single scenario. In this paper, we integrate support for unconditional preferences over nonfunctional requirements into this composition meta-framework.

### **A Transaction Management Model based on Compensation Planning Graph for Web Services Composition (ICWS2011-2035)**

*Lizhen Cui, Zongmin Shang, Yuliang Shi (Shandong University; Zibo Vocational Institute, China)*

To enforce reliability of composite Web Services at run-time, this paper proposes a transaction management model based on Compensation Planning Graph for WebService composition. First, a web service composition model with transactional properties is introduced. Second, in order to handle transaction when exceptions are occurred, compensation dependency relationships and Compensation Planning Graph is introduced, and an algorithm of automatic generation of compensation dependency relationships and transaction handling based on CPG is proposed. Finally, evaluation methods of QoS of web services and user satisfaction of transaction handling are given. During the execution of composite web services, this approach can guarantee compensation achieving through forward- or backward- compensation. In addition, in this model, a novel concept named Transfer Service is proposed to solve

the problem that there are no compensation services or unsuccessful retrievable services after many retry times. This model and method can improve self-adjustability and stability of composite services in the course of deployment and execution. Simulations prove that this approach can efficiently guarantee the reliability of composite services at run-time.

### **Metamorphic Testing for Web Services: Framework and a Case Study (ICWS2011-2036)**

*Chang-ai Sun, Guan Wang, Baohong Mu, Huai Liu, ZhaoShun Wang, T.Y. Chen (University of Science and Technology Beijing, China; Swinburne University of Technology, Australia)*

Since the development and consumption of Web services are completely separated under SOA environment, the consumers are normally provided with limited knowledge of the services and thus have little information about test oracles. The lack of source code and the restricted control of Web services limit the testability of Web services. To address the prominent oracle problem when testing Web services, we propose a metamorphic testing framework for Web services taking into account the unique features of SOA. We conduct a case study where the new metamorphic testing framework is employed to test a Web service that implements the electronic payment. The results of case study show the feasibility of the framework for web services, and also the efficiency of metamorphic testing. The work presented in the paper alleviates the test oracle problem when testing Web services under SOA.

### **Automatic Sampling of Web Services (ICWS2011-2037)**

*Mohammed Abu Jarour, Sebastian Oergel (University of Potsdam, Germany)*

With the widespread of Service-oriented Computing (SOC) and the increasing number of available web services in several domains, service discovery has become one of the main challenges in SOC. Lack of rich service descriptions is one of the several factors that exacerbate this challenge. Therefore, additional information about web services is required. Several approaches and sources have been proposed in the community to gather this information, such as domain experts, service providers, service consumers, etc. However, the increasing number of web services requires automatic approaches and additional sources of information. In this paper, we introduce a novel approach to generate annotations for web services, e.g., tags, by sampling their automatic invocations. The generated annotations are integrated in web forms that are used for future calls of these web services. Providing correct values for input parameters of web services is one of the main challenges involved in this work. We use four sources to assign values for input parameters, namely, random values, outputs of other operations within the same web service, other web services, and external data sources. We have implemented our approach and validated it through several experiments.

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## **Applications and Experiences Tracks**

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### **Applications and Experiences Track 1 – Process Management**

**Session Chair:** Ming Luo, IBM, USA

### **Modelling Collaborative Services for Business and QoS Compliance (ICWS2011-2038)**

*Jinhui Yao, Shiping Chen, Chen Wang, David Levy, John Zic (University of Sydney; CSIRO ICT Centre, Australia)*

Along with the SOA, companies can wrap their technological product as a service, to collaborate with others. Facing the ever-escalating global competition, such collaboration is crucial. The viability of this paradigm highly depends on the compliance and therefore the trustworthiness of all collaborators. However, it is challenging to achieve trustworthiness in such a dynamic cross-domain environment, as each participant may or may not act for individual benefits. As a solution, we have proposed to enforce strong accountability to enhance the trustworthiness. With this accountability, incompliance can always be determined in a provable and undeniable way. In this paper, we extend our work by proposing a novel modeling of the collaborative business process. Based on this modeling, we thoroughly analyze the evidence and proving procedure needed for different types of compliance, and evaluate the extent to which those compliance can be indeed proved. We have implemented a demonstrative system to show its effectiveness in real practice.

### **Verifying OWL-S Service Process Models (ICWS2011-2039)**

*Yuzhang Feng, Markus Kirchberg (Institute for Infocomm Research; National University of Singapore, Singapore)*

OWL-S is an ontology that provides the necessary vocabulary for describing various components of Web services so that automated discovery, composition and invocation of Web services can be made possible. The main component, the process model, describes the interaction protocol between a Web service and its clients. Such protocol includes not only the inputs, outputs, preconditions and results of the service, but also the control flow and data flow within the service. In this paper, we propose an approach to verify various properties of the process model of an OWL-S service. We define a set of mapping rules to translate a process model into a process algebra model and use a dedicated model checker. We handle the control flow of the process model and binding-based data flow. Preconditions and results are also included in our approach.

### **An Automatic Approach for Extracting Process Knowledge from the Web (ICWS2011-2040)**

*Hua Xiao, Bipin Upadhyaya, Foutse Khomh, Ying Zou, Joanna Ng, Alex Lau (Queen's University; IBM Canada Laboratory, Canada)*

Process knowledge enables service composition which integrates different services to implement business processes. In the current state of practice, business processes are primarily designed by experienced business analysts who have extensive process knowledge. It is challenging for novice business analysts and non-professional end-users to identify a complete set of services to orchestrate a well-defined business process due to the lack of process knowledge. In this paper, we propose an approach to extract process knowledge from existing commercial applications on the Web. Our approach uses a Web search engine to find websites containing process knowledge on the Internet. By analyzing the content and the structure of relevant websites, we extract and merge the process knowledge from various websites to generate an integrated ontology with rich process knowledge. We conduct a case study to compare our approach with a tool that extracts ontologies from textual sources. Experimental results are reported.

## Applications and Experiences Track 2 – QoS-based Services Composition

**Session Chair:** Yingzhou Zhang, Nanjing University of Posts and Telecommunications, China

### A Framework for Building Privacy-Conscious DaaS Service Mashups (ICWS2011-2041)

*Mahmoud Barhamgi, Djamal Benslimane, Chirine Ghedira, Salah-Eddine Tbahriti, Michael Mrissa (Claude Bernard Lyon1 University, France)*

Data Mashup is a special class of mashup application that combines information on the fly from multiple data sources to respond to transient business needs. Data mashup is a difficult task that would require an important programming skill on the side of mashups' creators, and involves handling many challenging privacy and security concerns raised by data providers. This situation prevents non-expert users from mashing up data at large. In this paper, we present a declarative approach for mashing-up data. The approach allows data mashup creators to build data mashups without any programming involved. The approach builds the mashups automatically and takes into account the data's privacy concerns. We evaluate the efficiency of the approach via a thorough set of experiments.

### Composing Non-Functional Concerns in Composite Web Services (ICWS2011-2042)

*Benjamin Schmeling, Anis Charfi, Mira Mezini (SAP Research Darmstadt; Software Technology Group, TU Darmstadt)*

The support for non-functional concerns (NFC) is essential for the success and adoption of web services. However, state of the art works offer only a limited support for these concerns especially when it comes to the composition of multiple non-functional concerns with composite web services. In this paper, we focus on the composition of non-functional concerns (NFA) with composite web services whose composition logic is made explicit using languages such as BPMN2 or WS-BPEL (gray box view). The gray box view reveals additional information on control flow, data flow, composed services, etc. NFAs can also be composite and constitute complex processes such as secure conversations or transactions which have to be integrated with composite web services. Additionally, the execution order of multiple super imposing NFA has to be declared.

### Adaptive Service Composition Based on Runtime Requirements Monitoring (ICWS2011-2043)

*Zhanlei Ma, Lin Liu, Hongji Yang, John Mylopoulos (Tsinghua University, China; De Montfort University, UK; University of Trento, Italy)*

In SOA environments, user needs and expectations are constantly changing. In such settings, composite services need to be adaptive to changes in user requirements and the environment. This paper proposes a conceptual framework for modeling compositional adaptation for services founded on a requirements monitoring facility. This facility helps maintain adherence between user requirements changes and the dynamics of service composition structure and quality attributes. Specifically, user requirements are represented as goals and softgoals, service composition structure is represented with a CSP-like grammar, and the adaptation mechanism is based on AI planning. The proposed approach is evaluated in a service simulation environment of real-world supply-chain adaptation scenarios.

## Applications and Experiences Track 3 – Semantic Services Composition

**Session Chair:** Brian Blake, University of Notre Dame, USA

### Inferring Data Flow in Semantic Web Service Composition (ICWS2011-2044)

*Freddy Lecue (The University of Manchester, UK)*

Automation of web service composition is one of the most interesting challenges facing the semantic web today. Data flow remains implicit and difficult to be inferred and automatically generated. Since web services have been enhanced with formal semantic descriptions, it becomes conceivable to exploit and reason on their semantic links (i.e., semantic matching between their functional output and input parameters) to infer data flow. Our approach has been directed to meet the main challenges facing the latter problem i.e., how to effectively i) guarantee whether a data flow is well-formed and ii) infer data flow between services based on their Description Logics (DL) descriptions. We apply constructive DL reasoning abduction, contraction and introduce the non standard DL reasoning join to model and infer data flow in compositions.

### Web Service Composition Techniques in a Health Care Service Platform (ICWS2011-2045)

*Pengwei Wang, Zhijun Ding, Changjun Jiang, Mengchu Zhou (Tongji University, China; New Jersey Institute of Technology, USA)*

The information technology has been recognized as one of the most important means to improve health care and curb its ever-increasing cost. However, existing efforts mainly focus on informatization of hospitals or medical institutions within organizations, and few are directly oriented to individuals. The strong demand for various health services from customers calls for the creation of powerful individual-oriented personalized health care service systems. Web service composition (WSC) and related technologies can greatly help one build such systems. This paper aims to present a newly developed platform called a Public-oriented Health care Information Service Platform (PHISP) and several novel WSC techniques that are used to build it. Among them include WSC techniques that can well support branch and parallel structures.

## Applications and Experiences Track 4 – Semantic Services Discovery

**Session Chair:** Shuiguang Deng, Zhejiang University, China

### Taxonomic Clustering and Query Matching for Efficient Service Discovery (ICWS2011-2046)

*Sourish Dasgupta, Satish Bhat, Yuyung Lee (University of Missouri – Kansas City, USA)*

Web Service clustering is a technique for efficiently facilitating service discovery. Most Web Service clustering approaches are based on suitable semantic similarity distance measure and a threshold. Threshold selection is difficult and often leads to unsatisfactory accuracy. In this paper, we have proposed a self-organizing based clustering algorithm called *Taxonomic clustering* for taxonomically organizing semantic Web Service advertisements. We have tested the algorithm on both simulation-based randomly generated test data and the standard OWL-S TC test data set. We have observed promising results both in terms of accuracy and performance.

### **Toward Semantics Empowered Biomedical Web Services (ICWS2011-2047)**

*Jia Zhang, Ravi Madduri, Wei Tan, Kevin Deichl, John Alexander, Ian Foster (Northern Illinois University; University of Chicago and Argonne National Lab; IBM T.J. Watson Research Center, USA)*

caGrid has accumulated a repository of biomedical services; however, how a cancer researcher can find proper services in the caGrid when needed remains a big challenge. This research aims to enhance the cyberinfrastructure of caGrid, by developing a mechanism that turns caGrid services into semantic aware interoperable services. We proposed a service semantics model, and developed a technique that automatically extracts semantic metadata from static WSDL service descriptions. Such semantic information is stored as loosely coupled annotations that can be queried using semantic Web techniques, to enhance services discovery and composition. We also proposed a two-phase discovery technique that helps users quickly identify interested service operations. This paper also reports our examinations over available techniques and recommends a feasible infrastructure for biomedical service reuse.

### **A Hybrid Approach to Recommending Semantic Software Services (ICWS2011-2048)**

*Liwei Liu, Freddy Lecue, Nikolay Mehandjiev (The University of Manchester, UK)*

The current proliferation of software services means users should be supported when selecting one service out of the many which meet consumer's needs. In this paper, we derive three requirements for software service recommender systems and then propose a hybrid recommendation approach to address these requirements and provide effective recommendations in conditions of scarce user feedback. The approach combines semantic Content-based reasoning and context-dependent Collaborative Filtering. The paper ends with the experiments based on a realistic set of semantic services against existing approaches.

## **Applications and Experiences Track 5 – Requirements-based Services Discovery**

**Session Chair:** Joe Tekli, Università Degli Studi Di Milano, Italy

### **Web Service Selection for Resolving Conflicting Service Requests (ICWS2011-2049)**

*Guosheng Kang, Jianxun Liu, Mingdong Tang, Xiaoqing (Frank) Liu, Kenneth K Fletcher (Hunan University of Science and Technology, China; Missouri University of Science & Technology, USA)*

Current methods of service selection do not consider multiple requests for the same functional web services. In such situations, conflicts occur when too many requesters select the same best web service. This paper aims at solving these conflicts and developing a global optimal service selection method for multiple related service requesters, thereby optimizing service resources and improving performance of the system. It uses Euclidean distance with weights to measure degree of matching of services based on QoS. A 0-1 integral programming model for maximizing the sum of matching degree is created and consequently. The model, together with a universal and feasible optimal service selection algorithm, is implemented (GOSSMR). Furthermore, to enhance its efficiency, Skyline GOSSMR is proposed. Time complexity of the algorithms is analyzed.

### **Selection of Composable Web Services Driven by User Requirements (ICWS2011-2050)**

*Zeina Azmeh, Maha Driss, Fady Hamoui, Marianne Huchard, Naouel Moha, Chouki Tibermacine (University of Montpellier; University of Rennes I, France; Université du Québec à Montréal, Canada)*

Building a composite application based on Web services when considering the various functional and non-functional capabilities is challenging. In this paper, we propose an approach for facilitating Web service selection according to user requirements. These requirements specify the needed functionality and expected QoS, as well as the composability between each pair of services. The originality of our approach is embodied in the use of Relational Concept Analysis (RCA), an extension of Formal Concept Analysis (FCA). Using RCA, we classify services by their calculated QoS levels and composability modes.

### **AWSP: An Automatic Web Service Planner based on Heuristic State Space Search (ICWS2011-2051)**

*Bin Wu, Shuiguang Deng, Ying Li, Jian Wu, Jianwei Yin (Zhejiang University, China)*

How to compose multiple Web services automatically to fulfill a given request has attracted much attention. This paper proposes a dedicated planner named AWSP (Automatic Web Service Planner) toward this problem. Compared with other AI planners, AWSP is characterized by its two different heuristic functions to reduce the search space greatly. A series of experiments based on test sets generated by WSBen show that 1) AWSP performs well even when the scale of the test set expands significantly. 2) AWSP has a smaller search space and performs better when using the backward search strategy than using the forward search strategy; 3) AWSP with the A\* heuristic function can get the solution with the shortest invocation path.

## **Applications and Experiences Track 6 – QoS-based Services Discovery**

**Session Chair:** Hakim Hacid, Alcatel-Lucent Bell Labs, France

### **Improving Web Service Discovery by a Functional and Structural Approach (ICWS2011-2052)**

*Rodrigo Amorim, Daniela Barreiro Claro, Denivaldo Lopes, Patrick Albers, Aline Andrade (Federal University of Bahia; Federal University of Maranhao, Brazil; Ecole Supérieure d'Electronique de l'Ouest, France)*

Nowadays, the most commonly used services discovery technique is semantic filters based on ontological concepts. However, such mechanisms can leave out some important Webservices of the matching process. Existing hybrid approaches combining traditional syntactic and semantic approaches remain restricted especially with respect to complexity, precision and time of execution. In this paper, we combine semantic filters based on functional properties with a structural approach, analyzing each neighbor relationship in an ontology. The results showed a considerable improvement in terms of performance and a complexity reduction with respect to other existing techniques. Furthermore, we implement a tool called OWLS-S Discovery.

### **CoWS: An Internet-Enriched and Quality-Aware Web Services Search Engine (ICWS2011-2053)**

*Meng Li, Junfeng Zhao, Lijie Wang, Sibao Cai, Bing Xie (Peking University, China)*

In this paper, we present a novel Web services search engine named CoWS, which enriches Web services information using the information captured from the Internet to provide quality-aware Web services search. The information captured can be classified into

two groups: functional descriptions and subjective feedbacks. We use the functional descriptions to enrich descriptions of Web services and the subjective feedbacks to calculate Web services' reputation. CoWS first ranks the services according to their functional similarities to a user's query, and then refines and re-ranks the services with both objective quality constraints (QoS) and subjective quality constraints (reputation). The experiments on a large-scale dataset show promising results.

### **A QoS-Aware Web Service Selection Algorithm based on Clustering (ICWS2011-2054)**

*Yi Xia, Ping Chen, Liang Bao, Meng Wang, Jing Yang (Xidian University; Artillery Command Academe of PLA, China)*

Efficiently and effectively selecting an appropriate service from a lot of independently developed services which have the same functionality but different QoS properties is essential for the effect of the composite service according to users' preference. In this paper, we propose a novel algorithm, named *QSSAC*, for service selection problem. This algorithm is based on the service clustering which can cluster a lot of atomic services of each task into a few classes according to their QoS properties. With the help of service clustering, our algorithm is able to reduce the execution time and guarantee the near-optimal result as well. Finally, three strategies are provided for re-selecting atomic services in dynamic environment. In experiment, we study the performance of *QSSAC* algorithm, and its feasibility has been demonstrated by simulation.

## **Applications and Experiences Track 7 – QoS-based Services Composition**

**Session Chair:** Incheon Paik, University of Aizu, Japan

### **Efficient Heuristic Approach with Improved Time Complexity for QoS-aware Service Composition (ICWS2011-2055)**

*Adrian Klein, Fuyuki Ishikawa, Shinichi Honiden (University of Tokyo; National Institute of Informatics, Japan)*

Given a composition, finding the set of services that optimizes some QoS attributes under given QoS constraints has been shown to be NP-hard. Therefore, heuristic algorithms are widely used, finding acceptable solutions in polynomial time. Still the time complexity of such algorithms can be prohibitive for real-time use. Thus, we propose a heuristic approach based on Hill-Climbing that makes effective use of an initial bias computed with Linear Programming, and works on a reduced search space. In our evaluation, we show that our approach finds near-optimal solutions and achieves a low time complexity.

### **Non-Cooperative Game Based QoS-Aware Web Services Composition Approach for Concurrent Tasks (ICWS2011-2056)**

*Haifeng Li, Qing Zhu, Yiqiang Ouyang (Central South University; Wuhan University, China ; University of Florida, USA)*

Existing Web service optimal combination approaches are mainly focused on single tasks by using "selfish" behavior to pursue optimal solutions. This causes conflicts because many concurrent tasks are competing for limited optimal resources, and the reducing of service quality in services. Based on the best reply function of quantified task conflicts and game theory, this paper establishes a mathematical model to depict the competitive relationship between multitasks and Web service under QoS constraints and it guarantees that every task can obtain optimal utility services considering other task combination strategies. Moreover, an iterative algorithm to reach the Nash equilibrium is also proposed. The proposed approach provides a new path for QoS-aware Web service with optimal combinations for concurrent tasks.

### **QoS-aware Service Composition for Workflow-based Data-Intensive Applications (ICWS2011-2057)**

*Yin Li, Chuang Lin (Tsinghua University, China)*

Existing research is devoted to selecting a set of servers to run the corresponding services in an application and achieving better QoS. Due to the data intensity of data flow, the communication between two server nodes may bring significant delay that can not be neglected when considering the performance of the whole application process. In this work, we consider not only the QoS on each server but also the transfer delay of data that affects the total latency. Algorithms are designed to determine a set of service candidates for web service workflow with different structural characteristics. We measure and utilize indispensable parameters to implement these algorithms. Further, we propose Lagrange and ARP algorithms to make comprehensive decisions.

## **Applications and Experiences Track 8 – Services Negotiation and Management**

**Session Chair:** Li Li, Avaya Labs Research, USA

### **A Hierarchical Approach to Service Negotiation (ICWS2011-2058)**

*Glenn Bruns, Mauricio Cortes (Bell Laboratories, Alcatel-Lucent, USA)*

Much existing work on service negotiation assumes that a provider will define its negotiation strategy in terms of the state of its resources. This approach can lead to complex strategy and assumes, unrealistically, that providers have full knowledge and control of their resources. We propose a hierarchical model of service negotiation in which negotiation strategy is defined in terms of sub-negotiations with internal or external agents. This model helps to manage the complexity of negotiation strategy by allowing it to be decomposed, with each component having well-defined scope. In this paper we present our hierarchical negotiation model, and a negotiation protocol and negotiation policy language based on it.

### **Automated State-Space Exploration for Configuration Management of Service-Oriented Applications (ICWS2011-2059)**

*Michael Smit, Eleni Stroulia (University of Alberta, Canada)*

Self-management implies the need for a model based on which configuration changes may be decided. Our previous work relied on an expert to manage the (simulated) application in order to collect the necessary observations for constructing the model. However, that method was agnostic about (a) the size of the system space as implied by the granularity of the observations, and (b) the sufficiency of the actual observations collected for understanding the application in a variety of configurations and environments. We replace the (expensive) expert domain knowledge with automatic approaches to ensuring coverage of the application, and demonstrate the superiority of this approach. We present empirical data.

## **Optimizing the Tradeoff between Discovery, Composition, and Execution Cost in Service Composition (ICWS2011-2060)**

*Immanuel Trummer, Boi Faltings (Ecole Polytechnique Fédérale de Lausanne, Switzerland)*

Quality-aware service composition starts from an abstract workflow. The goal is to maximize the workflow quality by choosing the right combination of services. Restricted resources motivate the question about the optimal trade off between composition effort and solution quality. In this paper, we aggregate the three phases, discovery, composition, and execution into a common cost metric. We present and analyze an iterative algorithm that automatically balances the effort spent in different phases. We are able to prove a near-optimal number of iterations. Additionally, we provide extensive experimental evaluations.

## **Applications and Experiences Track 9 – Services Engineering**

**Session Chair:** Jia Zhang, Northern Illinois University, USA

### **Regression Testing as a Service (ICWS2011-2061)**

*Sheng Huang, Zhong Jie Li, Ying Liu, Jun Zhu, Yang Hua Xiao, Wei Wang (Fudan University; Peking University; IBM China Research Lab, China)*

Selective regression testing involves retesting of software systems with a subset of the test suites to verify that. Existing studies have not discussed it in the context of SaaS. This paper presents the specific requirements, challenges and benefits in delivering regression test selection as a service (RTaaS). We introduce how to design and implement an RTaaS platform with a pilot study. The real customer cases illustrate that RTaaS is a cost-effective and easy way for software project teams to leap over technical barriers and tap into advanced regression testing selection technologies.

### **A Multi-Layered Approach for the Declarative Development of Data Providing Services (ICWS2011-2062)**

*Kevin P. Brown, Miriam A.M. Capretz (University of Western Ontario, Canada)*

Data Providing Services (DPSs) have the sole purpose of retrieving data from existing sources according to their input parameters while also providing a semantic description of the data they provide using a parametrized view over a domain ontology. A layered model of viewing DPSs is proposed consisting of the data acquisition, syntactic and semantic layers. It is shown that by defining all three layers, a DPS may be generated and managed exclusively by its declarative definition. This will increase the agility and efficiency. As a development model, a set of reusable messages are created; these messages are to be semantically annotated using a view over the domain ontology. These messages are used within the DPS definition where their views over the domain ontology are parametrized and the data acquisition layer is defined to acquire data from the source.

### **Transaction Similarity-Based Contextual Trust Evaluation in E-Commerce and E-Service Environments (ICWS2011-2063)**

*Haibin Zhang, Yan Wang, Xiuzhen Zhang (Macquarie University; RMIT University, Australia)*

The trust of sellers and transactions is a very important issue in e-commerce and e-service environments. At some e-commerce websites, a trust value of a seller is available. However, a buyer may be easily cheated by a malicious seller in a new transaction with the notorious value imbalance problem. To provide more objective trust result for a new potential transaction, a trust evaluation mechanism should be based on the ratings of past transactions. In this paper, we propose a new contextual trust evaluation method. Our method compares the transaction context similarity between the new transaction and past transactions, from which the trust value of the new transaction can be determined. Our method can identify and prevent potentially malicious transactions.

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## **Industry Tracks**

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### **Industry Track 1 – Business Process Management**

**Session Chair:** Christoph Meinel, Hasso-Plattner-Institute, Germany

### **Design and Describe REST API without Violating REST: A Petri Net Based Approach (ICWS2011-2064)**

*Li Li, Wu Chou (Avaya Inc., USA)*

There is a growing concern and debate on how to design RESTful web services (REST API) in a proper way. However, many web services that claim to be REST API are not hypermedia driven as prescribed by REST. This situation may lead to REST APIs that are not as scalable, extensible, and interoperable. To address this issue, this paper proposes REST Chart as a model and language to design and describe REST API without violating the REST constraints. REST Chart models a REST API as a special type of Colored PetriNet whose topology defines the REST API and whose token markings define the representational state space of user agents using that API. We demonstrate REST Chart with an example REST API. We also show how REST Chart can support efficient content negotiation and reuse hybrid representations to broaden design choices. Furthermore, we argue that the REST constraints, such as hypermedia driven and statelessness, can either be enforced naturally or checked automatically in REST Chart.

### **Modeling Business Process of Web Services with an Extended STRIPS Operations to Detection Feature Interaction Problems Runtime (ICWS2011-2065)**

*Jiuyun Xu, Kun Chen, Youxiang Duan, Stephan Reiff-Marganiec (China University of Petroleum, China; University of Leicester, UK)*

High level research issue—the feature interaction problem is also challenging the interoperation of service-oriented computing. Autonomy and distribution of service deploying style have made the needs of runtime detecting and resolving feature interaction in SOC research community. This paper investigates the detection of feature interactions in web services at runtime and proposes

ESTRIPS, an extended STRIPS operation conflict-free of services in business process detection method, which reasons from OWL-S and SWRL combined with runtime SOAP messages. First, we give the model of the feature interaction problem in business process during its execution and then the ESTRIPS method given in detail. The implementation of a prototype is illustrated. Using a real world scenario shows the plausibility of our method of detecting feature interactions of business process.

### **Rule-Based Run-Time Information Flow Control in Service Cloud (ICWS2011-2066)**

*Wei She, I-Ling Yen, Bhavani Thuraisingham, San-Yih Huang (University of Texas, Dallas; National Sun Yat-sen University, China)*

Service cloud provides added value to. Most existing web service security models focus on the protection of individual web services. To achieve fine-grained information flow control, it is also necessary to analyze the flow and processing of the data and derive the dependencies between the data dynamically generated or used in a service chain. In this paper, we develop a run-time information flow control model for service cloud. First, we develop a run-time dependency analysis mechanism which enables each service in the service chain to determine the correlation between the locally accessed data and the data dynamically generated by the services in the service chain. Then, we develop a model to enable each service in a service chain to specify. Finally, we design a run-time protocol to enforce these policies in a service chain.

## **Industry Track 2 – QoS Management**

**Session Chair:** Wu Chou, Avaya Labs Research, USA

### **Progressive Reliability Forecasting of Service-Oriented Software (ICWS2011-2067)**

*Andrew Liu, Ewa Musial (Syracuse Univ.; SUNY Albany, USA)*

A number of models have been developed for predicting reliability of traditional software, in which code-based defects are the main concerns for the causes of failures. In addition to residual defects, the reliabilities of SOA-based systems can be affected by their execution context, message transmission media, and their usages. We present a case study to demonstrate that the reliability of a service varies on an hourly basis, and reliability forecasts should be recalibrated accordingly. The results show that with progressive recalibration we provide more accurate reliability forecasts for the service.

### **On the Use of Fuzzy Dominance for Computing Service Skyline Based on QoS (ICWS2011-2068)**

*Karim Benouaret, Djamel Benslimane, Allel Hadjali (Lyon 1 University; Rennes 1 University, France)*

Nowadays, the exploding number of functionally similar Web services has led to a new challenge of selecting the most relevant services using QoS aspects. Recent approaches focus on computing service skyline over a set of QoS aspects. This can completely free users from assigning weights to QoS attributes. However, two main drawbacks characterize such approaches. In this paper, we introduce a new concept, called alpha-dominant service skyline, to address the above issues and we develop a suitable algorithm for computing it efficiently. Experimental evaluation conducted on synthetically generated datasets, demonstrates both the effectiveness of the introduced concept and the efficiency of the proposed algorithm.

### **On the Verification of Behavioral and Probabilistic Web Services using Transformation (ICWS2011-2069)**

*Giti Oghabi, Jamal Bentahar, Abdelghani Benharref (Concordia University, Canada; Abu Dhabi University, UAE)*

In this paper, we propose a preliminary approach for automating web service verification. We use Semantic Markup for Web Services (OWL-S) to describe web service behavior. We parse the OWL-S file and transform it automatically to a corresponding Markov chain diagram or Markov decision process, which are then transformed to a PRISM model to be used as input by PRISM, a probabilistic model checker, to verify automatically the web service behavior. We provide an implementation of the transformation algorithm through a developed software tool automating all the transformation and verification activities.

## **Industry Track 3 – Services Engineering**

**Session Chair:** Yuyung Lee, University of Missouri – Kansas City, USA

### **A Service-Oriented Framework for Hybrid Immersive Web Applications (ICWS2011-2070)**

*Lijun Mei, Yimin Wang, Qicheng Li, Jian Wang, Ziyu Zhu (IBM Research – China)*

Immersive Web (IW for short) applications such as Second Life and SimCity are increasingly popular among individual users and companies. However, it is difficult to build a hybrid IW application. In this paper, we propose a service-oriented framework to support the mashup of heterogeneous IW applications for hybrid IW applications. We first model each object in IW as an IW Object Service (IWOS) located by a unique URL with standardized service interfaces. We further propose a service-oriented framework to manipulate these IWOS instances, to support the transition of these objects mainly between different IW applications, and to enable the transition between IW applications and non-IW applications. Our framework also includes the fundamental services to build hybrid IW applications. Examples are provided.

### **A Dynamic Resource Allocation Algorithm for Database-as-a-Service (ICWS2011-2071)**

*Jie Zhu, Bo Gao, Zhihu Wang, Berthold Reinwald, Changjie Guo, Xiaoping, Wei Sun (Southeast University; IBM Research-China, China; Ministry of Education; IBM Almaden Research Center, USA)*

In Database-as-a-Service (DBaaS), a large number of tenants share DBaaS resources. While the DBaaS provider runs DBaaS to “share” resources across the entire tenant population to maximize resource utilization and minimize cost, the tenants subscribe to DBaaS at a low price point while still having resources conceptually “isolated” according to service level agreements (SLAs). To optimize this dichotomy of goals, we propose a dynamic resource allocation framework that periodically re-allocates resources to tenants to maximize resource utilization while tolerating a low risk of SLA violations. We model the resource allocation problem as a modified unbounded knapsack problem. Performed experiments showed promising results.

## **Long-Term Benefit Driven Adaptation in Service-Based Software Systems (ICWS2011-2072)**

*Jun Na, Bin Zhang, Yan Gao, Li Zhang, Zhi-liang Zhu (Northeastern University, China)*

Most of current adaptation approaches focus on single transaction, which makes it hard to take full advantage of such preferential policies in reselecting substitutable services. In this paper, we try to make the adaptation decision and reselect services from a broader view, current and predictable future executions. We call it "long-term benefit" to distinguish benefit in current approaches and propose a long-term benefit driven adaptation approach. Services that would bring the maximum expected long-term benefit would be selected and substituted into current instance. As the long-term benefit is accumulated in several executions, i.e. it depends on a decision sequence, we model the decision making problem as a sequential decision problem, and describe a realization based on partially observable Markov decision process (POMDP) for maximizing the real income in providing an SBS as an example.

## **Industry Track 4 – Services Assurance**

**Session Chair:** Hemant Jain, University of Wisconsin at Milwaukee, USA

## **An Attribute Assurance Framework to Define and Match Trust in Identity Attributes (ICWS2011-2073)**

*Ivonne Thomas, Christoph Meinel (Hasso-Plattner-Institute, Germany)*

Identity federation denotes a concept for the controlled sharing of user authentication and user attributes between independent trust domains. Using WS-Federation, service providers and identity providers can set up a Circle of Trust, a so called federation, in which each member is willing to trust on assertions made by another partner. However, if a member has to rely on information received from a foreign source, the need for assurance that the information is correct is a natural requirement prior to using it. Identity assurance frameworks exist that can be used to assess the trustworthiness of identity providers. The result of this assessment is a level of trust. However, existing approaches for evaluating identity assurance do not allow to define trust levels for individual attributes. In our trust model, we consider both: (a) trust in an identity provider as the issuer of assertions and (b) trust in single attributes that an identity provider manages. Examples are shown.

## **Fine-grained Metrics of Cohesion Lack for Service Interfaces (ICWS2011-2074)**

*Dionysis Athanasopoulos, Apostolos V. Zarras (INRIA-Paris-Rocquencourt, France; Univ. of Ioannina, Greece)*

A design issue that often appears in real-world services is that their interfaces are not cohesive. This issue may complicate the comprehension of the services functionalities and the maintenance of the applications that use them. The problem of existing approaches is that operations which operate on data characterized by similar, but not exactly matching, types are treated as being totally unrelated. Consequently, the aforementioned metrics may overestimate the cohesion lack of service interfaces. In this paper, we undertake a more elaborate approach to evaluate a set of real world services provided by Amazon. Specifically, we propose two fine-grained metrics of cohesion lack, which are defined with respect to the structural similarity of the input/output data types of interface operations. The proposed metrics are formally defined and analytically assessed.

## **Industry Track 5 – Service Security and Trust**

**Session Chair:** Vibhu S. Sharma, Accenture Technology Labs India

## **Automated Security Service Orchestration for the Identity Management in Web Service based Systems (ICWS2011-2075)**

*Robert Warschofsky, Michael Menzel, Christoph Meinel (Hasso-Plattner-Institute, Germany)*

The deployment and configuration of the security services usually requires expert knowledge about the systems and expert knowledge about security requirements and implementations which a person can only learn by experience. Implementing security requirements is a complex and error prone task, even for experts. For this paper, we analysed several service-based implementations for identity management and their differences in the service orchestration. We present an approach to derive the needed security services, their configuration, and their connections to the functional services, based on defined security requirements for a Web Service based system. Therefore, we evaluate the UML use case model of the system and apply service security patterns derived during the analysis of the identity management implementations.

## **A Subjective Probability Based Deductive Approach to Global Trust Evaluation in Composite Services (ICWS2011-2076)**

*Lei Li, Yan Wang (Macquarie University, Australia)*

In SOC environments, the trustworthiness of each service provider is critical for a service client when selecting one from a large pool of service providers. A trust value can be taken as a *subjective probability*, by which one party believes that another party can perform an action in a certain situation. Hence, subjective probability theory should be adopted in trust evaluation. In addition, in SOC environments, the global trust of a composite service should be evaluated based on both the subjective probability property of trust and complex invocation structures. In this paper, we first interpret the trust dependency caused by direct service invocations as conditional probability. Then, we propose a Subjective Probability based Deductive (SELECTIVE) approach to evaluate the subjective global trustworthiness of a composite service. All these processes follow subjective probability theory and keep the subjective probability property of trust in evaluations.

## **Dynamic Identity Delegation Using Access Tokens in Federated Environments (ICWS2011-2077)**

*Hidehito Gomi (Yahoo! Japan Corporation, Japan)*

Identity delegation is an act whereby an entity delegates his or her authority to use identity information to another entity. It has most often been implemented in enterprise environments, but previous studies have focused little on the dynamic data and access management model as well as the design from a practical viewpoint. An identity delegation framework is described for using access

tokens across security domains. The framework enables fine-grained access control with limited overhead cost for access management and permission assignment for delegated access.

## Industry Track 6 – Services Monitoring and Testing

Session Chair: Shiyong Lu, Wayne State University, USA

### StreamWeb: Real-Time Web Monitoring with Stream Computing (ICWS2011-2078)

*Toyotaro Suzumura, Tomoaki Oiki (IBM Research – Tokyo, Tokyo Institute of Technology, Japan)*

A new trend involves Web services such as Twitter beginning to publish streaming Web APIs that enable partners and end users to retrieve streaming data. In this paper we propose a real-time Web monitoring system called “StreamWeb” on top of a stream computing system called System S developed by IBM Research. The StreamWeb system allows developers to easily describe their analytical algorithms for a variety of kinds of Web streaming data without worrying about the performance and scalability, and provides real-time and scalable Web monitoring for massive amounts of data. As an experimental proof-of-concept application, our system can handle nearly 30 thousand Twitter messages per second on a system with 8 computing nodes.

### An Event-Based Reasoning Approach to Web Services Monitoring (ICWS2011-2079)

*Ehtesham Zahoor, Olivier Perrin, Claude Godart (Télécom SudParis, France)*

This paper presents an event based functionality integration framework to approach the issue of service personalization and service mashups. The proposed framework addresses the mashup issue from a new perspective by extracting and reasoning the context through user generated event, while recommending and aggregating the contextual services dynamically in response to the user’s functional requirements. An event hierarchy is proposed to retrieve contextual information and analyze underlying functionalities. The three layer system framework, service recommendation logic, and the functionality integration are also presented.

### Test Case Prioritization for Audit Testing of Evolving Web Services using Information Retrieval Techniques (ICWS2011-2080)

*Cu D. Nguyen, Alessandro Marchetto, Paolo Tonella (Fondazione Bruno Kessler, Italy)*

Audit testing (a form of regression testing in charge of checking for compatibility issues) is needed. As service compositions are often in continuous operation and the external services have limited (expensive) access when invoked for testing, audit testing has severe time and resource constraints, which make test prioritization a crucial technique (only the highest priority test cases will be executed). This paper presents a novel approach to the prioritization of audit test cases using information retrieval. This approach matches a service change description with the code portion exercised by the relevant test cases. So, test cases are prioritized based on their relevance to the service change. We evaluate the proposed approach on a system that composes services from eBay and Google.

## Industry Track 7 – Multicast and Mobile Wireless Communication

Session Chair: Zhongjie Wang, Harbin Institute of Technology, China

### Differential Caches for Web Services in Mobile Environments (ICWS2011-2081)

*M.S. Qaiser, P. Bodorik, D.N. Julta (Dalhousie University; Saint Mary’s University, Canada)*

Overhead delay, particularly the communication delay, associated with invocation and execution of web services is high. We present Differential Caches, with the accompanying Differential Updates method and the MobileSOAP (MoSOAP) protocol, to avoid transfer of repeated data, sent by a web service to an application. The protocol is flexible in that other optimization techniques, such as encoding, can also be applied. We report on results of experiments.

### Providing Light Weight Distributed Web Services from Mobile Hosts (ICWS2011-2082)

*Feda AlShahwan, Klaus Moessner, Francois Carrez (University of Surrey, UK)*

Processing and communication will drain the battery rapidly; hence, both should be kept at a minimum. This paper describes the outcomes of an investigation into simple offloading mechanisms that facilitate provision of adaptive and distributed RESTful mobile web services from resource constrained mobile devices. Offloading considers the distributed hosts processing as well as communication capabilities. Using queuing theory, the performance gained from distributing mobile web service tasks is explored. In addition, the theoretical boundaries of different flavours of offloading mechanisms are presented. The analytical results are shown.

### WS-Eventing SOAP-over-UDP Multicast Extension (ICWS2011-2083)

*David Gregorczyk (University of Lübeck, Germany)*

WS-Eventing is a W3C specification to enable publish-subscribe Web Services. This paper proposes a WS-Eventing extension for disseminating notifications by using a UDP multicast binding. To achieve this, some specification modifications will be done which do not affect legacy client implementations. We show that it is possible to extend WS-Eventing almost without losing backward compatibility. An exemplary proxy application illustrates that the extension can be embedded into open source service frameworks.

## Industry Track 8 – Service Composition

Session Chair: Jianwu Wang, UCSD, USA

### A History Record-based Service Optimization Method for QoS-Aware Service Composition (ICWS2011-2084)

*Lin Wenmin, Wanchun Dou, Luo Xiangfeng, Jinjun Chen (Nanjing University; Shanghai University, China; University of Technology, Australia)*

The performance of a service’s QoS may evolve relatively frequently with its internal changes or the changes of dynamic Internet environment, especially when some “intentional” deceptions are taken into consideration. Therefore, the service providers could not

always deliver their services according to their “promised” quality. In view of this challenge, a history record-based service optimization method, named *HireSome*, is investigated in this paper. This method aims at enhancing the credibility of service composition plan, taking advantage of a web service’s QoS history records, rather than using the tentative QoS values advertised by the service provider. At last, a case study and an experiment is presented for validating the method.

## **Identification of Semistructured Abstract Nonfunctional Properties for Automatic Service**

### **Composition (ICWS2011-2085)**

*Incheon Paik, Wuhui Chen, Ryohei Komiya (University of Aizu, Japan)*

Automatic Service Composition (ASC) provides a new value-added service from existing services by user’s request dynamically and automatically, both functional and nonfunctional requirements. Our research was motivated by the identification of abstract nonfunctional properties (NFPs) for a seamless ASC and proposes transformation from the abstract NFPs to intermediate-level NFPs based on the model of three levels of abstractness of NFPs. To solve the vagueness of the abstractness, we adapt approaches based not only on ontology but also on term similarity. The transformation between the intermediate and the concrete levels is carried out by a deterministic algorithm based on mapping of domain ontology. To evaluate the effectiveness of term similarity metrics for non-terminal terms, vector-based and large corpus-based approaches were investigated.

## **A Policy-based Framework for Automated Service Level Agreement Negotiation (ICWS2011-2086)**

*Zan Xiao, Donggang Cao, Chao You, Hong Mei (Peking University, China)*

Wireless sensor networks (WSNs) are attractive for monitoring and gathering physical information (e.g. *temperature*) via lots of deployed sensors. For WSN applications, Web service is one of the recommended frameworks to publish, invoke and manage services. However, the standard Web service description language, *WSDL*, only defines the service input and output while ignoring the corresponding IO relationships. This presents challenges in distinguishing services with similar IO. In this paper, we address this challenge by embedding the service policy into traditional *WSDL2.0* schema to describe the IO relationships. The service policy is then transformed into a tree and vector representation so that the similarity between different Web services can be quantitatively evaluated. Furthermore, a new service redundancy detection approach is proposed based on this similarity.

# **Work-in-Progress Tracks**

## **Work-in-Progress Track 1 – Service Communities and Privacy**

**Session Chair:** Weiping Li, Peking University, China

### **Implementation of Communities of Web Service Registries (ICWS2011-2087)**

*Mohamed Sellami, Walid Gaaloul, Samir Tata (TELECOM SudParis, France)*

In this paper, we propose to use communities as a mean to organize Web services registries in a multi-registry environment. First, we propose a semantic model for Web services registry description (WSRD). A WSRD description depicts the functionalities offered by services advertised by a given registry. Thereafter, we propose an implicit approach for building communities based on the WSRD descriptions using a fuzzy clustering technique. Eventually, this clustering will be helpful for selecting an adequate registry for service requesters. Provided experiments in this paper show the feasibility of our approach.

### **Aggregated Privacy-Preserving Identity Verification for Composite Web Services (ICWS2011-2088)**

*Nan Guo, Tianhan Gao, Bin Zhang, Ruchith Fernando, Elisa Bertino (Northeastern University, China; Purdue University, USA)*

An aggregated privacy-preserving identity verification scheme is proposed for composite Web services. It aggregates multiple component providers’ interactions of identity verification to a single one involving the user. Besides, it protects users from privacy disclosure through the adoption of zero-knowledge of proof of knowledge. This approach can dramatically reduce the computation time, independently on the number of identity attributes and component providers.

### **Privacy Preserving Personalized Access Control Service at Third Service Provider (ICWS2011-2089)**

*Xiuxia Tian, Chaofeng Sha, Xiaoling Wang, Aoying Zhou (Fudan University; Shanghai University of Electric Power; East China Normal University, China)*

More individual information including sensitive information, such as contact list in Mobile Phone or PDA, can be delegated to the professional third service provider to manage and maintain. However, in this paradigm the critical problems to be resolved are to guarantee both the privacy of delegated individual information and the privacy of authorized users. In this paper, we present an approach to implement the personalized access control at third service provider in a privacy preserving way. Our approach implements the critical problems above in this paradigm by using selective encryption, blind signature and the combination of role based access control and discretionary access control.

### **Apply WS-Management to Manage Real Resources: MAPE Use Case Study (ICWS2011-2090)**

*ZhiHui Lu, Jie Wu, WeiMing Fu (Fudan University, China)*

Web Services standard-based system resource management is a new direction. In this paper, in order to verify the WS-Management standard whether to satisfy the realistic system resource management requirements, we use IBM MAPE categories to find more WS-Management related use cases. We design three typical use cases based on MAPE principles. Finally, we make a conclusion and propose our next-step work.

## **CLAM: Cross-layer Management of Adaptation Decisions for Service-Based Applications**

### **(ICWS2011-2091)**

*Asli Zengin, Raman Kazhamiakin, Marco Pistore (Fondazione Bruno Kessler, Italy)*

Adaptation of service-based applications (SBA) is not trivial in their heterogeneous and dynamic execution context. While different approaches exist, most of them focus on a specific part of the SBA ignoring the overall impact of the adaptation on the whole

application. In this paper we propose a cross-layer adaptation manager (CLAM) that tackles this problem.

### **Social-based Web Services Discovery and Composition for Step-by-step Mashup Completion (ICWS2011-2092)**

*Abderrahmane Maaradji, Hakim Hacid, Ryan Skraba, Adnan Lateef, Johann Daigremont, Noel Crespi (Alcatel-Lucent Bell Labs France; Telecom SudParis, France)*

In this paper, we describe our work in progress on Web services recommendation for services composition in a Mashup environment, by proposing a new approach to assist end-users based on social interactions capture and analysis. This approach uses an implicit social graph inferred from the common composition interests of users. We describe the transformation of users-services interactions into a social graph and a possible means to leverage that graph to derive service recommendation. As this work is in progress, this proposal was implemented within a platform called SoCo where preliminary experiments show interesting results.

### **Work-in-Progress Track 2 – Service Recommendations and Reputation**

**Session Chair:** Cui Lin, California State University, Fresno, USA

### **NRCF: A Novel Collaborative Filtering Method for Service Recommendation (ICWS2011-2093)**

*Zibin Zheng, Junliang Chen, Michael R. Lyu (Beijing University of Posts and Telecommunications; The Chinese University of Hong Kong, China)*

Since there are many Web services on the Internet, personalized Web service selection and recommendation is very important. In this paper, we present a new similarity measure for Web service similarity computation and propose a normal recovery collaborative filtering (NRCF) method for personalized Web service recommendation.

### **Reputation-Driven Web Service Selection based on Collaboration Network (ICWS2011-2094)**

*Xilu Zhu, Bai Wang, Shangguang Wang (Beijing University of Posts and Telecommunications, China)*

To enhance the collaboration trust during web service selection, a reputation model called collaboration reputation is proposed. The reputation model is built on web service collaboration network (WSCN), which is constructed in terms of the composite service execution log. Thus, the WSCN aims to maintain the trustworthy collaboration alliance among web services. In WSCN, the collaboration reputation can be assessed by two metrics, one called invoking reputation is computed by recommendation, which is selected from the community structure hiding in WSCN, the other is assessed by the invoked web service.

### **Multiple Representations of Web Services: Discovery, Clustering and Recommendation (ICWS2011-2095)**

*Mustapha Aznag, Mohamed Quafafou, Nicolas Durand, Zahi Jarir (Aix-Marseille II University, France; University of Cadi Ayyad, Morocco)*

This paper analyses several web services representations considering traditional textual descriptions based on the information contained in WSDL files. Unfortunately, textual web services descriptions are dirty and need significant cleaning to keep only useful information. To deal with this problem, we introduce a rules based text tagging method which allows to filter web service descriptions to keep only significant information. A new representation based on such filtered data is then introduced. Unfortunately, a lot of web services have empty descriptions, for this reason, we consider also web services representations based on the WSDL file structure. Alternatively, we introduce a new representation called symbolic reputation which is computed from relationships between web services.

### **Web Services Discovery and Composition: a Schema Matching Approach (ICWS2011-2096)**

*Sana Sellami, Omar Boucelma (Aix-Marseille University, France)*

Automated matching of service descriptions is the key to service discovery and composition. In this paper, we propose an approach for web services discovery and composition. The approach relies on (1) SAWSDL, a simple and generic annotation language, (2) an XML representation of a web service that carries both syntactic (e.g., WSDL) and semantic (e.g., SAWSDL) information, and (3) the reuse of available schema matchers. The approach departs from existing ones because it does not advocate a specific matchmaking algorithm, and it promotes the combination of different schema matchers, allowing multiple discovery and composition strategies.

### **Data-Dependency aware Trust Evaluation for Service Choreography (ICWS2011-2097)**

*Longtao Huang, Shuiguang Deng, Ying Li, Jian Wu, Jianwei Yin (Zhejiang University, China)*

This paper proposes a novel trust evaluation method for service choreography. Compared with current work towards this problem, it considers not only the trust for individual partner services and the explicit trust relation among partner services that have logical dependencies for each other, but also the implicit trust relation implied in data-dependencies among services. A series of experiments, using the simulation tool NetLogo, are carried out to compare the evaluation results between the proposed method and the method without data-dependency consideration. The result shows that taking consideration of the data-dependency trust improves the accuracy of trust evaluation to a great extent.

### **A Formal Model of Service Computing and Its Applications on Service Discovery (ICWS2011-2198)**

*Yingzhou Zhang, Wei Fu, Lei Chen, Bihuan Xu (Nanjing University of Posts and Telecommunications; Nanjing University, China)*

With the rapid development of services and software, how to share, integrate and discover them properly in open and dynamic network environment is one of the most important challenges for software technology. With monad techniques, we present a novel formal semantic model for service oriented computing in a black-box observation way. The monad-based model can help us formally describe and further study on software components and services through monads' properties such as abstraction, reflection and composability. This model relatively improves service reuse and discovery, and it significantly facilitates web service composition and enables integration of legacy applications.

## Work-in-Progress Track 3 – Semantic Services and Integration

Session Chair: Sherif Sakr, University of New South Wales, Australia

### Ontology-Driven Query Expansion using Map/Reduce Framework to Facilitate Federated Queries (ICWS2011-2199)

*Neda Alipanah, Pallabi Parveen, Latifur Khan, Bhavani Thuraisingham (University of Texas at Dallas, USA)*

In view of the need for a highly distributed and federated architecture, a robust query expansion has great impact on the performance of information retrieval. We aim to determine ontology-driven query expansion terms using different weighting techniques. For this, we consider each individual ontology and user query keywords to determine the Basic Expansion Terms (BET) using a number of semantic measures including Betweenness Measure (BM) and Semantic Similarity Measure (SSM). We propose a Map/Reduce distributed algorithm for calculating all the shortest paths in ontology graph. Map/Reduce algorithm will improve considerably the efficiency of BET calculation for large ontologies.

### Constructing Operation-level Ontologies for Web Services (ICWS2011-2100)

*Xumin Liu, Hua Liu (Rochester Institute of Technology; Xerox Corporation)*

We propose an integrated framework that extracts semantics from WSDL descriptions and constructs operation-level ontologies for Web services. The semantics mainly focus on the functional features of Web services, which facilitate the efficient usage of Web services, such as service discovery and service composition. We use service operations as the first class objects to define service functionalities. We first create service ontologies by measuring the relevance between service operations and clustering operations into functionally relevant groups. We then construct the structure of the service ontologies through a hierarchical clustering algorithm.

### A Petri Net based Hybrid Optimal Controller for Deadlock Prevention in Web Service Composition (ICWS2011-2101)

*Jing Bi, Zhiliang Zhu, Haitao Yuan, Yushun Fan, Ming Tie (Northeastern University; Tsinghua University; Beijing Institute of Nearspace Vehicle's System Engineering, China)*

In the process of web service composition, the check and prevention of semantic incompatibility is one of the most important issues. In this paper, a controlled Petri net (CtlPN)-based model for web service composition is proposed. Meanwhile, the optimal controller is constructed, such that the appropriate vectors of controllable place and arc are appended in the key transition which can lead to deadlock states. In addition, for the semantic incompatibility case, a policy based on appending optimal controller is presented. It is proved that our policy can be a good solution. The proposed controller is transformed as the activity of BPEL.

### An Event-Based Functionality Integration Framework (ICWS2011-2102)

*Zhenzhen Zhao, Sirsha Bhattacharai, Noel Crespi (Télécom SudParis, France)*

This paper presents an event-based functionality integration framework to approach the issue of service personalization and service mashups. In contrast to existing data integration approaches, the proposed framework addresses the mashup issue from a new perspective by extracting and reasoning the context through user-generated event, while recommending and aggregating the contextual services dynamically in response to the user's functional requirements. An event hierarchy is proposed to retrieve contextual information and analyze underlying functionalities.

### Conformance Verification between Web Service Choreography and Implementation using Learning and Model Checking (ICWS2011-2103)

*Warawoot Pacharoen, Toshiaki Aoki, Athasit Surarerks, Pattarasinee Bhattarakosol (Chulalongkorn University, Thailand; Japan Advanced Institute of Science and Technology, Japan)*

In this paper, we propose an alternative approach for verifying a conformance between choreography and the black box implementation of stateful Web service whose only external behaviors can be observed. Our framework uses an adapted version of Angluin's algorithm to infer a Mealy machine model that represents the observable behaviors of the implemented Web service. By transforming the Mealy machine to the modeling formalism LTS, the model checker LTSA can be used for checking a trace equivalence relation which is the conformance criterion in this work.

### A Framework for Ontology Evolution Management in SSOA-Based Systems (ICWS2011-2104)

*Soumaya Slimani, Salah Baïna, Karim Baïna*

The existing distributed ontology evolution approaches are not scaled to dynamic environments like Semantic service architecture (SSOA). As the SSOA-based system grows in size, the complexity of ontology change management increases, especially if the services ontologies are heterogeneous. In this paper, a novel agent-based ontology evolution framework is developed for services which consume ontologies in semantic SOA-based applications. A prototype is built by using the JADE agent platform for evaluation.

## Work-in-Progress Track 4 – Quality of Service Analysis and Control

Session Chair: ZhiHui Lu, Fudan University, China

### A New QoS Prediction Approach Based on User Clustering and Regression Algorithms (ICWS2011-2105)

*Yuliang Shi, Kun Zhang, Bing Liu, Lizhen Cui (Shandong University, China)*

QoS has become an important measure for web service selection. In this paper, we present an approach which can provide the approximate QoS value for users, and support finding the optimal web service. Firstly, it clusters the users based on location and network condition, then according to the QoS historical statistics of users in the same cluster, uses the linear regression algorithm to predict the QoS value based on invocation time and workload.

### **On-the-fly Detection Approach of Control Dependency Deadlocks in BPEL (ICWS2011-2106)**

*Deng Na, Li Desheng, Li Changbao, Chen Junliang, Liu Chuanchang (Beijing University of Posts and Telecommunications, China)*

During the design procedure of BPEL processes, there may be control dependency deadlocks among the activities in BPEL. We design a novel Agree/Refuse Matrix (ARM) to real-time detect control dependency deadlocks. Online detection approach can be integrated into ActiveBPEL Designer to extend their functions and improve the accuracy of BPEL processes. Most importantly, this method's real-time property can help avoiding detecting the whole process from scratch caused by process's partial modifications.

### **An Abstract Transaction Model for Testing the Web Services Transactions (ICWS2011-2107)**

*Ruben Casado, Javier Tuya, Muhammad Younas (University of Oviedo, Spain; Oxford Brookes University, UK)*

Transactions are a fundamental technology for building efficient and reliable web service based applications. Various models and protocols have been developed by academic and industrial research community in order to effectively manage web services transactions. We propose a novel abstract model for dynamically modeling distinct web services transaction protocols. Model-based testing techniques can be used on the abstract model in order to automatically generate test scenarios.

### **CloudDB AutoAdmin: Towards a Truly Elastic Cloud-Based Data Store (ICWS2011-2108)**

*Sherif Sakr, Liang Zhao, Hiroshi Wada, Anna Liu (University of New South Wales, Australia)*

Database-as-a-service (DaaS) is a new paradigm for data management in which a third party service provider hosts a database as a service. The SLA of cloud database services are mainly focusing on providing their customers with high availability (99.99%) to the hosted databases. However, they are not providing any guarantee or support on the performance and scalability aspects. Therefore, it is on the shoulder of the consumer applications to take care of additional responsibilities and challenges to achieve SLA requirements.

### **A Web Service Performance Evaluation Approach based on Users Experience (ICWS2011-2109)**

*Changbao Li, Bo Cheng, Junliang Chen, Pingli Gu, Na Deng, Desheng Li (Beijing University of Posts & Telecommunications Beijing, China)*

Web service evaluation is one key problem in web service discovery and selection. In this paper, we propose an approach to evaluate the web service performance. Our approach is based on users experience, and we apply the idea and result in common webs evaluation fields to help construct our evaluation system. We import the Alexa ranking to help evaluate the information providing performance of web services; and the idea of PageRank to help designing our evaluation method for the function sharing performance of web services.

### **Predicting Software Service Availability: Towards a Runtime Monitoring Approach (ICWS2011-2110)**

*Davide Lorenzoli, George Spanoudakis (City University London, UK)*

This paper presents a prediction model for software services availability measured by the mean-time-to-repair (MTTR) and mean-time-to-failure (MTTF) of a service. The prediction model is based on the experimental identification of probabilistic prediction for variables that affect MTTR/MTTF, based on monitoring service data collected at runtime.

## **Work-in-Progress Track 5 – Context-Aware and Mobile Wireless Services**

**Session Chair:** Zhixiong Chen, Mercy College, USA

### **Mobility-aware Selection of Mobile Web Services (ICWS2011-2111)**

*M. Adel Serhani, Abdelghani Benharref (UAE University; Abu Dhabi University, United Arab Emirates)*

Quality of Web Service (QoWS) support for Mobility-aware Web services (MWS) is critical. In this paper, we propose a selection model for MWS based on QoWS and device resources requirements. The main purpose is to support the client in selecting MWS based on desired QoWS as well as on its device resources availability. We propose a verification scheme to verify the conformity of claimed MWS QoWS and required device resources compared to the published one. The implementation and verification is reported.

### **An Event Driven Model for Context-aware Service (ICWS2011-2112)**

*Tong Mo, Weiping Li, Weijie Chu, Zhonghai Wu (Peking University, China)*

In context-aware service, service is provided based on the current scene of customer. However, the fact is that the vast majority of context change does not cause the change of scene, and monitoring context to determine the scene directly is inefficient, especially of the multi-context application. We use event which is defined by context as the motivation of scene change and propose an event driven model of context-aware service: EDM. A case of smart home service is discussed to show how to use EDM to do the requirement analysis, design, and implementation of context-aware service. Experimental results are reported.

### **A Comprehensive Device Collaboration Model for Integrating Devices with Web Services under Internet of Things (ICWS2011-2113)**

*Feng Chen, Changrui Ren, Jin Dong, Qinhuo Wang, Jinfeng Li, Bing Shao (IBM Research, China)*

To achieve Smart Planet, one key challenge is to integrate devices into business process. SOA is an ideal infrastructure for business process management as applications are invoked using standard interfaces and protocols. It's convenient to use device oriented web services (doWS) to encapsulate devices functions. A doWS may conflict with other doWS because devices can't be controlled by more than one client at the same time. This brings additional complexity to web service composition. In this paper, we propose a comprehensive device collaboration model to doWS choreography. Analysis shows that the model is effective in the Internet of things.

### **Improving Web API Discovery by Leveraging Social Information (ICWS2011-2114)**

*Romina Torres, Boris Tapia, Hernan Astudillo (Universidad Técnica Federico Santa María, Chile)*

A common problem that mashup developers face is the discovery of APIs that suit their needs. As humans, we learn by example, following community previous decisions when creating mashups. Most techniques do not consider at all reusing this social

information. In this paper, we propose to combine current discovery techniques (exploration) with social information (exploitation). Our preliminary results show that by considering the reciprocal influence of both sources, the discovery process reveals APIs that would remain with low rank because of the preferential attachment (popularity) and/or the lack of better descriptions (discovery techniques).

### **Service Evolution Management based on Usage Profile (ICWS2011-2115)**

*Marcelo Yamashita, Karin Becker, Renata Galante (Universidade Federal do Rio Grande do Sul, Brazil)*

In the context of large scale usage of a service, changes cause different impact on client applications. This paper proposes to focus on compatibility from the point of view of usage patterns to deal with service evolution issues in a more flexible and less costly way. The idea is to summarize the behavior of client applications into usage profiles, from which metrics that represent the impact of changes can be derived. This valuable information may support service providers on decisions about service lifecycle. The paper discusses the adoption of usage profiles and presents a framework for the automatic evaluation of service changes impact during its lifecycle.

### **Generating Workflow Models from OWL-S Service Descriptions with a Partial-Order Plan Construction (ICWS2011-2116)**

*Bochao Wang, Armin Haller, Florian Rosenberg (Australian National University; CSIRO ICT Centre, Australia)*

In this work we construct partial order plans from a pool of atomic services described in OWL-S. We make extensions to Partial Order Planning to allow multiple conditional effects in action definitions. The purpose is to handle the uncertain behavior of Web services with incomplete initial information. We post-process the partial order plan to auto-generate a workflow model. We developed a method to identify a subset of workflow patterns from the solution plan to create a workflow diagram.

# 2011 IEEE Eighth International Conference on Services Computing (SCC2011)

## Research Track

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### Research Track 1 – Services System

**Session Chair:** Junliang Chen, Beijing University of Posts and Telecommunications, China

### **SATE- Service Boundary and Abstraction Threshold Estimation for Efficient Services Design (SCC2011-3001)**

*Kalapriya Kannan, Gandhi Sivakumar, Nanjangud C Narendra (IBM Research India; IBM Australia)*

One key guiding principle of SOA is implementation abstraction, which fosters complete encapsulation of implementations, exposing only the primitives as interaction points with the service. Granularity of service abstractions defines the different level of primitives exposed to prospective service consumers. The primitives being the only external representation for a service, their design is extremely important. So far there has been no systematic approach to apply design principles such that right level of abstractions can be defined. We present a tool called Service Abstraction Threshold Estimator (SATE). Given the available implementation artifacts, SATE allows varying levels of primitives to be defined, elicits the complexity associated with different levels of primitives and provides a threshold estimation engine that displays the optimal level of abstraction that can be achieved in a given service development environment. We demonstrate SATE on a real-world example, and also evaluate SATE against design decisions taken by software architects.

### **Adaptive Request Prioritization in Dynamic Service-oriented Systems (SCC2011-3002)**

*Roman Khazankin, Daniel Schall, Shahram Dustdar (Vienna University of Technology, Austria)*

One of the open issues is to prioritize service requests in dynamically changing environments where concurrent instances of processes may compete for resources. Here we propose a runtime monitoring approach to observe the actual state of the system. We argue that priorities should be assigned to requests based on potential violations of SLA objectives. While most existing work in the area of quality of service monitoring and SLA modeling focuses typically on purely technical systems, we consider service-oriented systems spanning both software-based services and human actors. Adaptive request scheduling in such systems is challenging due to the poorly predictable behavior of human actors in performing tasks. Our approach helps to cope with the challenges by prioritizing service requests that may cause violations of SLAs and corresponding objectives.

### **Proactive SLA Negotiation for Service Based Systems: Initial Implementation and Evaluation Experience (SCC2011-3003)**

*Khaled Mahbub, George Spanoudakis (City University London, UK)*

This paper describes a framework that we have developed to integrate proactive SLA negotiation with dynamic service discovery to provide cohesive runtime support for both these activities. The proactive negotiation of SLAs as part of service discovery is necessary for reducing the extent of interruptions during the operation of a service based system when the need for replacing services in it arises. The developed framework discovers alternative candidate constituent services for a service client application, and negotiates/agrees but does not activate SLAs with these services until the need for using a service becomes necessary. A prototype tool is reported.

### Research Track 2 – Cloud Management

**Session Chair:** Hans-Arno Jacobsen, University of Toronto, Canada

### **Introducing Semantics to Cloud Services Catalogs (SCC2011-3004)**

*Yu Deng, Michael R. Head, Andrzej Kochut, Jonathan Munson, Anca Sailer, Hidayatullah Shaikh (IBM T.J. Watson Research Center, USA)*

A formal catalog representation of Cloud services is critical. The technologies and tools provided by the Semantic Web community are well suited to achieve this formal representation. In this paper, we give an analysis on the commonality and differences of typical Cloud service offerings and of their catalog actions' mappings to delivery operations. We introduce a new ontological representation that leverages Semantic Web technology to formally model the structure and relationships of these service offerings and their operational processes. Our algorithm to select and order the execution of appropriate delivery operations uses this representation together with a new notion of safe sequences. This algorithm realizes the catalog action requests while ensuring system robustness by following sequencing rules we developed to prevent failures during the fulfillment processes for complex offerings.

### **Dynamic Processor Resource Configuration in Virtualized Environments (SCC2011-3005)**

*Hai Jin, Li Deng, Song Wu, Xuanhua Shi (Huazhong University of Science and Technology, China)*

Virtualization can provide significant benefits in data centers, such as dynamic resource configuration, live virtual machine migration. Services are deployed in VMs and resource utilization can be greatly improved. In this paper, we present VScheduler, a system that dynamically adjusts processor resource configuration of virtual machines, including the amount of virtual resource and a new mapping of virtual machines and physical nodes. VScheduler implements a two-level resource configuration scheme – local resource configuration (LRC) for an individual virtual machine and global resource configuration (GRC) for a whole cluster or data center. GRC especially takes variation tendency of workloads into account when remapping virtual machines to physical nodes. We implement our techniques in Xen and conduct a detailed evaluation using RUBiS and dbench. The experimental results show promising results.

### **Data Augmentation as a Service for Single View Creation (SCC2011-3006)**

*Ullas Nambiar, Tanveer A. Faruque, K. Hima Prasad, L. Venkata Subramaniam, Mukesh K. Mohania (IBM Research, India)*

The task of augmenting data available within the enterprise with data purchased from third party providers or that residing in a public domain such as Web often results in warehouses that contain databases having incomplete and/or inconsistent data. In this paper, we present Data Augmentation as a service (DAaaS) that can help business in creating a consistent and usable single view of entities of interest. Specifically, our service will enable business rule writers to quickly create data augmentation rules by using our approximate functional dependency driven rule generation scheme. An accompanying challenge comes from having to manage a large number of rules and ensuring that new rules do not negate already existing rules. To mitigate this problem a rule-management and evaluation system that uses the Ripple Down Rules (RDR) framework is provided as part of our service. Using several large real-world datasets, we show our ability to learn rules and to effectively handle those conflicts with high accuracy.

## **Research Track 3 – Service Discovery**

**Session Chair:** Philippe Thiran, University of Namur, Belgium

### **Recommend-As-You-Go: A Novel Approach Supporting Services-Oriented Scientific Workflow Reuse (SCC2011-3007)**

*Jia Zhang, Wei Tan, John Alexander, Ian Foster, Ravi Madduri (Northern Illinois University; IBM T.J. Watson Research Center; University of Chicago and Argonne National Laboratory, USA)*

This project aims to help domain scientists find interested services and reuse successful processes to attain their research purposes in the form of workflows. In contrast to existing interface-based services discovery approaches, this paper proposes a novel approach of proactively recommending services in a workflow composition process, based on service usage history. The underpinning is a People-Service-Workflow (PSW) network that models existing scientific artifacts, services and workflows, and their past usage relationships into a social network. Various social network analysis techniques are applied to discover hidden knowledge accrued. A prototyping search engine has been developed as a proof of concept, and is seamlessly integrated as a plug-in into the Taverna workbench.

### **QoS-based Service Ranking and Selection for Service-based Systems (SCC2011-3008)**

*Stephen S. Yau, Yin Yin (Arizona State University, USA)*

In this paper, a QoS-based service ranking and selection approach is presented to help users to select the service that best satisfies users' QoS requirements from a set of services having already satisfied users' functionality requirements. To determine how well a service satisfies users' concerned QoS requirements, a set of functions is presented to normalize services' QoS on various QoS aspects with different metrics and scales, compute services' satisfaction scores on each QoS aspect, and combine each services' satisfaction scores on all QoS aspects together as an overall satisfaction scores. Our approach has the following advantages: 1) selects the service that best satisfies users QoS requirements, 2) improves the flexibility in users' QoS requirement specification, and 3) uses the prospect theory to more accurately model the relation between services' QoS and their satisfaction scores.

### **Self-Adaptive Fuzzy QoS-Driven Web Service Discovery (SCC2011-3009)**

*Romina Torres, HernanAstudillo, Rodrigo Salas (Universidad Técnica Federico Santa María; Universidad de Valparaíso, Chile)*

Current fuzzy-based techniques are expert and/or consensusbased, and therefore too fragile, expensive, non-scalable and nonself-adaptive. In this paper we introduce a new methodology to support requesters in selecting Web services by automatically connecting imprecisely defined QoS constraints with overly precise service QoS offerings over the time. We address the dynamism of the market by using each time a modified fuzzy c-means module that allows providers to automatically organize themselves around the QoS levels. The advantage of our approach is that consumers can specify their QoS constraints without really knowing what are the current best quality ranges. We illustrate our approach with a case of study.

## Research Track 4 – Cloud Migration

Session Chair: Umesh Bellur (Indian Institute of Technology Bombay, India)

### Migration to Multi-Image Cloud Templates (SCC2011-3011)

*Birgit Pfizmann, Nikolai Joukov (IBM T. J. Watson Research Center, USA)*

A key vehicle by which enterprises hope to achieve reducing IT costs is cloud computing, and they start to show interest in clouds outside the initial sweet spot of development and test. As business applications typically contain multiple images with dependencies, one is starting to standardize on multi-image structures. Enterprises have huge investments in their existing business applications. The promises of clouds can only be realized if a significant fraction of these existing applications can be migrated into the clouds. We therefore present analysis techniques for mapping existing IT environments to multi-image cloud templates. We propose multiple matching criteria, leading to tradeoffs between the number of matches and the migration overhead, and present efficient algorithms for these special graph matching problems. We present results from analyzing an existing enterprise environment with about 1600 servers.

### Management of SOA-Based Context-Aware Applications Hosted in a Distributed Cloud Subject to Percentile Constraints (SCC2011-3012)

*Keerthana Bloor, Rada Chirkova, Tiia Salo, Yannis Viniotis (North Carolina State University; IBM Software Group, USA)*

We consider geographically distributed data centers forming a collectively managed cloud computing system. The need for differentiated QoS for each customer class is incorporated into an SLA negotiated between the context-aware application provider and the cloud provider. We propose Data-aware Session-grained Allocation with gi-FIFO Scheduling (DSAgS), a novel decentralized request management scheme deployed in each of the geographically distributed datacenters, to globally reduce the penalty charged to the cloud computing system. Our simulation evaluation shows that our dynamic scheme far outperforms commonly deployed management policies. We further optimize our solution for dynamic, data-intensive context-aware applications, by proposing a “context level” cache replacement policy.

### Improving Performance and Availability of Services Hosted on IaaS Clouds with Structural Constraint-Aware Virtual Machine Placement (SCC2011-3010)

*Deepal Jayasinghe, Tamar Eilam, Malgorzata Steinder, Ian Whally, Ed Snible, Calton Pu (CERCs; IBM T.J. Watson Research Center; Georgia Tech, USA)*

Increasing popularity of modern virtualization based data centers continues to raise new questions. In this paper we aim to answer focusing on one such question: how to improve performance and availability of services hosted on IaaS clouds. Our system, structural constraint-aware virtual machine placement (SCAVP), supports three types of constraints: demand, communication and availability. We formulate SCAVP as an optimization problem and show its hardness. We design a hierarchical placement approach with four approximation algorithms that efficiently solves the SCAVP problem for large problem sizes. We provide a formal model for the application (to better understand structural constraints) and the datacenter (to effectively capture capabilities), and use the two models as inputs to the placement problem. We evaluate SCAVP in a simulated environment.

## Research Track 5 – Service Measurement

Session Chair: Akhil Kumar, Penn State University, USA

### Dynamic Fractal Clustering Technique for SOAP Web Messages (SCC2011-3013)

*DhiaAl-Shammary, Ibrahim Khalil (RMIT University Melbourne, Australia)*

Aggregation of SOAP messages is an effective solution that has been developed to significantly reduce network. The major problem of the aggregation techniques is that they require efficient similarity criteria that can compute the similarity of SOAP messages as group-wise and not just pair-wise. In this paper, a new unsupervised auto class Fractal clustering technique is proposed for clustering SOAP messages into a dynamic number of clusters according to their Fractal similarities. The experimental results showed that the proposed Fractal clustering technique can improve the performance of Web services significantly better. Furthermore, the proposed Fractal clustering technique potentially reduces the required processing time in comparison with other standards.

### Enhancing Penetration Testing with Attack Signatures and Interface Monitoring for the Detection of Injection Vulnerabilities in Web Services (SCC2011-3014)

*Nuno Antunes, Marco Vieira (University of Coimbra – Portugal Coimbra, Portugal)*

Web services are often deployed with critical software bugs that may be maliciously exploited. Developers often trust on penetration testing tools to detect those vulnerabilities but the effectiveness of such technique is limited by the lack of information on the internal state of the tested services. This paper proposes a new approach for the detection of injection vulnerabilities in web services. The approach uses attack signatures and interface monitoring to increase the visibility of the penetration testing process. We implemented a prototype tool to detect SQL Injection vulnerabilities in SOAP. An experimental evaluation was conducted.

### Provisioning Norm: An Asymmetric Quality Measure for SaaS Resource Allocation (SCC2011-3015)

*M. Brent Reynolds, Kenneth M. Hopkinson, Mark E. Oxley, Barry E. Mullins (Naval Surface Warfare Center Crane Division; Air Force Institute of Technology, USA)*

Analytical calculation of the quality of a configuration is necessary for effectively assigning new services to servers and reorganizing assigned services. This work describes the Provisioning Norm which meets this critical need. The Provisioning Norm (an asymmetric norm) analytically calculates the quality of a configuration, the placement of services on server nodes. The Provisioning Norm partially orders all possible configurations for a set of nodes and services from best to worst by numerically biasing over-provisioned configurations relative to under-provisioned configurations. This work proves that the parameter to the Provisioning Norm function has a value which partitions the partially ordered configurations into over-provisioned configurations and under-provisioned configurations. The application of the Provisioning Norm in a testing environment is illustrated.

## Research Track 6 – Workflow Management

Session Chair: Arif Bramantoro, National Institute of Information and Communications Technology (NICT), Japan

### Automated Attribute Inference in Complex Service Workflows Based on Sharing Analysis (SCC2011-3016)

*Dragan Ivanovic, Manuel Carro, Manuel Hermenegildo (Universidad Polit´ecnica de Madrid; IMDEA Software Institute, Spain)*

The properties of data and activities in business processes can be used to greatly facilitate several relevant tasks performed at design- and run-time. Business processes are often described using workflows. We present an approach for mechanically inferring business domain-specific attributes of workflow components (including data items, activities, and elements of sub-workflows), taking as starting point known attributes of workflow inputs and the structure of the workflow. We achieve this by modeling these components as concepts and applying sharing analysis to a Horn clause-based representation of the workflow. The analysis is applicable to workflows featuring complex control and data dependencies, embedded control constructs, and embedded component services.

### Semantic Notions of Weakly Correct AND/XOR Business Workflows based on Partial Synchronization (SCC2011-3017)

*Akhil Kumar, Anup K. Sen, Meda H. Sundari, Amitava Bagchi (Penn State University, USA; Tata Consultancy Services Pune; Heritage Inst. of Tech, India)*

Workflows coordinate the execution of multiple tasks or services. This paper presents a novel approach to model workflows based on partial synchronization. We develop new notions of weak correctness called semantic correctness and redundancy soundness that permit semantically correct execution instances with some partially finished paths, and show how to deal with them by the notion of transactional "undo". The properties of partial synchronization using strong and weak corresponding pairs are analyzed, and illustrated with realistic examples. An algorithm called WeakVerify is developed to check a workflow for weak correctness properties. This algorithm makes use of an existing algorithm for strict verification.

### OPQL: A First OPM-Level Query Language for Scientific Workflow Provenance (SCC2011-3018)

*Chunhyeok Lim, Shiyong Lu, Artem Chebotko, Farshad Fotouhi (Wayne State University; University of Texas-Pan American, USA)*

Most existing systems store provenance data in a way closely coupled to the underlying provenance storage strategies. In this paper, we present OPQL, an OPM-level provenance query language, that is directly defined over the Open Provenance Model (OPM). An OPQL query takes an OPM graph as input and produces an OPM graph as output. Therefore, OPQL queries are not tightly coupled to the underlying provenance storage strategies. Our main contributions are: (i) we design OPQL, including graph patterns and an OPM-based graph algebra for OPQL, that efficiently supports provenance lineage queries; (ii) we implement OPQL in our OPMPROV system, where the result of OPQL queries is displayed as an OPM graph via the OPMPROV browser. An experimental study is conducted to evaluate the performance and feasibility of OPQL for provenance querying.

## Research Track 7 – Service Composition

Session Chair: Shiping Chen, CSIRO ICT Centre, Australia

### Top-k Web Service Compositions using Fuzzy Dominance Relationship (SCC2011-3019)

*Karim Benouaret, Djamal Benslimane, Allel Hadjali, Mahmoud Barhamgi (Claude Bernard Lyon1 University; University of Rennes 1, France)*

User preferences are a key aspect that must be taken into account in the composition scheme. In this paper, we present an approach to automatically compose Data Web services while taking into account the user preferences. User preferences are modeled thanks to fuzzy sets. We use an RDF query rewriting algorithm to determine the relevant services. The fuzzy constraints of the relevant services are matched to those of the query using a set of matching methods. We rank-order services using a fuzzification of Pareto dominance, then compute the top-k service compositions. We propose also a method to improve the diversity of returned compositions while maintaining as possible the compositions with the highest scores. Finally, we present a thorough experimental study of our approach.

### Bridging the Gap between Semantic Web Service Composition and Common Implementation Architectures (SCC2011-3020)

*Fuyuki Ishikawa, Satoshi Katafuchi, Florian Wagner, Yoshiaki Fukazawa, Shinichi Honiden (National Institute of Informatics; Waseda University; The University of Tokyo, Japan)*

Semantic web techniques have been leveraged in planning methods for automated service composition. Typically, inputs and outputs of services are described in abstract concepts for efficient and meaningful matching between output of one service and input of another. However, existing methods have not examined concrete data structures. To address the problem, this paper proposes a matching method that can be incorporated into existing planning methods to ensure consistency in concrete data structures. The proposed method applies a two-phase matching process to efficiently filter out services that do not match at the abstract level. It also applies a data structure to organize similar services according to their relationships for efficient matching during the planning process.

### Exception Diagnosis for Composite Service based on Error Propagation Degree (SCC2011-3021)

*Yu Dai, Lei Yang, Bin Zhang, Zhiliang Zhu (Northeastern University China)*

The problem of diagnosis for composite service becomes one key issue in the adaptive service composition. This paper proposes an approach for diagnosing composite service based on error propagation degree. After analyzing the error propagation relation between the services, the uncertain casual relation between the exception and the service is formed by the way of computing the error propagation degree. And then the diagnosis algorithm which is based on the error dependent matrix is established. The diagnosis can be achieved by fuzzy reasoning. This approach can preserve the efficiency and accuracy of the diagnosis for composite service under

the uncertain environment by the computation of the error propagation degree and fuzzy reasoning.

## Research Track 8 – Service Quality Modeling

**Session Chair:** Nianjun Zhou (Joe), IBM Watson Research Center, USA

### A Game Theoretic Approach for Analyzing the Efficiency of Web Services in Collaborative Networks (SCC2011-3022)

*Babak Khosravifar, Mahsa Alishahi, Jamal Bentahar, Philippe Thiran (Concordia University, Canada; University of Namur Namur, Belgium)*

Because web services are loosely-coupled business applications, they are called to cooperate in distributed computing for the sake of efficiency. In this paper we propose a model formalizing web services efficiency considering different related parameters and a game-theoretical framework analyzing the web services strategies allowing them to maximize this efficiency. Many theoretical results are proved and confirmed through extensive simulations.

### A Composed Approach for Automatic Classification of Web Services Robustness (SCC2011-3023)

*Rui Oliveira, NunoLaranjeiro, Marco Vieira (University of Coimbra, Portugal)*

Testing Web Services (WS) for robustness is a lengthy and arduous process. Previous research indicates that well-known automatic classification algorithms can be used to automate this step. However, the applicability of such algorithms is also limited, as they are frequently unable to deal with the large diversity of outputs present in typical WS scenarios, thus producing incorrect results. In this paper we propose an approach that allows the automatic classification of the results of WS robustness tests. The technique integrates rule-based classification (including domain rules) and conventional machine-learning algorithms trained using generic data. The proposed approach was used to classify a large set of results of tests performed over publicly available WS and also over in-house implementations of several TPC benchmarks. Results show the effectiveness of the technique.

### Modeling and Analysis of Dependability Attributes of Service Computing Systems (SCC2011-3024)

*Jiwei Huang, Chuang Lin, Xiangzhen Kong, Yemei Zhu (Tsinghua University; Chinese Institute of Electronics, China)*

Dependability is an important consideration during the design and development of IT systems and services. But in service computing systems, the traditional definition and evaluation methods from the systems' and components' point of view meet challenges. In this paper, we change the angle of view, and study the dependability and their attributes from the service-oriented perspective. A stochastic model using semi-Markov process is put forward, and the quantitative analysis of the dependability attributes is carried out. By extending and transforming this model, the mean time to dependability attributes failure is computed. Some theorems are proposed and proved, to show the interrelationships and comparisons of the different dependability attributes.

### Evaluating Feedback Ratings for Measuring Reputation of Web Services (SCC2011-3025)

*Shanguang Wang, Zibin Zheng, Qibo Sun, HuaZou, Fangchun Yang (Peking University; University of Hong Kong, China)*

Existing of malicious ratings and different preferences of different service users often lead to a bias towards positive or negative ratings. In this paper, we propose a novel reputation measure method for Web services. The proposed method employs two phases (i.e., malicious rating detection and rating adjustment) to enhance the reputation measure accuracy. We first detect malicious feedback ratings by the Cumulative Sum Method, and then reduce the affect of different user feedback preferences by using Pearson Correlation Coefficient. Extensive experiments are conducted. Experimental results show that our proposed method is effective and can enhance the reliability of service selection

## Research Track 9 – Workflow Modeling

**Session Chair:** Andreas Wombacher, University of Twente, Netherlands

### Modelling Workflow Executions under Role-based Authorisation Control (SCC2011-3026)

*Ligang He, KeweiDuan, Xueguang Chen, DeqingZou, Zongfen Han, Ali Fadavinia, Stephen A. Jarvis (University of Warwick; University of Bath, UK; Huazhong University, China)*

This paper presents a novel mechanism for modelling workflow execution in cluster based resource pools under Role-Based Access Control (RBAC)schemes. Our modelling approach uses Coloured Timed Petri-Nets, and various authorization constraints are modelled. The interactions between workflow authorisation and workflow execution are also captured in the model. The construction of the authorization model for a workflow can be automated. A Petri-net simulation tool, the CPN-Tool, is utilised to implement the developed modelling mechanism and simulate the constructed model. Both system-level performance and application-level performance can be obtained from model simulations. This work can be used to plan system capacity and investigate the impact of authorization policies on system and application performance.

### Detecting Concurrency-Related Problematic Activity Arrangement in WS-BPEL Programs (SCC2011-3027)

*Yitao Ni, Lu Zhang, Zhongjie Li, Tao Xie, Hong Mei (Peking University, China; North Carolina State University, USA)*

A composite web service often interacts with several partner web services hosted in different servers. These partner web services are represented as activities in a WS-BPEL program describing the composite web service. Invoking the maximal number of these activities concurrently is essential for improving its performance. But complex message coupling and control dependency between activities in a composite web service may prevent them from being arranged correctly and efficiently. In this paper, we propose an approach for detecting problematic activity arrangement in a WS-BPEL program based on analyzing message propagation and activity dependency in the program. The underlying idea of our approach is to check whether activities with dependency are arranged as concurrent and whether activities without dependency are arranged as sequential. Preliminary empirical results are reported.

## **Precise Mappings between Business Process Models in Versioning Scenarios (SCC2011-3028)**

*Christian Gerth, Markus Luckey, Jochen M. Kuester, Gregor Engels (University of Paderborn, Germany; IBM Research, Switzerland)*

An important prerequisite for process model version control is an elaborated matching approach that results in precise mappings between different process model versions. The challenge of such an approach is to deal with syntactically different process models that are semantically equivalent. For that purpose, matching techniques must consider the semantics of process modeling languages. In this paper, we present a matching approach for process models in a versioning scenario. Based on a term formalization of process models, we enable an efficient and effective way to match syntactically different but semantically equivalent process models resulting in precise mappings.

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# **Applications and Experiences Track**

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## **Applications and Experiences Track 1 – Workflow Management**

**Session Chair:** Yan Wang, Macquarie University, Australia

### **How Physical Objects and Business Workflows can be Correlated (SCC2011-3029)**

*Andreas Wombacher (University of Twente, The Netherlands)*

SOA ease integration of heterogeneous systems. Systems are integrated since they model an overlapping part of the physical world, i.e., physical objects exchanged between different parties. For workflows handling physical objects, the correlation of sensor data with workflow states and workflow state changes are investigated in this paper. Further, the implications of the state or state change correlation on the workflow execution and the support by existing service infrastructures are discussed.

### **Undoing Event-Driven Adaptation of Business Processes (SCC2011-3030)**

*Sébastien Mosser, Gabriel Hermosillo, Anne-Françoise Le Meur, Lionel Seinturier, Laurence Duchien (University of Lille, France)*

As business processes continue to gain relevance in different domains, dynamicity is becoming a great concern. Static processes no longer cover the actual needs of constantly changing environments, and process adaptation is a must in order to maintain competitive levels. While creating dynamically adaptable business processes can be a challenging task, undoing these adaptations is a natural functionality that has not been studied in depth. Straight forward approaches for unadaptation can easily end up with corrupted processes, bringing uncertainty to the whole business logic. In this paper we bring forward a solution for efficiently undoing a business process adaptation in event-driven environments, considering also the correlated adaptations that happened afterwards

### **Reference Models for SaaS Oriented Business Workflow Management Systems (SCC2011-3031)**

*Bin Wu, Shuiguang Deng, Ying Li, Jian Wu, Jianwei Yin (Zhejiang University, China)*

SaaS has recently made a great impact on the software industry and changed the traditional lifetime of software. To obtain the benefit of SaaS, more and more software products have been converted into SaaS model, including business workflow management systems (BWfMS). Compared with the traditional BWfMSs, SaaS oriented BWfMSs introduce a new set of features which demand a new architectural design for SaaS oriented BWfMSs. Although several SaaS oriented BWfMSs have been developed, a study from an architectural perspective for SaaS oriented BWfMSs is still missing. The main contributions of this paper are: 1) it depicts four different scenarios where SaaS oriented BWfMSs work; 2) it proposes a reference model for SaaS oriented BWfMSs at each SaaS maturity level; 3) to validate the feasibility of the proposed reference model, it implements a specific BWfMS named WAAS.

## **Applications and Experiences Track 2 – Service Composition and Verification**

**Session Chair:** Maja Vukovic, IBM T.J. Watson Research Center, USA

### **Comparison of Bio-Inspired Algorithms for Peer Selection in Services Composition (SCC2011-3032)**

*Jun Shen, GhassanBeydoun, Shuai Yuan, Graham Low (University of Wollongong; University of Technology; University of New South Wales, Australia)*

One of the challenges for the P2P-based service composition process is how to effectively discover and select the most appropriate peers to execute the service applications when considering multiple properties of the requested services. Different ontology-based e-service profiles have been proposed to facilitate handling multiple properties and to enhance the service oriented process in order to achieve the total or partial automation of service discovery, selection and composition. This paper investigates how the ACO (Ant Colony Optimisation) algorithm and the GA (Genetic Algorithm) may facilitate P2P-based (Peer-to-Peer) service selection with multiple service properties. The performance of both algorithms is studied.

### **A Spring based Framework for Verification of Service Composition (SCC2011-3033)**

*Anshuman Mukherjee, ZahirTari, Peter Bertok (RMIT University, Australia)*

The safety and reliability of such loosely coupled systems entirely depend on the precision of service descriptions. Consequently any implicit assumption or unforeseen usage scenarios can lead to catastrophic fiascos. This paper extends the Spring framework to devise a verification framework for service composition wherein each BPEL activity is represented by a Java bean. The framework instantiates the beans corresponding to activities in a BPEL specification and injects the dependencies to yield a beanfactory. Thereafter Java Architecture for XML Binding (JAXB) 2 APIs are used to transform the bean-factory into an XML based formal-model (e.g. Coloured Petri nets (CPN)) or an interchange format (e.g. Petri Net Markup Language (PNML)) for simulation and verification. The proposed framework also helps to combat the ad-hoc nature of existing solutions.

## **Flexible Ontology-Independent and QoS-enabled Dynamic Web Services Composition Using Google**

### **Distance (SCC2011-3034)**

*Rui Ding, Dawn N Jutla (Saint Mary's University, Canada)*

Problems with ontology-dependent approaches for dynamic web services composition occur when ontologies are poorly maintained or unavailable in a domain, or the costs of maintenance exceed their benefits. This paper proposes the use of Google Distance as an ontology-independent method for the semantic similarity matching stage of web services discovery. Further, it provides an improved method for matching QoS parameters in the operational similarity matching stage of web services selection. We provide comparisons between our and existing QoS-enabled service discovery approaches in two major categories of web composition methods: workflow-based and AI-based.

## **Applications and Experiences Track 3 – Service Composition and Analysis**

**Session Chair:** Sébastien Mosser, University of Lille, France

### **Towards an Automated Gap Analysis for e-Service Portfolios (SCC2011-3035)**

*Norman May, Ulrich Scholten, Robin Fischer (SAP AG Walldorf; Karlsruhe Institute of Technology, Germany)*

Intermediaries for e-services continuously gain momentum, powered by a materializing Internet of Services. However, QoS still exhibits considerable shortcomings, as no structured process to enhance consumer satisfaction is available yet. To improve the match of delivered e-service quality and expected service quality on the consumer side, we develop a portfolio optimization process that integrates both, the consumer's as well as the intermediary's perspective. First, we introduce a toolkit for an e-service-oriented gap analysis. Thereupon, we identify monitoring points to measure service quality gaps automatically. A subsequent aggregation of measured data into customized feedback information allows for applying the toolkit to continuously optimize e-service portfolios.

### **Adaptive QoS-Aware Service Process Reconfiguration (SCC2011-3036)**

*Jing Li, Dianfu Ma, Xiupei Mei, Hailong Sun, Zibin Zheng (Beihang University; University of Hong Kong, China)*

During execution process, Web Services may become faulty and violate the predefined QoS constraints. Service processes need to adapt to the runtime faults so as to support reliable service-based applications. In this paper, we study the problem of runtime service process reconfiguration under end-to-end QoS constraints. An adaptive QoS-aware service process reconfiguration approach is proposed. Supplementary services are selected during service composition and then used as a backup source for efficient recovery; a region-based reconfiguration algorithm is proposed to minimize the reconfiguration cost by identifying a limited reconfiguration region that includes a small number of services. Experimental results are reported.

### **Analyzing Fault-Impact Region of Composite Service for Supporting Fault Handling Process**

**(SCC2011-3037)**

*Azlan Ismail, Jun Yan, Jun Shen (University of Wollongong, Australia; Universiti Teknologi MARA, Malaysia)*

A fault situation occurs to a service needs to be well analyzed and handled to ensure the reliability of composite service. The analysis can be driven by understanding the impact caused by the faulty service on the other services as well as the entire composition. We propose an approach to analyzing the temporal impact and generating the impact region. The region can be utilized by the handling mechanism to prioritize the services to be repaired. The approach begins by estimating the updated temporal behavior of the composite service after the fault situation occurs, followed by identifying the potential candidates of the impact region. The concept of temporal negative impact is introduced to support the identification activity. Intuitively, the approach can assist in reducing the number of service changes in handling the fault situation.

## **Applications and Experiences Track 4 – Semantic Services**

**Session Chair:** Masahide Nakamura, Kobe University, Japan

### **Reconciliation of Ontology Mappings to Support Robust Service Interoperability (SCC2011-3038)**

*Asad Masood Khattak, Zeeshan Pervez, Khalid Latif, A.M. JehadSarkar, Sungyoung Lee, Young-Koo Lee (Kyung Hee University, Korea; NUST, Pakistan; Hankuk University of Foreign Studies, Korea)*

With the discovery of new knowledge in the field and accommodating the knowledge in domain ontologies makes the ontology to evolve from one consistent state to another. This consequently makes existing mappings between ontologies unreliable and staled due to the changes in resources. So there is a need for mapping evolution to eliminate discrepancies from the existing mappings. To re-establish the mappings between dynamic ontologies, existing systems restart the complete mapping process which is time consuming. The approach proposed in this paper provides the benefits of mapping reconciliation between the updated ontologies. It takes less time as compared to the existing systems. It only considers the changed resources and eliminates the staleness from the mappings. This approach uses the change history of ontology to drastically reduce the time required for reconciling mappings among ontologies.

### **Correlating Business Objectives with Services: an Ontology-Driven Approach (SCC2011-3039)**

*Lam-Son Lê, Aditya K. Ghose, Muralee Krishnan, Krishnajith M. Krishnankunju, Konstantin Hoesch-Klohe (University of Wollongong, Australia)*

This paper reports on a project that seeks to overturn established management orthodoxy by establishing that business objectives can be adequately modeled by leveraging a domain ontology and that methodological and tool support can be provided for the task of correlating the objectives of an organization and its service offerings. This paper presents an interim report from this project that describes how to leverage a domain ontology in i) building business objective/goal models in a top-down manner (required to be able to refine these to a level where there could be an ontological match between the languages used to describe objectives and services); ii) assessing the degree of ontological match between low-level objectives and business services as a step towards an automated framework for establishing strategic service alignment. We introduced our in-progress toolkit called ServAlign.

### **Discovering Linkage Patterns among Web Services Using Business Process Knowledge (SCC2011-3040)**

*Mohammed AbuJarour, Ahmed Awad (University of Potsdam, Germany)*

Finding more comprehensive relations requires rich semantic service descriptions that are not so common in practice. Experiments have shown that similar users do not necessarily use the same web services. Using service compositions gives good results, however, researchers assume that they have access to such compositions, which is not the typical case in practice. In this work, we propose a novel approach to discover relations among web service in the form of linkage patterns based on the configurations of business processes that use them. We specify types and weights of the discovered linkage patterns based on control flow patterns in business processes. We have implemented this approach using Oryx, a process modeling tool and repository, and Depot, a service registry.

## **Applications and Experiences Track 5 – Service Selection**

**Session Chair:** Wei Tan, IBM T.J. Watson Research Center, USA

### **Web Service Selection based on Similarity Evaluation (SCC2011-3041)**

*HaoGao, Jun Yan, Yi Mu (University of Wollongong, Australia)*

Non-functional property is of paramount importance for Web services to function. However, service selection with consideration of Quality of Service is a challenge. This paper presents an approach to service selection by measuring the similarity between the web service publication and the service request. We identify five tendencies of the nonfunctional dimensions in the service requests; and present a flexible matchmaking approach which enables users to preset the negotiable preferences. Unlike other service selection approaches, we obtain the relative distance to compute the similarity score for generating the ranking list. Specifically, we introduce a novel method for evaluating the similarity between two categorical values based on the semantics and set theory.

### **Reputation-based Selection of Language Services (SCC2011-3042)**

*ShinsukeGoto, Yohei Murakami, Toru Ishida (Kyoto University, Japan)*

In language services such as machine translation, one of the QoS metrics is translation accuracy. However, the problems are that evaluating the translation accuracy is too expensive, that the translation accuracy varies with the difficulty of the task, and that the usefulness of the translation to the user depends on the abilities of the user. In this paper, we propose a framework that selects a useful service for a specific user and task by using reputation information of users, obtained at low cost. First, hypothetical reasoning is used to estimate the partial order relation between the accuracy of the language services, the language ability of the users, and the difficulty of the tasks. Second, deductive reasoning is applied to recommend useful services given the user and the task. We propose a reputation-based language service selection system combining a partial order acquisition system with a service selection system.

### **Preference-based Discovery of Dynamically Generated Service Offers (SCC2011-3043)**

*Maciej Zaremba, Tomas Vitvar, Sami Bhiri, Manfred Hauswirth (University of Innsbruck, Austria; National University of Ireland)*

The majority of service discovery approaches operate on abstract service descriptions. However, a single service often provides a significant number of possible service offers which are not reflected in abstract service descriptions. In this paper, we define a preference-based discovery model which operates on rich search request descriptions and dynamically generated individual service offers. We define search request model that include hard constraints, rich preferences, and flexible input parameters. We use a combination of utility functions and weighted rules for modeling rich preferences. We apply our results to an international shipping scenario in the experiment to prove the feasibility and usefulness of our approach in a realistic scenario

## **Applications and Experiences Track 6 – Services Composition**

**Session Chair:** Ming Zhao, Florida International University, USA

### **Controlled Flexibility in Business Processes Defined for Service Compositions (SCC2011-3044)**

*Malinda Kapuruge, Jun Han, Alan Colman (Swinburne University of Technology, Australia)*

As business needs change, the defined processes supporting the business also need to change and adapt, giving rise to the need for flexible business processes. However, a service composition is a collaborative environment where the service providers, consumers as well as the aggregator have business goals to achieve. Safeguarding such goals can be a daunting task upon numerous runtime modifications to business processes, but it is necessary to ensure the viability of the composition with respect to the business goals of all the parties. Therefore the flexibility needs to be controlled but without unnecessary restrictions. In this paper we propose a novel architectural approach to model, enact and manage business processes and their changes based on explicitly represented service relationships of a service composition.

### **CBBCM: Clustering based Automatic Service Composition (SCC2011-3045)**

*Ying Ma, Liang Chen, Jian Hui, Jian Wu (Zhejiang University, China)*

As the number of web services is increasing, the performance of automatic service composition is faced with challenges. In this paper, we propose an approach based on backward chaining method to compose web services with high performance and good Qos, called Clustering Based Backward Chaining Method (CBBCM). We use k-means method to cluster services as the preliminary work. Services are clustered according to the semantic similarities of their output parameters. Skyline is used as an optimization to set services with good Qos on the top of each cluster. Then the adapted backward chaining method is applied to compose services. We evaluate our approach and the backward chaining method through experiment with different datasets.

### **QoS-Driven Service Composition with Multiple Flow Structures (SCC2011-3046)**

*Wen-Jun Li, Xi Li, Xiao-Jun Liang, Xiao-Cong Zhou (Sun Yat-sen University, China)*

Based on a hierarchical Colored Petri Nets, an approach named LOSGC (Local Optimal Selection with Global Constraints) is proposed. The new approach is applicable to real-time distributed systems with general flow structures, including sequential, while, conditional choice and parallel operations. The global constraints are decomposed into local constraints according to flow structures, and then the distributed local selections are utilized to select optimal services that satisfy local constraints. A case study is performed.

## Applications and Experiences Track 7 – Service Pricing

**Session Chair:** Nour Ali, Lero-The Irish Software Engineering Research Centre, Ireland

### **Towards Pay-As-You-Consume Cloud Computing (SCC2011-3047)**

*Shadi Ibrahim, Bingsheng He, Hai Jin (Huazhong University, China; Nanyang Technological University, Singapore)*

Our case studies demonstrate significant variations in the user costs, indicating significant unfairness among different users from the micro-economic perspective. Further studies reveal the reason for such variations is interference among concurrent virtual machines. The amount of interference cost depends on various factors, including workload characteristics, the number of concurrent VMs, and scheduling in the cloud. In this paper, we adopt the concept of pricing fairness from micro economics, and quantitatively analyze the impact of interference on the pricing fairness. To solve the unfairness caused by interference, we propose a pay-as-you-consume pricing scheme, which charges users according to their effective resource consumption excluding interference. The key idea behind the pay-as-you-consume pricing scheme is a machine learning based prediction model of the relative cost of interference.

### **Price Heuristics for Highly Efficient Profit Optimization of Service Composition (SCC2011-3048)**

*Xianzhi Wang, Zhongjie Wang, Xiaofei Xu (Harbin Institute of Technology, China)*

As the de facto provider of composite services, the broker charges the consumers; on the other hand, it awards cost to the providers whose services are involved in the composite services. Besides traditional quality-oriented optimization from the consumers' point of view, the profit that a broker could earn from the composition is another objective to be optimized. But just as the quality optimization, service selection for profit optimization suffers from dramatic efficiency decline along with the growth in the number of candidate services. On the premise that the expected quality are guaranteed, this paper presents a "divide and select" approach for high-efficiency profit optimization, with price as heuristics. This approach can be applied to both static and dynamic pricing scenarios of service composition. Experiments demonstrate the feasibility.

### **Differentiated Service Pricing on Social Networks Using Stochastic Optimization (SCC2011-3049)**

*Alexei A. Gaivoronski, Denis Becker (Norwegian University, Norway)*

This paper develops a combined simulation and optimization model that allows to optimize different service pricing strategies defined on the social networks under uncertainty. For a specific reference problem we consider a telecom service provider whose customers are connected in such network. Besides the service price, the acceptance of this service by a given customer depends on the popularity of this service among the customer's neighbors in the network. One strategy that the service provider can pursue in this situation is to stimulate the demand by offering the price incentives to the most connected customers whose opinion can influence many other participants in the social network. We develop a simulation model of such social network and show how this model can be integrated with stochastic optimization in order to obtain the optimal pricing strategy. Our results are reported.

## Applications and Experiences Track 8 – Evolutionary Service Composition

**Session Chair:** Shiping Chen, CSIRO ICT Centre, Australia

### **Client Update: A Solution for Service Evolution (SCC2011-3050)**

*Meriem Ouederni, Gwen Salaiin, Ernesto Piementel (Grenoble INP, INRIA, France; University of Malaga, Spain)*

In service-based systems, service evolution might raise critical communication issues since the client cannot be aware of the changes that have occurred on the black-box services side. In this paper, we propose an automated process to adapt the client to the changes that have occurred. Our approach relies on a compatibility measuring method, and changes the client interface to ensure the system compatibility. This solution is fully automated inside a prototype tool we have implemented

### **Cultural Language Service: a Discovery, Composition and Organization (SCC2011-3051)**

*Arif Bramantoro, Toru Ishida (National Institute of Information and Communications Technology; Kyoto University)*

The lack of accuracy is the main issue in language service research. Two features of culture analysis and contents are currently not available in language services. Our main contribution is that we provided a necessary framework of service discovery, composition and organization for cultural language service. In service discovery, we implemented semantic similarity in cultural language services by utilizing language service ontology. In service composition, we presented hybrid language service architecture to provide multi level analysis in cultural text and culture contents in multimedia. In service organization, we provided multi-objective constraint optimization able to accommodate the characteristic of language services organized in multi culture environment.

### **A Granular Concurrency Control for Collaborative Scientific Workflow Composition (SCC2011-3052)**

*Xubo Fei, Shiyong Lu, Jia Zhang (Wayne State University; Northern Illinois University, USA)*

A collaborative scientific workflow management system allows participating scientists to design and compose common scientific workflows concurrently. Concurrency control has become one of the key challenges in collaborative scientific workflow composition, which aims to facilitate collaboration while ensuring the correctness and consistency of the results generated from concurrent operations. We have previously proposed a locking scheme to support simple scientific workflow compositions, in which workflows are flat (not hierarchical). In this paper, we take a step forward to propose a new granular scientific workflow locking scheme, which captures dependency relationships between workflows, to support general hierarchical workflow compositions. We also conduct several experiments to evaluate the performance of the concurrency control.

## Applications and Experiences Track 9 – Service Monitoring and Testing

**Session Chair:** Song Wu, Huazhong University of Science and Technology, China

## **Magnifier: Online Detection of Performance Problems in Large-Scale Cloud Computing Systems (SCC2011-3053)**

*HaiboMi, Huaimin Wang, Gang Yin, HuaCai, Qi Zhou, Tingtao Sun, Yangfan Zhou (National University; Alibaba Cloud Co. Ltd; The Chinese Univ. of Hong Kong, China)*

Existing end-to-end request tracing approaches are not suitable for online anomaly. In this paper, we propose an approach, namely Magnifier, to rapidly diagnose the source of performance degradation in large-scale non-stop cloud systems. In Magnifier, the execution path graph of a user request is modeled by a hierarchical structure, and anomalies are detected from higher layer to lower layer separately. In each layer every node is assigned a newly created identifier in addition to the global identifier of the request, which significantly decreases the size of parsing trace logs and accelerates the anomaly detection process.

## **Building a Service-Oriented Monitoring Framework with REST and Nagios (SCC2011-3054)**

*Gregory Katsaros, Roland Kübert, Georgina Gallizo (HLRS, Stuttgart, Germany)*

Regardless of the rapid evolution in the fields of services and web technologies, ensuring the QoS of computing resources still remains an important topic. To this end, monitoring computing resources and application execution is an integral part of the services computing value chain. In this paper we present the architectural design and implementation of a service framework that monitors the resources of a physical as well as virtual infrastructure. Our solution extends Nagios, a widely used monitoring toolkit, through the implementation of NEB2REST, a RESTful Event Brokering module

## **Model-Based Testing of Service-Oriented Applications via State Models (SCC2011-3055)**

*Andre Takeshi Endo, Adenilso Simao (Universidade de São Paulo (USP), Brazil)*

SOA and web services have been used to foster the development of loosely coupled, interoperable, and distributed applications. Mission-critical and business process systems can be implemented with them, requiring a high level of quality. Model-based testing allied with state models is a promising candidate due to its efficiency, effectiveness, and flexibility. In this paper, we propose a modelbased testing process to verify service-oriented applications. Finite state machines are used to model and support the test case generation. We evaluated the applicability of our process with a case study using a prototype tool.

## **Applications and Experiences Track 10 – Service Applications**

**Session Chair:** I-Ling Yen, University of Texas at Dallas, USA

### **IRTG: A Grid Middleware for Bioinformatics (SCC2011-3056)**

*Kamal Taha, RamezElmasri (Khalifa University Abu Dhabi, UAE; University of Texas at Arlington, USA)*

Frequently used queries in bioinformatics applications should be given special treatment. We propose in this study a query processor called IRTG that expedites the processing of frequently used queries. IRTG can be considered as a type of middleware running at a central site. It classifies queries per their types and ranks the query types based on their frequencies. The results of queries whose types are classified as frequently used types will be cached at the middleware. Thereafter, each frequently used query of these types will be answered from the middleware rather than from remote sites, which improves the query's response time. We evaluate IRTG experimentally

### **OdinTools - Model-Driven Development of Intelligent Mobile Services (SCC2011-3057)**

*Andrew Meads, Ian Warren (University of Auckland, New Zealand)*

To address the challenges associated with the development of mobile services, we have developed Odin, a middleware which masks complexity, allowing rapid development of mobile services. Odin, however, does not allow cross-platform development, which is an important concern with today's wide variety of mobile devices. To solve this problem, we have designed OdinTools - a model-driven toolkit for cross-platform development of mobile services. Leveraging appropriate metamodels, a prototype has been implemented in Eclipse and Marama that allows developers to model mobile services in a platform-independent manner.

## **Applications and Experiences Track 11 – Service Quality Control**

**Session Chair:** David W Chadwick, University of Kent, UK

### **Fine-Grained Modeling of Web Services for Test-Based Security Certification (SCC2011-3058)**

*Marco Anisetti, Claudio A. Ardagna, Ernesto Damiani (Università degli Studi di Milano Crema (CR), Italy)*

We present a solution for test-based security certification of services that models the service under certification using a Symbolic Transition System (STS). The STS-based model is readily derivable from the WSDL and Web Service Conversation Language (WSCL), and can be enriched with details about test-based conditions on inputs and outputs, implementation details, and security specifications. In addition, we show how such fine-grained modeling can be included in a test-based security certification process. Finally, we discuss how this process can be integrated within the Web service life-cycle and used for matching users' preferences and comparing certificates of different services.

### **Optimizing DaaS Web Service based Data Mashups (SCC2011-3059)**

*Mahmoud Barhamgi, Chirine Ghedira, Djamel Benslimane, Salah-Eddine Tbahriti, Michael Mrissa (Claude Bernard Lyon1 University, France)*

Data Mashup is a special class of mashup application that combines information on the fly from multiple data sources to respond to transient business needs. In this paper, we propose two optimization algorithms to optimize Data Mashups. The first allows for selecting the minimum number of services required in the data mashup. The second exploits the services' constraints on inputs and outputs to filter out superfluous calls to component services in the data mashup. These two algorithms are evaluated and tested in the healthcare application domain, and the reported results are very promising.

### **A New Approach for Quality Enforcement in Communities of Web Services (SCC2011-3060)**

*Abdelghani Benharref, M. Adel Serhani, Salah Bouktif, Jamal Bentaha (Abu Dhabi University, United Arab Emirates; Concordia University, Canada)*

In this paper, we augment the community approach by defining a specific-purpose community to monitor Web Services operating in any Web Services community. This monitoring community consists of a set of Web Services capable of observing other Web Services. Clients, providers, as well as managers of communities can make use of the monitoring community to check if a Web Service is operating as expected. This paper defines the overall architecture of the monitoring community, the business model behind, different rules and terms to be respected by its members, services it offers to its various classes of customers. The paper also presents promising experimental results using the monitoring community.

## **Applications and Experiences Track 12 – Service Models**

**Session Chair:** Massimo Villari, University of Messina, Italy

### **A Dependency-aware Hierarchical Service Model for SaaS and Cloud Services (SCC2011-3061)**

*Wang Rui, Zhang Yong, Liu Shijun, Wu Lei, Meng Xiangxu (Shandong University, China)*

In this paper, services are classified into three levels in accordance with different business requirements. Services are assembled by choosing lower-level services or other services at the identical level. Tenant applications are implemented by way of choosing services in composite business level. A hypergraph-based service model is used to represent hierarchical services and multi-tenancy applications. A dependency is a relation between services wherein a change to one of the services implies a potential change to the others. We propose algorithms based on directed hypergraph which can represent dependencies between services and applications to verify the correctness of dependencies during the application construction period and we implement a SCA-based platform for the large-scale multi-tenancy application construction.

### **A Clustering based Schema Matching Scheme for Improving Matching Correctness of Web Service Interfaces (SCC2011-3062)**

*Byoungoh Kim, Ho Namkoong, Dongman Lee, Soon J. Hyun (Korea Advanced Institute of Science and Technology Daejeon, Korea)*

An interface adapter is used to allow a client application to transparently work with a service available in the local. To generate adapters for users, interface matching is the first job to find out all the possible method matching pairs between a source interface and a target interface. Existing method matching schemes compare the schemas of source and target interfaces but they have low recall and precision because they only consider signatures and names of interfaces. For solving these problems, we propose a cluster-based schema matching scheme. By clustering methods in terms of parameter similarity, the proposed scheme can match methods more precisely than existing schema matching schemes. We detect incorrect matches based on analysis of incorrect method matching pairs.

## **Applications and Experiences Track 13 – Quality Measurement**

**Session Chair:** Reiff-Marganec, University of Leicester, UK

### **A Petri-Net Model for the Publish-Subscribe Paradigm and its Application for the Verification of the Bonjourgrid Middleware (SCC2011-3063)**

*Leila Abidi, Sami Evangelista (Universit'e de Tunis, Tunisie; Universit'e de Paris 13 France)*

In this article we focus on the modelization of the BonjourGrid protocol which is based on the Publish-Subscribe (Pub-Sub) paradigm, a paradigm for asynchronous communication that is useful for implementing some approaches in distributed programming. The aim of this paper is to isolate the generic mechanisms of construction for the publish-subscribe approach then to model and verify, based on those mechanisms, the BonjourGrid protocol that allows the coordination of multiple instances of desktop grid middleware. We produce models using colored Petri nets to describe a specific modeling approach for the Pub-Sub paradigm. The ideas are illustrated along the BonjourGrid case study and they constitute methodology of building Pub-Sub systems.

### **Measuring the Conceptual Coupling of Services Using Latent Semantic Indexing (SCC2011-3064)**

*Ali Kazemi, Ali NasirzadehAzizkandi, Ali Rostampour, Hassan Haghghi, PooyanJamshidi, Fereidoon Shams (Shahid Beheshti University GC, Iran; Dublin City University, Ireland)*

Having loosely coupled services not only increases service reusability, but also prevents the propagation of changes to other services and thus simplifies maintenance of service-oriented systems as well. In this paper, we focus on measuring conceptual coupling as an indicator of how much a service depends on the other services from functional point of view. Latent Semantic Indexing (LSI) is a well-known technique in the field of information retrieval (IR) which has been widely used to measure the degree of semantic relationship between text based documents. In this paper, a metric namely CCS is proposed to measure the degree of conceptual coupling of a service to its environment based on the LSI technique. The proposed metric is evaluated theoretically based on a set of coupling principles.

### **A Metrics Framework for Evaluating SOA Service Granularity (SCC2011-3065)**

*SaadAlahmari, Ed Zaluska, David C De Roure (University Southampton, UK)*

To evaluate the design of services in service-based systems, quality measurements are essential to decide tradeoffs between SOA quality attributes. Current SOA quality metrics pay little attention to service granularity as an important key design feature that impacts other internal SOA quality attributes. In this paper we introduce the structural attribute of service granularity for the analysis of other internal structural software attributes: complexity, cohesion and coupling. Consequently, metrics are proposed for measuring SOA internal attributes using syntax code. These metrics will assist in development of optimal service design by considering appropriate trade-offs. An example case study is included to demonstrate proposed metrics.

## Applications and Experiences Track 14 – Service Allocation

**Session Chair:** Shiyong Lu, Wayne State University, USA

### **Jerrymouse: a Tool for a Flexible and Dynamic Distribution of Web Service Requests (SCC2011-3066)**

*Paulo S L Souza, Bruno S Façal, Marcos J Santana, Regina H C Santana, Jonathan de Matos, Ed Zaluska (University of Sao Paulo; State University of Ponta Grossa, Brazil; University of Southampton, UK)*

This paper presents a novel architecture for distributing web service requests on clusters of servers. The architecture facilitates a transparent dynamic distribution of requests according to a range of specified policies. This enables a flexible performance in respect of different objectives, services and platforms (typically based on server workload). The architecture has been successfully demonstrated with a prototype implementation (called “Jerrymouse”). Our preliminary results with Jerrymouse indicate stable behaviour and worthwhile performance gains (compared with Apache HTTP Server). A specific policy to deliver reduced cluster electricity savings has also been successfully implemented.

### **On-Line Real-Time Service Allocation and Scheduling for Distributed Data Centers (SCC2011-3067)**

*Shuo Liu, Gang Quan, Shangping Ren (Florida International University; Illinois Institute of Technology, USA)*

With the prosperity of Cluster Computing, Cloud Computing, Grid Computing, and other distributed high performance computing systems, Internet service requests become more and more diverse. The large variety of services plus different QoS considerations make it challenging to design effective allocate and scheduling algorithms to satisfy the overall service requirements, especially for distributed systems. In addition, energy consumption issue attracts more and more concerns. In this paper, we study a new energy efficient, profit and penalty aware allocation and scheduling approach for distributed data centers in a multi-electricity-market environment. Our approach efficiently manages computing resources to minimize the processing and transferring energy dollar cost in an electricity price varying environment.

### **An Enhanced PROMETHEE Model for QoS-Based Web Service Selection (SCC2011-3068)**

*RaedKarim, Chen Ding, Chi-Hung Chi (Ryerson University, Canada; Tsinghua University, China)*

Since selecting a web service based on QoS is essentially a Multi-Criteria Decision Making (MCDM) problem, various MCDM models would be suitable for implementing the selection systems. In this paper, we propose to use an enhanced PROMETHEE model for QoS-based web service selection. Many selection algorithms assume the independency between the QoS criteria, which is not very accurate. Thus, our first enhancement is to take into account the QoS interdependency by using the Analytical Network Process (ANP) to calculate the weight/priority associated with each criterion. User’s QoS requirement is not considered in the original PROMETHEE model. As a consequence, during the process of finding an optimal service, when tradeoff decisions are involved, we may end up with a service which optimizes the overall QoS criteria, however, does not satisfy the user request. To overcome this insufficiency, our second enhancement is to check the outranking flows of each service with respect to the request in the ranking step.

## Industry Track

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### **Industry Track 1 – Enterprise Management**

**Session Chair:** Alfred Zimmermann, Reutlingen University, Germany

#### **Towards a Service-Oriented Component Model for Autonomic Management (SCC2011-3069)**

*Yoann Maurel, Philippe Lalanda, Ada Diaconescu (Laboratoire Informatique de Grenoble F-38041, France)*

The purpose of this paper is to present a service-oriented framework that facilitates the development and management of dynamically extensible autonomic managers. We propose an architecture based on the opportunistic collaboration of very specialized and coherent modules called administration tasks. The current framework prototype has been implemented as a specialized Service-Oriented Component Model. It allows the dynamic integration of autonomic tasks and their management based on contextual evolutions.

#### **Managing Enterprise IT Systems using Online Communities (SCC2011-3070)**

*Maja Vukovic, Vijay Naik (IBM T.J. Watson Research, USA)*

The essential information, is often in collective possession of the infrastructure and application specialists. In this paper, we describe the Knowledge Harvesting & Information Synthesis System (KHISS), which engages enterprise online communities to capture the information required for IT optimization activities. We describe our experience in deploying KHISS principles to manage enterprise IT infrastructure and application portfolio, as a first step in on-Cloud migration – a large business transformation activity. We discuss the challenges in attracting and maintaining enterprise online communities, as well as in assuring the quality of knowledge collected through this collaborative mechanism to guide the strategic decisions about enterprise IT environment.

#### **Managing Software Assets in a Global Enterprise (SCC2011-3071)**

*Matthew McCarthy, Lorraine Herger (IBM; IBM Research, USA)*

The IBM Corp invents, develops and manufactures IT products, including computer systems and software, system networks, storage hardware and microelectronic products. The IBM CIO Global Infrastructure Architecture and Strategy (CIO GIAS) team is responsible for running and optimizing IBM’s internal IT operations which include more than 500,000 users connecting to over 20,000 servers across 170 countries. The solution described below, implemented between 2008-2011, is a response to managing software licenses in one of the world’s largest distributed enterprises.

### **Industry Track 2 – Services Applications**

**Session Chair:** Patrick Hung, University of Ontario Institute of Technology, Canada

## **Intelligent Scheduling Algorithm and Application in Modernizing Manufacturing Services** (SCC2011-3072)

*Yaojun Chen, Liang-Jie Zhang, Qian Wang (Kingdee International Software Group CO., Ltd, China)*

An intelligent scheduling algorithm based on multiagents and genetic algorithm is proposed to overcome flexible job-shop automation and optimization problems in manufacturing industry. The algorithm is made of a management-agent, a scheduling-agent and machine-agents. Static scheduling is realized by a customized genetic algorithm, while dynamic scheduling is realized by these coordinative agents. Several scenarios are used to illustrate that the proposed system is practical, efficient and advanced.

## **Application Framework for Efficient Development of Sensor as a Service for Home Network System** (SCC2011-3073)

*Masahide Nakamura, Shuhei Matsuo, Shinsuke Matsumoto, Hiroyuki Sakamoto, Hiroshi Igaki (Kobe University; Tokyo University of Technology, Japan)*

How to implement sensor services efficiently and reliably is an open issue. This paper presents an application framework, called Sensor Service Framework (SSF), that supports developers to build and deploy sensor services in the home network system (HNS). The SSF prescribes device-neutral features and APIs for the sensor devices to be deployed as Web services. Writing a small amount of code with the SSF, the developer can easily deploy any sensor device as a service in the HNS. The sensor service can provide a standardized access to heterogeneous sensor devices, as well as a context management service with user-defined conditions. We then present a sensor mashup platform (SMuP), allowing the dynamic composition of the existing sensor services.

## **Industry Track 3 – Services Development Frameworks**

**Session Chair:** Dharmender Singh Kushwaha, Motilal Nehru National Institute of Technology, India

### **Leveraging Cloud Platform for Custom Application Development (SCC2011-3074)**

*Nianjun Zhou, Da PengAn, Liang-Jie Zhang, Chih-Hong Wong (IBM T.J. Watson Research Center, USA; IBM Global Business Service Solution, China)*

Compared with packaged application, custom application developments (CAD) experience the frustration of higher project overhead and less certainty. Project uncertainty comes from unique customer requirements and lack of standardized methods and toolsets to follow. Therefore, a CAD project is more difficult to achieve cost reduction and asset reuse. In this paper, we present a cloud platform to alleviate this problem through an integration of a) standard methods; b) standardized toolsets aligned with those methods; c) project management environments with pre-defined work breakdown structure (WBS) aligned with those methods and toolsets; and d) infrastructure support from the cloud technology. We believe that such a cloud platform will become a fundamental approach for large enterprises to develop CAD or other solutions for their clients.

### **Capability Diagnostics of Enterprise Service Architectures using a Dedicated Software Architecture Reference Model (SCC2011-3075)**

*Alfred Zimmermann, HerlgeBuckow, Hans-Jürgen Groß, Oliver F. Nandico, Gunther Piller, Karl Prutt (Reutlingen University; McKinsey & Company – Berlin; Daimler - Stuttgart; University of Applied Sciences Mainz; Capgemini – Munich; Capgemini – Hamburg, SOA Innovation Lab, Germany)*

The SOA Innovation Lab investigates the practical use of vendor platforms in a service-oriented context. Current approaches for assessing architecture quality and maturity of service-oriented enterprise software architectures are rarely validated and were intuitively developed, having sparse reference model, metamodel or pattern foundations. Our contribution is to extend existing enterprise and software architecture reference models and maturity frameworks to accord with a sound metamodel approach. We have developed a pattern language for assessing the architecture quality of adaptable service-oriented enterprise systems.

### **REFINTO: An Ontology-Based Requirements Engineering Framework for Business - IT Alignment in Financial Services Organizations (SCC2011-3076)**

*Emem Umoh, Pedro R. Falcone Sampaio, Babis Theodoulidis (University of Manchester, UK)*

This paper proposes an ontology-based framework and tool to guide the requirements engineering process in RAD projects for financial solution application development. The framework is aimed at empowering IT, business and solutions analysts with a knowledge repository that helps to address terminology gaps between different project stakeholders and quickly manage the requirements engineering process in response to rapidly changing business demands. We also illustrate how the framework and tool are being used to support RAD projects in the development of financial trading systems for a top 5 global investment bank.

## **Industry Track 4 – Services Selection and Composition**

**Session Chair:** Anna Cinzia Squicciarini, Penn State University, USA

### **ServiceMap: Providing Map and GPS Assistance to Service Composition in Bioinformatics** (SCC2011-3077)

*Wei Tan, Jia Zhang, Ravi Madduri, Ian Foster, David De Roure, Carole Goble (IBM T.J. Watson Research Center, Northern Illinois University; Argonne National Laboratory Oxford University, USA; Oxford University, UK; University of Manchester, UK)*

This paper presents a follow-up work of our network analysis on myExperiment, an online scientific workflow repository. The motivation comes from two common questions proposed by bio-scientists: 1) Given services which I plan to use, what are other services usually used together with them? and 2) Given two or more services I plan to use together, can I find an operation chain to connect them based on others' past usage? Aiming to provide a system-level GPS-like support to answer the two questions, we present ServiceMap, a network model established to study the best practice of service use. We propose two approaches over the ServiceMap: association rule mining and relation-aware, cross-workflow searching. Our approaches were validated using the real-life data obtained from the myExperiment repository. Empirical statistics of the constructed service network are also reported.

## **Building FCA-based Decision Trees for the Selection of Heterogeneous Services (SCC2011-3078)**

*Stéphanie Chollet, Vincent Lestideau, Philippe Lalanda, Yoann Maurel, Pierre Colomb, Olivier Raynaud (Laboratoire d'Informatique de Grenoble; de Modélisation, France)*

Late-binding and substitutability offered by the service-oriented approach improve adaptability but increase the need for fast and efficient algorithms to select services. In this paper, we proposed to use the Formal Concept Analysis (FCA) approach as a classification tool to select services at run time, according to user specifications. We propose to classify existing services and generate a decision tree to help user select the most appropriate service (s). One of advantages of using FCA is the ability to select without additional cost an equivalent service in the case of a service must be replaced at runtime. Our approach have been implemented and validated on pervasive use cases within a European collaborative project.

## **Composition Context Matching for Web Service Recommendation (SCC2011-3079)**

*Nguyen Ngoc Chan, Walid Gaaloul, Samir Tata (TELECOM SudParis, France)*

The tremendous growth in the amount of available web services impulses many researches on proposing discovery mechanisms to help designers compose services. However, most of the proposed solutions ignore in their discovery queries the upcoming services' interactions within the being designed compositions. In this paper, we present an original recommendation approach to discover a requested service to be incorporated into a specific composition. We propose to take into account the composition context specified through the process fragment surrounding the requested service, and benefit from the modeling and usage of previous service compositions to build our recommendations.

## **Industry Track 5 – Services Testing**

**Session Chair:** Geetika T. Lakshmanan, IBM T.J. Watson Research Center, USA

## **An Event-Driven Approach for Runtime Verification of Inter-Organizational Choreographies (SCC2011-3080)**

*Aymen Baouab, Olivier Perrin, Claude Godart (Nancy University, France)*

Inter-organizational service-based processes are increasingly adopted by different companies when they cannot achieve goals on their own. As a result, conformance problems arise and it must be ensured that the integrity of processes execution remains guaranteed. In this paper, we propose new components, to be deployed along the boundaries of each participating organization, offering external flow control, and notification in case of violation detection, while providing process execution traceability. To achieve our goals, we propose an event-based approach in which inter-organizational exchanges are perceived as events. We define event patterns for filtering the desirable incoming and outgoing messages.

## **Verify Enterprise System Implementation through Business Process Model-based Test Suite Generation (SCC2011-3081)**

*Bing Shao, Qinhuo Wang, Changrui Ren, Miao He, Jin Dong (IBM Research, China)*

In the practice of process-centric systems implementations, business process modeling is becoming more crucial. This paper introduces an approach to automatically generate test suites for the process paths to check the consistency, which is very important, between the business process model and the implementation of Enterprise System. The paper also presents a supporting tool to apply this approach in SAP implementation. A large-scale enterprise transformation program is discussed as a case study.

## **A Novel Test and Evaluation Scheme for WS-Management Protocol and its Implementation (SCC2011-3082)**

*ZhiHui Lu, XiaoHongGao, Jie Wu (Fudan University, Donghua University, China)*

WS-Management is a general Web Services-based protocol for managing system and network resources. Wiseman is an open source project which implements the WS-Management specification. The paper presents three new test evaluation schemes for WS-Management Protocol and its Implementation project-Wiseman. We also present our two improvement contribution points to the Wiseman project.

## **Industry Track 6 – Services Monitoring**

**Session Chair:** Aditya K. Ghose, University of Wollongong, Australia

## **A Real-time Risk Assessment and Mitigation Engine based on Dynamic Context (SCC2011-3083)**

*Sinem Guven, Catalin MihaiBarbu (IBM T.J. Watson Research Center, USA, IBM Global Services Delivery Center, Czech Republic)*

Today, the risk of a service related change is typically assessed at change record creation time by a Change Requester either manually or through answering a fixed set of questions. Such deficiencies of the standard practice to assess risk of a change may, thus, result in inaccurate assessment, which can lead to unmitigated risks. We present a novel Risk Engine, which takes into account a rich, dynamic change context to calculate and mitigate the risk of a service related change in real-time with increased accuracy and reliability. We describe the recipe for creating the Risk Engine along with several user studies.

## **A Business Centric Monitoring Approach for Heterogeneous Service Composites (SCC2011-3084)**

*Geetika T. Lakshmanan, Paul T. Keyser, Aleksander Slominski, Francisco Curbera (IBM T.J. Watson Research Center, USA)*

Composite applications contain a heterogeneous collection of services. This paper introduces a business centric monitoring framework to bridge the gap between the business and service levels in complex business applications. Our technical approach focuses on using business information invariants to define one or more monitor sets in order to relate service activity to business composite execution. We apply this framework to enable end-to-end monitoring of heterogeneous composite business applications. In this paper we present

a prototype using monitor sets for monitoring an order management composite implemented on IBM's WebSphere Integration Developer (WID) v7 and tested on WebSphere Business Monitor v7.

### **Sustainable Service Level Agreements (SCC2011-3085)**

*Thiago Giulio Barroero, Gianmario Motta, Marco Durante (University of Pavia; Italy)*

Our paper provides a method to manage sustainable service levels in call centers. We defined a service level management process and a related capacity and workforce management that considers Erlang-A operational model for staffing levels. Based on such model, we compute the minimum sustainable price for a service contract based on the fixed service levels, and enable transparent pricing against a certified service level. The model has been implemented in a tool and is being tested in real call centers.

## **Industry Track 7 – Business Process Management**

**Session Chair:** Chao Wang, University of Science and Technology of China

### **Towards a Constraint-based Framework for Dynamic Business Process Adaptation (SCC2011-3086)**

*Zan Xiao, Donggang Cao, Chao You, Hong Mei (Peking University, China)*

In this paper, we propose a constraint-based framework for supporting dynamic business process adaptation. In our framework, process adaptations are performed in a modular way based on process fragments. Process fragments are standalone fragments of processes that can be reused across multiple processes. Processes are composed of a series of fragments. The relationships among fragments are specified in a constraint-based way. The adaptation logic to select concrete fragments is separated from business logic in a process and can be defined in a policy-based approach. Processes are dynamically generated based on the constraints and adaptation policies according to the operating environments, so it is flexible to adapt to the ever-changing operating environments and business requirements. We have implemented a prototype to demonstrate and evaluate our approach.

### **Uniform Modeling of Resources and Business Processes Using Business Entities (SCC2011-3087)**

*Rong Liu, Anil Nigam, Zhe Shan, Frederick Y. Wu (IBM T.J. Watson Research; Penn State University, USA)*

To fully support the rich interaction between resources and business processes in a real business environment, we introduce a novel approach where resources are modeled in much the same way that we model business processes. Resources are systematically modeled as full-fledged business entities to capture resource behavior and the interactions between resources and business processes. A service-oriented resource management architecture is developed to manage resources and support a range of resource allocation patterns and policies. This architecture can be integrated with BPM applications. This new approach to modeling resources sheds light on the interplay between business processes and resources.

### **LiSEP: a Lightweight and Extensible Tool for Complex Event Processing (SCC2011-3088)**

*Ivan Zappia, David Parlanti, Federica Paganelli (Università di Firenze, Italy)*

Complex Event Processing is considered as a promising asset, as it enables to effectively extract meaningful events from raw data streams originated by sensing infrastructures, for enterprise processes and applications consumption. This paper proposes a novel CEP engine conceived with extensibility, interoperability, modularity and scalability requirements in mind. More specifically, we propose a Lightweight Stage-based Event Processor (LiSEP), based on a layered architectural design. Thanks to the adoption of Stage-Event Driven Architecture principles, core event processing logic is decoupled from lowlevel thread management issues. This results in an easy-to-understand and extensible implementation while testing results show performance scalability. We also report on the development of an ongoing case study on dangerous goods monitoring.

## **Industry Track 8 – Case Studies**

**Session Chair:** Jian Wu, Zhejiang University, China

### **SOMP: Service-Oriented Multi Processors (SCC2011-3089)**

*Chao Wang, Junneng Zhang, Xuehai Zhou, Xiaojing Feng, Xiaoning Nie (University of Science and Technology of China; Suzhou Institute of USTC, China; Infineon Technologies AG Munich, Germany)*

We introduce SOA into Multi-processor system on chip (MPSoC) design. In this paper, we propose a service-oriented multi-processor SOMP, which integrates embedded processors and hardware IP cores as computing servants on a single chip. SOMP provides unified programming interfaces for users through utilizing diverse computing resources. In order to demonstrate the performance of SOMP, we implemented it on a Digilent Virtex5LX110T FPGA board and designed several sample test applications for verification purpose.

### **Sensor Service Selection through Switch Options (SCC2011-3090)**

*Sahin Cem Geyik, Boleslaw Szymanski, Petros Zerfos, Abbe Mowshowitz (Rensselaer Polytechnic Institute; IBM T.J. Watson Research; City University of New York; USA)*

In this paper, we propose to use real options theory for selecting component services. Real options are designed to reduce the risk associated with an investment by delaying the investment decision for a certain period of time or by allowing for the substitutions of initial investment. Thus, they enhance managerial flexibility and add to the overall value of a project but at the same time they incur certain costs.

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## **Work-in-Progress Track**

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### **Work-in-Progress Track 1 – Services Discovery**

**Session Chair:** Patrick Hung, University of Ontario Institute of Technology, Canada

### **QoS-Based Distributed Service Selection in Large-Scale Web Services (SCC2011-3091)**

*Limin Pan, Liang Chen, Jian Hui, Jian Wu (Zhejiang University, China)*

Inspired by MapReduce, we design a system architecture and Preprune-Refine framework in this paper to handle distributed web services. Extensive experiments show that our Preprune-Refine framework performs efficiently and effectively and scales well.

### **An Enhanced QoS Prediction Approach for Service Selection (SCC2011-3092)**

*Liang Chen, YipengFeng, Jian Wu, Zhibin Zheng (Zhejiang University; The Chinese University of Hong Kong, China)*

In this paper, we propose an enhanced QoS prediction approach to predict the missing QoS values for QoS-based selection. Compared with existing QoS prediction methods, our proposed ASmooth approach has two differences: 1) using Ac cosine equation for similarity calculation to remove the impact of different QoS scale; 2) adding a data Smoothing process to improve the prediction accuracy. An extensive performance study based on a real public dataset is reported to verify the prediction accuracy of our proposed approach

### **A Clustering Method for Web Service Discovery (SCC2011-3093)**

*Liu Jianxiao, He Keqing, Wang Jian, Ning Da (Wuhan University, China)*

With the development of web service applications, how to improve the efficiency of service discovery is an important research work in modern times. From the aspect of service function, this paper clusters web services to form service clusters based on service ontology which is generated by domain modeling. It can significantly reduce the overhead and enhance the service discovery efficiency. The corresponding service clustering algorithm and experiments are given to verify the feasibility of the proposed method.

### **Using 3-Way Satisfaction for Web Service Selection (SCC2011-3094)**

*Erbin Lim, Philippe Thiran, ZakariaMaamar, Jamal Bentahar (University of Namur, Namur; Zayed University, U.A.E; Concordia University, Canada)*

This paper examines the problem of Web service selection in a community. Selection methods thus far neglect the satisfaction of Web services and the community to which they belong. In this paper we propose a method of selecting a Web service based on the satisfaction of all three parties - user, Web service and community. The proposed solution consists of first formalizing the selection process and then using linear programming techniques to define a score function.

### **Discovering Service Similarity by Testing (SCC2011-3095)**

*Joshua Church, Amihai Motro (George Mason University, USA)*

We describe a comprehensive methodology for discovering service similarity (substitutability) by testing. Our solution does not rely on the service descriptions provided by authors, and it avoids common information retrieval techniques. The only information our method expects is that every service in the repository will be annotated with its inputs and outputs, and that each input and output will be associated with a domain from a published list.

### **A Multi-dimensional Social Tagging Method for Semantic Web Services (SCC2011-3096)**

*Ning Da, HdKe-Qing, Peng Rong, Liu Jian-Xiao (Wuhan University Wuhan, China)*

To solve the problem of insufficient capacity of semantic description of web services, a multi-dimensional social tagging method for semantics of web services is proposed. Under guidance of general social tagging model, users will annotate services manually from the domain the services attribute to, services theme and selfreference, and simultaneously, the functional and nonfunctional properties of the services are automatically tagged. A method of service semantics emerge automatically is proposed.

## **Work-in-Progress Track 2 – SOA**

**Session Chair** Hua Liu, Xerox Corporation, USA

### **An Architecture for Managing and Delivering Trustworthy Context-dependent Services (SCC2011-3097)**

*Naseem Ibrahim, Mubarak Mohammad, VangalurAlagar (Concordia University, Canada)*

A precise definition of services is necessary to discover, publish, and deliver them. Services, when provided, should satisfy their binding contractual obligations, be seen as trustworthy by the users, and correctly fulfill the needs of the context in which they will be used. The FrSeC architecture proposed in this paper aims to fulfill these needs. The architecture is formally describable, supports specification, publication, discovery, selection, and composition of services with context-dependent contracts

### **On-Demand Service-Oriented Architecture and Standardization (SCC2011-3098)**

*Fei He, Keqing He, Peng Liang, Jian Wang (Wuhan University, China)*

With the increased number of richness service resources, and maturity of SOA-based solutions, it is critical to develop an innovative software engineering methodology for user-centric and ondemand service oriented computing. This paper proposes the RGPS (Role-Goal-Process-Service) requirements metamodeling framework for service requirements elicitation, analysis, and modeling. Meanwhile, the standardization on service interoperability is a key driver to realize on-demand services based on various service resources. We have developed the ISO standards series: MFI (meta-model framework for interoperability) and MFI (Ontology-RGPS).

### **Cloud Service Delivery across Multiple Cloud Platforms (SCC2011-3099)**

*Ines Houidi, Marouen Mechtri, Wajdi Louati, Djamel Zeghlache (TELECOM SudParis, France)*

The paper presents work-in-progress on the cloud service provisioning across multiple cloud providers. The work assumes the emergence of Cloud Brokers between customers and cloud providers. The brokers split user requests and ensure provisioning from multiple providers. An exact splitting algorithm is developed to efficiently split the cloud requests among the multiple cloud platforms with the aim of decreasing the cost for customers.

### **An Ontology based Service Creation Process (SCC2011-3100)**

*BudanWu, Junliang Chen (Peking University, China)*

This paper proposes an ontology-based service creation process framework to apply ontology really for software service development. An ontology system that facilitates reuse in service creation process was designed, a four-phase service creation process was proposed, and a shipping case was carried out on our service creation tool to show the increasing service reuse rate under the ontology based service creation process framework

### **MyDeepWeb: An Integration Service for your OWN Deep Web Data (SCC2011-3101)**

*SherifSakr, Anna Liu (University of New South Wales, Australia)*

Most of the major Internet services provide standard APIs that allow developing software applications that can read and write data from their underlying data store after providing the credential access information of registered accounts. The MyDeepWeb system is designed to let the Web users interact with their Internet services normally while, behind the scene, the information of their objects will be extracted, consolidated, linked and then populated into a single private cloud-based data store where the user can have integrated access to their data objects from anywhere through multiple devices.

## **Work-in-Progress Track 3 – Services Coordination**

**Session Chair:** Zhe Shan, Penn State University, USA

### **A Model-Driven BPM Approach for SOA Mediation Information System Design in a Collaborative Context (SCC2011-3102)**

*Wenxin Mu, Frédéric Bénaben, Hervé Pingaud, Nicolas Boissel-Dallier, Jean-Pierre Lorré (Université de Toulouse, Mines ALBI; EBM WebSourcing – Petals link, France)*

In a collaborative situation, involving several partners, a BPM approach may be useful to support the design of a Mediation Information System (MIS), in charge of ensuring interoperability between partners' IS. For such an objective, there are two main barriers: building collaborative business process cartography, and fill the deep semantic gap between business activities and technical web-services. This article aims at presenting state of the art, results and current works.

### **Towards a Flexible Event-driven SOA based Approach for Collaborating Interactive Business Processes (SCC2011-3103)**

*Da Zhu, Yang Zhang, Bo Cheng, Junliang Chen (Beijing University of Posts & Telecommunications, China)*

This paper proposes Event-driven SOA as an extension of SOA for business process collaboration in Internet of Things (IoT). Compared with traditional SOA based service collaboration method, this approach will facilitate real-time event processing as well as decentralized and autonomous service coordination. We illustrate the collaboration process under the proposed architecture by applying it to a smart surgical management scenario.

### **Integration of Business and Manufacturing Processes through Industrial Machinery as a Service Approach (SCC2011-3104)**

*VirgilioGilart-Iglesias, Francisco Maciá-Pérez, Diego Marcos-Jorquera, Francisco J. Mora-Jimeno, Juan A. Gil-Martínez-Abarca (University of Alicante, Spain)*

In manufacturing organizations it is difficult to reach the requirements of new business models due to technological and conceptual constraints between elements located at different levels of the organization, which prevents the integration of business and manufacturing processes. In this paper, a new industrial machinery model is proposed, named IMaaS, showing the industrial machinery as a set of business processes, removing the conceptual constraints, and exposed as services.

### **Policy Driven Services Coordination for Building Social Networks based Applications (SCC2011-3105)**

*Javier A. Espinosa-Oviedo, Genoveva Vargas-Solary, José Luis Zechinelli-Martínez, Christine Collet (Fundación Universidad de las Américas Puebla, Mexico; Grenoble Informatics Laboratory; Grenoble Institute of Technology, France)*

We present an approach for observing and reacting on the execution of services coordinations to ensure NFP's policies specified by the coordination designer. For example, update the status of all user Facebook, Twitter and Yahoo accounts or maintain the current. It is possible to associate a personalized behaviour: atomic integration of information retrieved from different social network services, automatic generation of an integrated view of the operations executed in different social networks.

### **Decentralized Service Management based on Homophily for Self-Adaptive SOMAS (SCC2011-3106)**

*E. del Val, M. Rebollo, V. Botti (Universitat Politècnica de València, Spain)*

Humans create social structures in a self-organized way based on a feature called homophily. This paper proposes the use of homophily in Service-Oriented Multiagent Systems to create efficient self-organized structures and provide a decentralized service management.

### **SPARQL-to-SQL Query Translation: Bottom-Up or Top-Down? (SCC2011-3107)**

*AndreyKashlev, Artem Chebotko (University of Texas - Pan American, USA)*

While it can be expected that relational query optimizers produce identical query execution plans for semantically equivalent bottom-up and top-down queries, is this usually the case in practice? To address this question, we study bottom-up and top-down translations of SPARQL queries with complex nested optional graph patterns that yield SQL queries with left outer joins whose reordering is not always possible. This paper reports our on-going research and performance study.

## **Work-in-Progress Track 4 – Services QoS**

**Session Chair:** Artem Chebotko, University of Texas - Pan American, USA

### **Policy Consolidation and Privacy-vital Information Flow Control in Composite Services (SCC2011-3108)**

*Yang Zhang, Jun-Liang Chen (Beijing University of Posts & Telecommunications, China)*

Although many privacy-aware models and methods were proposed, the protection technology of privacy is underway. This paper aims at addressing privacy-aware access control in composite services. We introduce an automaton-based monitoring solution for privacy-vital information flow for a single execution of a composite service. In addition, this paper also gives a policy consolidation algorithm based on orchestration structures and attribute composition, which can also be used to ine privacy policies.

### **Multi Domain-Specific Modeling of the Security Concerns of Service-Oriented Architectures (SCC2011-3109)**

*Juan Pedro Silva Gallino, Miguel de Miguel, Javier F. Briones, Alejandro Alonso (Universidad Polit'ecnica de Madrid (UPM), Spain)*

Model-driven development methodologies provide inherent benefits such as increased productivity, greater reuse, and better maintainability, etc. Efforts on achieving model-driven development of SOAs already exist, but there is currently no standard solution that addresses nonfunctional aspects of these services as well. This paper presents an approach to integrate these non-functional aspects in the development of web services, with an emphasis on security.

### **On the Performance of Hosting Mobile Web Services on Mobile Devices (SCC2011-3110)**

*Rabeb Mizoui, M.Adel Serhani, Rachida dssouli, Abdelghani Benharref, Ikbal Taleb (Concordia University, Canada; Khalifa University; UAE University; Abu Dhabi University; UAE)*

Mobile web services are barely tested and the potential of utilizing them in real-life settings is not known yet. In this paper, we present an architecture to test web services hosted on mobile devices as well as some preliminary results. We target to evaluate the QoS of these web services such as their response time, availability, throughput, and scalability and to evaluate the overall performance of mobile device host with main focus on the battery consumption.

### **SlapOS: A Multi-purpose Distributed Cloud Operating System Based on an ERP Billing Model (SCC2011-3111)**

*Christophe Cérin, Jean-Paul Smets, RomainPourteaud (Universit'é de Paris 13; Nexedi SA, France)*

SlapOS is an open source grid operating system for distributed cloud computing, combining grid computing and Enterprise Resource Modeling (ERP) to provide IaaS, PaaS, and SaaS through a simple, unified API. Thanks to its unified approach and modular architecture, SlapOS has been used as a research testbed to benchmark NoSQL databases and optimize process allocation over intercontinental Cloud. SlapOS opens new perspectives for research in the area of resilience and security on the Cloud.

### **Towards Financial Planning as a Service (SCC2011-3112)**

*Jochen Martin, Simon Caton, Tobias Conte, ChristofWeinhardt (Research Center for Information Technology; Karlsruhe Service Research Institute, Germany)*

The financial crisis has recalled the importance of proper financial planning. Companies which are organized as a multitude of legal entities are in particular affected by planning irregularities. To optimize the financial planning process and to cope with the challenges, we propose our service model "Financial Planning as a Service" (FiPlaaS). This approach allows companies to redesign their planning processes according to SOA principles and to achieve substantial improvements in performance.

# **2011 IEEE Seventh World Congress on Services (SERVICES2011)**

## **Research Papers**

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### **SERVICES Research Session 1 – Services Negotiation and Composition**

**Session Chair:** Ming Luo, IBM, USA

#### **Negotiation towards Service Level Agreements: A Life Cycle based Approach (SERVICES2011-4001)**

*Sajid Ibrahim Hashmi, Rafiqul Haque, Eric Schmieders, Ita Richardson (University of Limerick, Ireland; University of Duisburg, Germany)*

In this research, we propose a stakeholder negotiation strategy for Service Level Agreements, which is based on prioritizing stakeholder concerns based on their frequency at each phase of the SBS development life cycle. We make use of a Collaxa BPEL Orchestration Server Loan service example to demonstrate the applicability of the proposed approach. In addition, we simulate the negotiation priority values to predict their potential impact on the cost of the SLA negotiation.

#### **Social Web Mashups Full Completion via Frequent Sequence Mining (SERVICES2011-4002)**

*Abderrahmane Maaradji, Hakim Hacid, Athena Vakali, Ryan Skraba (Alcatel Lucent Bell Labs, France, Aristotle University)*

In this paper we address the problem of Web Mashups full completion which consists of predicting the most suitable set of (combined) services that successfully meet the goals of an end-user Mashup, given the current service (or composition of services) initially supplied. We model full completion as a frequent sequence mining problem and we show how existing algorithms can be applied in this context. To overcome efficiency and recommendation granularity, we propose FESMA, an algorithm for computing frequent sequences of services and recommending completions.

## Applications and Industry Track Papers

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### SERVICES Applications and Industry Session 1 – Services Modeling

Session Chair: Cu D. Nguyen, Fondazione Bruno Kessler, Italy

#### **A Practical Architecture of Cloudification of Legacy Applications (SERVICES2011-4003)**

*Dunhui Yu, Jian Wang, Bo Hu, Jianxiao Liu, Xiuwei Zhang, Keqing He, Liang-Jie Zhang (Wuhan University; Kingdee International Software Group CO., Ltd, China)*

Based on RGPS meta-model framework and International standards-ISO/IEC 19763, an architecture for cloudification of legacy applications is proposed, which consists of three parts: a Web portal, a SaaS service supermarket, and a SaaS application development platform. In this paper, we take an open-source software as an example to illustrate the proposed approach. We develop a prototype CloudCRM to demonstrate the basic procedure for cloudification of legacy applications and the feasibility of the proposed approach.

#### **Management Model Proposal for Portuguese Public Administration Shared Services**

(SERVICES2011-4004)

*Luisa Domingues, José António Cordeiro Gomes (ISCTE-IUL / ISTA / ADETTI-IULA, Portugal)*

The appeal of this research is to find a solution able to support strategic management decisions preserving both the process control and the quality of the delivered services. Based on Yin's case study methodology and a matching process, the shared services analysis model (SSAM) has been developed. SSAM contributes with a formal analysis structure based in main pillars that sustain the shared services implementation in Portuguese public administration. The defined pillars will be used as analysis vectors to create a performance model able to evaluate shared services implementation and to anticipate future actions.

#### **Radar Management Model and Its Application in Enterprise Transformation and Upgrading**

(SERVICES2011-4005)

*Liang-Jie Zhang, Sheng-Ping Wu, Xiang Gao, Yu-Hui Liu, Ming-Yu Chen (Kingdee International Software Group CO., Ltd; Hohai University, China)*

Enterprise management is facing greater challenge of transformation and upgrading. Based on three years of studies of thousands of enterprises in 12 industries, the article puts forward Radar Management Model (RMM) and Enterprise Management Maturity Model (E3M) from the perspective of system engineering, which provides systematic theory and engineering guidance for enterprise transformation and upgrading. Using the models, enterprises are able to diagnose the problems with their business and management, and identify their management maturity level, as well as priority and strategy of business improvement.

## Work-in-Progress Track Papers

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### SERVICES Work-in-Progress Session 1 – Services Management

Session Chair: Jiuyun Xu, China University of Petroleum, China

#### **Human Task Support in Service Composition (SERVICES2011-4006)**

*Lei Yang; Yu Dai; Bin Zhang (Northeastern University, China)*

This paper presents a composite service execution engine, which can support human tasks and improve their execution by an approach of human task scheduling. In the approach, the performance evaluation model is proposed, which can reflect the performance of the human service resources objectively and comprehensively. Based on this model, the initial scheduling as well as re-scheduling methods for solving the problem is proposed to find the human service resource with better performance.

#### **SLICEE: A Service Oriented Middleware for Intensive Scientific Computation (SERVICES2011-4007)**

*Jonathan Piat, François Moreews, Olivier Collin, Dominique Lavenier, Alexandre Cornu (Alexandre Cornu Symbiose team INRIA Rennes, France)*

Bioinformatics applications are often structured as workflows composing a set of operations to perform on large data sets. SLICEE (Service Layer for Intensive Computation Execution Environment) abstracts scheduler cluster calls by handling command submission and data management. A workflow client orchestrates SLICEE services exploiting data parallelism, and deal with data routing between tasks. A storage management layer optimizes data transfers with a reference passing mechanism.

#### **Improving Organizational Password Policy Compliance via Open Source Tools (SERVICES2011-4008)**

*Christopher M. Frenz (Mercy College, USA)*

This study demonstrated two open source applications that can readily be customized and used by organizations to improve compliance with password policies and to ensure the quality of passwords within organizations. The tools address both ends of the password spectrum, in that one tool consists of CGI server code used to generate secure random passwords, while the other tool exemplifies techniques.

## SERVICES Cup

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**Session Chair:** Yuhong Yan, Concordia University, Canada

### **CEclipse an Online IDE for Programing in the Cloud (SERVICES2011-4009)**

*Ling Wu, Guangtai Liang, Shi Kui, Qianxiang Wang (Peking University, China)*

Although online IDE can bring developers a lot of convenience for their developing process, some tough problems are still less touched. This paper summarized three main kinds of actual problems from three aspects (Function implementation, Security guarantee, Advanced utilization) encountered when using the online IDE, and proposed three solutions (Services composition, Program behavior analysis, Program behavior mining) to handle these according problems. Finally, this paper introduce a real online IDE (CEclipse).

### **SSC4Cloud Tooling: An Integrated Environment for the Development of Business Processes with Security Requirements in the Cloud (SERVICES2011-4010)**

*Fernando Antonio Aires Lins, Robson Wagner Albuquerque de Medeiros, Bruno Leonardo Barros Silva, André Ricardo da Silva Souza, David Levy Lucena Alves Aragão, Julio Cesar Damasceno, Paulo Romero Martins Maciel, Nelson Souto Rosa, Bryan Stephenson, Jun Li (Federal University of Pernambuco,;University of Pernambuco, Brazil; HP Labs, USA)*

Despite the increasing need for specifying security mechanisms in web service compositions in the Cloud, this topic remains a challenge. This work presents an environment to collaboratively model business processes considering security requirements and to automatically deploy them in the Cloud with security requirements enforcement. The business process is realized through the utilization of web service composition. This environment consists of a set of tools to support the business process modeling and secure service composition execution in the Cloud. The proposed approach is showcased in a Virtual Travel Agency scenario.

### **A Model-Driven Approach for Monitoring ebBP Business Transactions (SERVICES2011-4011)**

*Simon Harrer, Andreas Schönberger, Guido Wirtz (University of Bamberg, Germany)*

EbXML BPSS (ebBP) is well-suited to specify B2B interactions as choreographies of so-called BusinessTransactions. Our approach streamlines the monitoring of ebBP BusinessTransactions leveraging model-driven engineering. First, hierarchical communicating automata are used to formalize BusinessTransactions. Second, WS-BPEL implementations of these automata are derived such that monitoring events are propagated to a monitoring. Third, the monitoring service translates the monitoring events into choreography progress by visually highlighting the active and visited states within the hierarchical automata.

## Ph.D. Symposium

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**Session Chair:** Zhihong Mao, University of Pittsburgh, USA

### **Optimizing the Distribution of Software Services in Infrastructure Clouds (SERVICES2011-4012)**

*Ulrich Lampe (Technische Universität Darmstadt, Germany)*

IaaS in the form of virtual machines provides limited supplies of virtual resources, due to restrictions of the underlying physical hardware. At the same time, the execution of SaaS instances leads to a specific demand for these resources. Based on this observation, I introduce the Software Service Distribution Problem, i.e., the challenge of (cost-)efficiently distributing the execution of software service instances across available cloud infrastructure providers and virtual machine types under resource constraints.

### **Autonomic Business-Driven Decision Making for Adaptation of Web Service Compositions (SERVICES2011-4013)**

*Qinghua Lu (University of New South Wales; Australia)*

Runtime adaptation of Web service compositions can usually be done in several ways, so it is necessary to decide which adaptation approach to take. This research provides a novel decision making approach, new management algorithms, and a middleware architecture for runtime adaptation of Web service compositions in ways that maximize business value, satisfying all given constraints.

### **Web Services Open Test Suites (SERVICES2011-4014)**

*Nabil El Ioini (Free University of Bolzano, Italy)*

In our effort to improve WS testing infrastructures, we propose a framework for service integrators to collaborate during Web Services testing by making test suites open to the public and share testing results.

## Cloud Computing Industry Summit

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**Session Chair:** Shigeru Hosono, NEC Corporation, Japan

### **SOA Service Design and Governance: Experience at Credit Suisse (SERVICES2011-4015)**

*Beat Liver, Keith Tice (Credit Suisse Information Technology, Switzerland)*

This paper briefly outlines how the Enterprise Integration Architecture governs the service landscape and continuously develops the Service-Oriented Architecture and its supporting middleware and tools. A brief summary of the current state of SOA at Credit Suisse is provided, which includes examples illustrating the necessity of strong and continuous governance and which sketches out some key topics for further development.

### **Architecture Design and Assessment with Design Matrix (SERVICES2011-4016)**

*Min Min, Koji Kimita, Fumiya Akasaka, Yoshiki Shimomura, Tatsunori Hara, Tamio Arai (NEC Service Platforms Research Laboratories, China; Tokyo Metropolitan University; The University of Tokyo, Japan)*

Practices of developing applications based on SOA principles need to be renovated to meet new requirements for large-scale data processing and to adapt advancements in IT infrastructures in cloud computing. Resource planners will have a significant role. This paper presents architecture design methods, which reinforce designing and assessing architecture with an applied Design Structure Matrix (DSM). This approach can embrace development of business logics of applications and IT resources to run in the cloud.

## Plenary Poster

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### **Meaningful Service Classifications for Flexible Service Descriptions (SERVICES2011-4017)**

*Sudhir Agarwal, Martin Junghans (Karlsruhe Institute of Technology (KIT), Germany)*

We present a formal underpinning for Web service classes by viewing them as a set of services that fulfill a logical combination of constraints on functional and non-functional properties. A hierarchy of service classes is automatically derived by their formal definition and can be exploited for an efficient service retrieval. In addition, we show in this paper how service classes can be used (i) to create service descriptions and (ii) to create service requests.

### **Service Adaptation at Message Level (SERVICES2011-4018)**

*Jian-min Jiang; Shi Zhang; Ping Gong; Zhong Hong (Fujian Normal University, China)*

In SOA, adaptation techniques aim to automatically generate adapters. However, the generation of the adapter is a complicated task and requires extra knowledge to resolve all kinds of mismatches. We propose a novel model, called a protocol structure, which is used to model services and adapters and detect the mismatches among services. Once developers present interface mappings among services, adapters can be derived from the interface mappings.

### **A Model-Driven Governance Analysis Tool for SOA-based Systems (SERVICES2011-4019)**

*Dario Correal, Diana Cruz (Systems and Computing Engineering University of Los Andes, Colombia)*

Without an adequate control measure SOA could quickly lead to be unmanageable for IT administrators and architects. In this paper we propose a strategy based on Model-Driven Engineering (MDE) to provide support to architecture governance, allowing the definition of policies on SOA systems as well as the assessment of these policies within the solution architecture.

### **An Ontology-based Method for Rendering Execution Results of Dynamically Invoked Web Services (SERVICES2011-4020)**

*Chao-liang Zhong, Akihiko Matsuo, Jun Zhang, Zhu-long Wang, Hao Yu (Fujitsu Research and Development Center, China)*

An ontology-based method and a rendering engine are proposed. Domain ontology is utilized to annotate the types of inputs and outputs of a Web service. Templates are generated and stored according to each type described in the ontology. The rendering engine first finds out the type of the execution results, and then retrieves corresponding templates with the URL of the type.

### **A Deployment of Service Elements based on QoS (SERVICES2011-4021)**

*Soumia Kessal, Noémie Simoni (CNRS, France)*

To create and launch new services offerings rapidly and successfully, they must deploy their services in the adequate hosting environment. We propose in this paper “a Deployment of Service Elements based on QoS” to meet the Service Level Agreement (SLA) from the deployment phase. To do this, a QoS and service models are necessary to automate the mapping between the design and operation. A “Usage Profile” is defined for this deployment.

### **Reputation-based Web Service Selection for Composition (SERVICES2011-4022)**

*Srividya Kona Bansal, Ajay Bansal (Arizona State University; Georgetown University, USA)*

In this paper, we extend our Web service Composition framework to include selection and ranking of services based on their reputation score. With the increasing popularity of Web-based Social Networks like LinkedIn, Facebook, and Twitter, there is great potential in determining the reputation score of a particular service provider using Social Network Analysis. We present a technique to calculate a reputation score per service using centrality measure of Social Networks.

### **Developing a Conceptual Relationship between Web Service Supply Chain Entities (SERVICES2011-4023)**

*Krithika V, ArshinderKaur, Chandra Sekaran, C. Rajendran (IIT, India)*

The advent of enablers like SOA and development of web service applications has enabled online / dynamic service supply chain networks (SSCNs) formed by dynamic collaboration of many serving entities. It is important to study the relationship and dependency between each entity of web SSCNs. The dynamic service supply chains are mostly pure online services. We take a scenario based illustration of two such online service supply chains to show the feasibility of the concept.

## Workshops

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### SEASS Workshop

#### SEASS Session 1

**Session Chair:** Shiping Chen, CSIRO ICT Centre, Australia

#### **Selection of Service Adaptation Strategies based on Fuzzy Logic (SERVICES2011-4024)**

*Seyed Hossein Siadat, Barbara Pernici (Politecnico di Milano, Italy)*

Web Service adaptation and evolution is receiving huge interest in the SOA community due to dynamic and volatile web service environment. However, formulating QoS parameters and their relationship with adaptation behaviour of a service based system is a difficult task. In this paper, a Fuzzy Inference System (FIS) is adopted for capturing overall QoS and selecting adaptation strategies using fuzzy rules. In particular, hierarchical fuzzy systems were used to reduce the number of rules. Our approach is able to efficiently

select adaptation strategies with respect to QoS changes.

### **Externalizing the Autopoietic part of Software to Achieve Self-adaptability (SERVICES2011-4025)**

*Romina Torres, Herman Astudillo (Universidad Técnica Federico Santa María, Chile)*

The autopoietic/allopoietic duality has been proposed to address the fact that Software systems must look to their own survival besides their successful mission completion. This article describes a framework to add autopoietic capabilities to composite Software systems, by using an external self-organized market full of service providers willing to provide services for satisfying new requirements and recovering actions. The approach is exemplified when QoS agreement violation happens.

### **Towards Self-Organizing Service-Oriented Architectures (SERVICES2011-4026)**

*Walter Binder, Daniele Bonetta, Cesare Pautasso, Achille Peternier, Diego Milano, Heiko Schuldt, Nenad Stojni, Boi Faltings, Immanuel Trummer (University of Lugano (USI); University of Basel; Artificial Intelligence Laboratory, Switzerland)*

Currently, the development of service-oriented applications requires many manual tasks and prevailing infrastructure is often based on centralized components that are central points of failure and easily become bottlenecks. In this paper, we promote self-organizing SOA that considers self-organizing features for the whole life-cycle of a service-oriented application, from creation to execution, optimization, and monitoring.

## **WS-CS-Testing Workshop**

### **WS-CS-Testing Session 1**

**Session Chair:** Yuhong Yan, Concordia University, Canada

### **A Performance Comparison of Web Service Object (SERVICES2011-4027)**

*Tommi Aihkialo, Tuomas Paaso (VTT Technical Research Centre of Finland)*

The performance of web services depends to a great extent on the efficiency of data transfer and on a number of related factors, such as network's possible latency, the efficiency of the used data marshalling and unmarshalling scheme, and the resulting length of the chosen message wire format. Several object marshalling and unmarshalling schemes aimed for data transfer in the web service domain were tested. The chosen schemes relied on XML, JSON and other binary alternatives. The practical marshalling and unmarshalling performance was measured and calculated. The results were analysed.

### **Open Web Services Testing (SERVICES2011-4028)**

*Nabil El Ioini, Alberto Sillitti (Free University of Bolzano)*

Web services (WS) and SOA applications add a new level of abstraction to the existing stack of technologies and development methodologies, but also add new challenges such as testing. We propose a framework for service integrators to collaborate during Web Services testing by making test suites open to the public and share testing results.

### **A Measure Standard for Ontology-based Service Recommendation (SERVICES2011-4029)**

*Zhi Yang, Budan Wu, Junliang Chen (Beijing University of Posts & Telecommunications, China)*

How to recommend the suitable services according to personalized requirement becomes an urgent question. In this paper, membership function is analyzed and recommendation measure standard is proposed. With dynamic programming theory, an ontology-based approach of service recommendation is provided. Membership as measure index is used to divide high relative services, medium relative services and low relative services. Only high relative services are recommended to the user.

### **Using Traceability to Support SOA Impact Analysis (SERVICES2011-4030)**

*Mamoun A. Hirzalla, Andrea Zisman, Jane Cleland-Huang (DePaul University, USA; City University, UK)*

We present IntelliTrace, an intelligent traceability framework to support impact analysis across different modeling layers of a SOA-based system. The framework uses traceability links among different SOA artifacts to analyze the impact that changes in SOA-based systems can have in KPIs. The change impact analysis is triggered by different situations. A prototype tool has been implemented and an extensive case study built around an online airline reservation system is used to evaluate the framework.

## **SWF Workshop**

### **SWF Session 1**

**Session Chair:** Shiyong Lu, Wayne State University, USA

### **Analyzing Execution Dynamics of Scientific Workflows for Latency Minimization in Resource Sharing Environments (SERVICES2011-4031)**

*Yi Gu, Qishi Wu, Nageswara S.V. Rao (University of Memphis; Oak Ridge National Laboratory, USA)*

Many computation-intensive scientific applications feature complex workflows of distributed computing. We formulate workflow mapping as an optimization problem for latency minimization, whose difficulty essentially arises from the topological matching nature in the spatial domain, which is further compounded by the resource sharing complicity in the temporal dimension. We conduct a rigorous analysis of the resource sharing dynamics in workflow executions, which constitutes the base for a workflow mapping algorithm to minimize the end-to-end delay. The correctness and performance of the dynamics analysis is verified.

### **A Method to Mine Workflows from Provenance for Assisting Scientific Workflow Composition (SERVICES2011-4033)**

*Reng Zeng, Xudong He, W.M.P. van der Aalst (Florida International University, USA; Eindhoven University of Technology, The Netherlands)*

In many disciplines, individual workflows are large and complicated due to the large quantities of data used. As such, the workflow construction is difficult when relevant domain knowledge is missing or the workflows require collaboration within multiple domains. This paper presents a method based on provenance to mine models for scientific workflows, including data and control dependency. The mining result can either suggest part of others' workflows for consideration, or make familiar part of workflow easily accessible.

### **On Performance Modeling and Prediction in Support of Scientific Workflow Optimization** (SERVICES2011-4032)

*Qishi Wu, Vivek V. Datla (University of Memphis Memphis, USA)*

The computing modules in distributed scientific workflows must be mapped to computer nodes in shared network environments for optimal workflow performance. Finding a good workflow mapping scheme depends on an accurate prediction of the execution time of each individual computational module. We investigate the problem of modeling scientific computations and predicting their execution time based on a combination of hardware/software properties. We employ statistical learning techniques.

## **SWF Session 2**

**Session Chair:** Shiyong Lu, Wayne State University, USA

### **Scientist-Centered Workflow Abstractions via Generic Actors, Workflow Templates, and Context Awareness for Groundwater Modeling and Analysis** (SERVICES2011-4034)

*George Chin Jr., Chandrika Sivaramakrishnan, Terence Critchlow, Karen Schuchardt, Anne H.H. Ngu (Penn State University, USA)*

Networking and Clouding computing systems should be modeled and analyzed as a composite service provisioning system to obtain thorough understanding about the user's perception of Cloud service performance. This research investigates application of SOA in network virtualization for composing network and Cloud services, and analyzes the achievable performance of composite network-Cloud service provisioning. This paper proposes a SOA-based network virtualization paradigm, describes a service-oriented framework for composing network and Cloud services, proposes a new approach to modeling service capabilities of composite network-Cloud service provisioning systems, and develops analysis techniques for performance.

### **Towards Composing Data Aware Systems Biology Workflows on Cloud Platforms: A MeDICi-based Approach** (SERVICES2011-4035)

*Ian Gorton, Yan Liu, Yin Jian, Anand Kulkarni, Adam Wynne (Pacific Northwest National Laboratory, USA)*

The synergy of client side workflow tools with cloud platforms is a promising approach to share and reuse data and workflows. In such systems, the location of data and computation is essential consideration in terms of QoS for composing a scientific workflow across remote cloud platforms. In this paper, we describe a cloud-based workflow for genome annotation processing that is underpinned by MeDICi – a middleware designed for data intensive scientific applications. An execution layer routes the workflow requests to the processing steps collocated with the data. We demonstrate our approach by composing two workflows.

### **Kernel Level Support for Workflow Patterns** (SERVICES2011-4036)

*Manish Kumar, Thomas J. Hacker, John A. Springer, Brandeis Marshall (Purdue University, USA)*

Today, scientific computing is highly data intensive and relies on workflows. A file system that includes native kernel functionalities to support workflow execution would address the issue of parallel processing as well as portability. Such a file system would improve scientific computing performance. This paper describes an approach we developed to add workflow functionality to the Linux kernel and native file system to help simplify the use of workflow management systems for scientific computing.

### **Approaches for Implementing Persistent Queues within Data-Intensive Scientific Workflows** (SERVICES2011-4037)

*Michael Agun, Shawn Bowers (Gonzaga University)*

For many data-intensive workflows the dataflow model often requires data buffering. Current systems largely perform buffering through in-memory. We describe an alternative framework that leverages external storage to implement buffers (which we refer to as persistent queues) within data-intensive scientific workflows. Our framework can easily be used with different underlying storage technologies. In addition, the use of persistent queues can provide detailed provenance information “for free” by capturing the input and output information of each workflow component during workflow execution.

## **SWF Short Paper Session 3**

**Session Chair:** Shiyong Lu, Wayne State University, USA

### **Supercomputing and Scientific Workflows Gaps and Requirements** (SERVICES2011-4038)

*Terence Critchlow, George Chin Jr. (Pacific Northwest National Laboratory, USA)*

Workflows have not yet made significant strides managing finegrain, concurrent tasks directly on supercomputing platforms. As scientific computing becomes an increasingly important discovery method and high performance computing environments become more complex, addressing this gap becomes critical. Using a simple use case as motivation, this paper describes the current barriers to using workflow engines in a supercomputing environment and outlines the new capabilities that must be provided.

### **A Physical and Virtual Compute Cluster Resource Load Balancing Approach to Data-Parallel Scientific Workflow Scheduling** (SERVICES2011-4039)

*Jianwu Wang, Prakashan Korambath, Ilkay Altintas (San Diego Supercomputer Center, UCSD; UCLA, USA)*

To execute workflows on a compute cluster resource, workflow engines can work with cluster resource manager software to distribute jobs into compute nodes on the cluster. We discuss how to interact with traditional Oracle Grid Engine and recent Hadoop cluster resource managers using a dataflow-based scheduling approach to balance compute resource load for data-parallel workflow

execution. Our experiments show that Oracle Grid Engine outperforms Hadoop for CPU-intensive applications on smallscale clusters.

### **Towards a Cost Model for Scheduling Scientific Workflows Activities in Cloud Environments (SERVICES2011-4040)**

*Vitor Viana, Daniel de Oliveira, Marta Mattoso (Federal University, Brazil)*

Parallelizing a scientific workflow in the cloud environment is not trivial. One of the complex tasks is to define the number and types of virtual machines and to design the parallel execution strategy. Due to the number of options for configuring an environment it is a hard task to do it manually and it may produce negative impact on performance. This paper proposes a cost model based on concepts of QoS in clouds to help determining an adequate configuration of the environment according to restrictions imposed by scientists.

### **A UNICORE Plugin for HPC-enabled Scientific Workflows in Taverna 2.2 (SERVICES2011-4041)**

*Sonja Holl, Olav Zimmermann, Martin Hofmann-Apitius (Forschungszentrum Juelich Juelich; Fraunhofer Institute for Algorithms and Scientific Computing (SCAI), Germany)*

We describe the development of a novel plugin for the Taverna workflow system, which provides transparent and secure access to HPC/grid resources via the UNICORE grid middleware, while maintaining the ease of use that has been the main reason for the success of scientific workflow systems. A use case from the bioinformatics domain demonstrates the potential of the UNICORE plugin for Taverna by creating a scientific workflow that executes the central parts in parallel on a cluster resource.

## **Management in Cloud Workshop**

### **Management in Cloud Session 1**

**Session Chair:** Liang-Jie (LJ) Zhang, Kingdee International Software Group CO., Ltd, China

### **A Survey of Cloud Storage Facilities (SERVICES2011-4042)**

*Hrishikesh Dewan, R. C. Hansdah (SIEMENS, Indian Institute of Science, India)*

Cloud computing provides computing requirements for applications involving very large data sets which cannot possibly be handled efficiently using traditional computing infrastructure. In this paper, we describe storage services provided by three well known cloud service providers and give a comparison of their features with a view to characterize storage requirements of very large data sets as examples. We also review other kinds of storage that have come up in the recent past for cloud computing.

### **Sticky Session Support in Auto Scaling IaaS Systems (SERVICES2011-4043)**

*Michele Stecca, Luca Buzzucco, Massimo Maresca (University of Padua, Italy)*

We analyze the issues related to the management of sessions in Web Applications running on Auto Scaling IaaS systems. We focus on the effect of scaling operations (i.e., dynamic addition/removal of virtual machines) on the Sticky Session paradigm provided by Web Servers. We propose two different solutions, namely Session Monitoring and Session Migration, and describe the implementation of the former in the Open Source Eucalyptus IaaS system.

### **ECB: Enterprise Cloud Bus based on WS-Notification and Cloud Queue Model (SERVICES2011-4044)**

*Pingli Gu, Yanlei Shang, Junliang Chen, Miaoting Deng, Bojia Lin, Changbao Li (Beijing University of Posts & Telecommunications, China)*

ESB would not be able to deal with the exchange of data among multiple ESBs. In this paper, we propose an Enterprise Cloud Bus (ECB) framework that combines the WS-Notification with cloud computing. We design and implement the Subscribe Request Queue cloud service model that supports real-time communication among distributed ESBs, and supports running non-Service components or composition services deployed on distributed ESB or in different business process.

### **Management in Cloud Session 2**

**Session Chair:** Min Luo, IBM, USA

### **VirtualRank: A Prediction Based Load Balancing Technique in Virtual Computing Environment (SERVICES2011-4045)**

*Qingyi Gao, Peng Tang, Ting Deng, Tianyu Wo (Beihang University, China)*

We present VirtualRank, a load balancing technique that determines when and where to migrate virtual machines. VirtualRank predicts load tendency in the upcoming time slots. After triggering migration, the technique selects the potential migration target applying the Markov stochastic process. Finally the weighted probability method is applied to confirm the final migration target. We implement our techniques in virtual computing environment iVic and conduct a detailed evaluation.

### **Local and Global Optimization of MapReduce Program Model (SERVICES2011-4046)**

*Congchong Liu, Shujia Zhou (University of Maryland, USA)*

This paper proposes a solution to optimize the MapReduce program model and demonstrate it with X10. We develop an adaptive load distribution scheme to balance the load on each node and consequently reduce across-node communication cost occurring in the Reduce function. We exploit shared-memory in each node to further reduce the communication cost with multi-core programming.

### **Management in Cloud Session 3**

**Session Chair:** Stephen S. Yau, Arizona State University, USA

### **A Framework for Cloud Embedded Web Services Utilized by Cloud Applications (SERVICES2011-**

4047)

*Mohamed Wahib, Asim Munawar, Masaharu Munetomo, Kiyoshi Akama (Hokkaido University, Japan)*

We anticipate there will be an opportunity for designing and implementing applications/services to be embedded in the cloud for use by applications in the cloud. We propose a framework for WS deployment in the cloud to be usable by applications residing in the same cloud. The authoritative nature of clouds would enable more efficient models for WS publishing, indexing and description. In this paper, we highlight the challenges and opportunities, different aspects, together with an end-to-end use case.

### **Cloud-based Event-processing Architecture for Opinion Mining (SERVICES2011-4048)**

*Stella Gatzju Grivas, Marc Schaaf, Michael Kaschewsky, Guillaume Bouchard (University of applied Sciences NWSwitzerland; Bern University of Applied Sciences, Switzerland; Xerox Research Center Europe Grenoble, France)*

We show how a smart distributed architecture enables an efficient and scalable design for opinion mining on internet-based content that answers key challenges such as integrating heterogeneous data sources and adapting to events through dynamic system configuration. We present a novel approach of semantic complex event processing in a novel approach of semantic complex event processing in a cloud environment capturing different levels of information, such as event data as well as associations.

### **Adaptive Fault Tolerance in Real Time Cloud Computing (SERVICES2011-4049)**

*Sheheryar Malik, Fabrice Huet (Research Team OASIS, France)*

A fault tolerance model for real time cloud computing is proposed. The reliability of the virtual machines is adaptive. A metric model is given for the reliability assessment. The proposed technique is based on the execution of design diverse variants on multiple virtual machines, and assigning reliability to the results produced by variants. The system focuses on forward recovery.

## **Services Composition Workshop**

### **Services Composition Session 1**

**Session Chair:** Patrick Hung, University of Ontario Institute of Technology, Canada

### **Simplifying Web Service Discovery & Validating Service Composition (SERVICES2011-4050)**

*Shrabani Mallick, Rajender Pandey, Sanjeev Neupane, Shakti Mishra, D.S. Kushwaha (Motilal Nehru National Institute of Technology, India)*

In this paper, we address Web service composition problem with the signature-based service discovery and composition approach. In the proposed approach, each web service is described by WSDL. Our design eliminates the need of complicated discovery agents like UDDI and also facilitates validation of the service before actually accessing it for integration. The composition problem has been modelled as a finite state machine. We propose a simple yet efficient algorithm DISCOMP for the discovery and composition.

### **Towards a Genetic Algorithm Approach to Automating Workflow Composition for Web Services with Transactional and QoS-Awareness (SERVICES2011-4051)**

*Yang Syu, Yong-Yi FanJiang, Jong-Yih Kuo, Shang-Pin Ma (Fu Jen Catholic University, Taiwan)*

This paper addresses the issue of automatic composing Web Services into an executable workflow not only according to user's functional requirements but also to their transactional properties and QoS characteristics. We propose an automatic composition approach through genetic algorithm. Experimental results are presented.

### **Facilitating Service Creation via Partial Specification and Automated Composition (SERVICES2011-4052)**

*Ramide Dantas, Ernani Azevedo, Cyrus Dias, Thiago Lima, Djamel Sadok, Carlos Kamienski, Börje Ohlman (Universidade Federal de Pernambuco Recife, Brazil; Ericsson AB Stockholm, Sweden)*

Proposals for complete or partial automation of service composition exist, the majority relying on artificial intelligence-based planning, automated proof techniques, or graph-based solutions. Although sound, these approaches present practical issues that prevent their use. This paper presents a composition tool that allows for partial service specification along with a composition algorithm based on the semantic matching of services inputs and outputs.

### **Services Composition Session 2**

**Session Chair:** Jia Zhang, Northern Illinois University, USA

### **A Functional-Scalable Architecture for Automatic Service Composition (SERVICES2011-4053)**

*Incheon Paik, Wuhui Chen, Ryohei Komiya (University of Aizu, Japan)*

Complete automatic service composition (ASC) system requests solving very large and complex realistic problems require consistent architecture. Most studies of service composition are based on four stages (planning, discovery, selection, and execution). However, they have not considered the functional scalability of ASC involving nested dynamic services. We present a blueprint for a modified four-stage composition architecture to allow for scalability in managing the nested composition flow.

### **Web API Creation for Enterprise Mashup (SERVICES2011-4054)**

*Masahiro Tanaka, Terunobu Kume, Akihiko Matsuo (Fujitsu Labs Ltd., Japan)*

In the case of the Mashup of enterprise web applications, or Enterprise Mashup, it is quite difficult since these applications are often not intended to be reusable and have no Web APIs. In this paper, we describe a light-weight Web API creation methodology to create Web APIs for enterprise web applications much more easily. We developed the implementation of our methodology and applied it to actual applications to evaluate its effectiveness.

## Services Discovery Workshop

### Services Discovery Session 1

Session Chair: Hong Cai, IBM, China

#### **An Extended WS-CDL Method for On-demand Web Service Selection (SERVICES2011-4055)**

*Liu Jianxiao, He Keqing, Wang Jian, Feng Zaiwen, Ning Da (Wuhan University, China)*

WS-CDL (Web Services Choreography Description Language) is a W3C candidate recommendation for the description of peer-to-peer collaborations for the participants in web services interaction. This paper extends WS-CDL from the aspect of goal that services to implement, and this can lay the foundation of on-demand service selection.

#### **A Genetic Algorithm based Approach to Service Identification (SERVICES2011-4056)**

*Ali Kazemi, Ali Rostampour, Pooyan Jamshidi, Eslam Nazemi, Fereidoon Shams, Ali Nasirzadeh Azizkandi (Shahid Beheshti University, Iran; Dublin City University, Ireland)*

Existing service identification approaches are often prescriptive and based on the architect's experience, therefore might lead to non-optimal designs. In this paper, an automated method for identifying business services has been proposed by adopting design metrics based on top-down decomposition of processes. This method takes a set of enterprise business processes as input and produces a set of non-dominated solutions representing appropriate business services using a multi-objective genetic algorithm.

#### **Taxonomy for Evolution of Service-based System (SERVICES2011-4057)**

*Zaiwen Feng, Keqing He, Rong Peng, Yutao Ma (Wuhan University, China)*

With the rapid development of service computing related technology, the number of application of service based system (SBS) in enterprise is increasing rapidly. In this paper, we propose a taxonomy framework for evolution of SBS, which is illustrated from five perspectives: why, who, where, when and how.

### Services Discovery Session 2

Session Chair: Zaiwen Feng, Wuhan University, China

#### **A Model for Dynamic Services Discovery over Largely Distributed Providers Based On Qos and Business Processes Contexts (SERVICES2011-4058)**

*Alexandre Perin de Souza, Ricardo J. Rabelo (Federal University, Brazil)*

This paper addresses the problem of BPM and SOA integration presenting a model of dynamic discovery of services as an approach to improve the agility of SOA-based applications. We offer comprehensive, integrated, open and standard-based environment which considers functional and non-functional requirements besides business processes' contexts.

#### **Semantic Annotation of Web Services with Lexicon-Based Alignment (SERVICES2011-4059)**

*Deniz cantürk, Pinar Senku I (METU, Turkey)*

Using ontology is the most common practice to specify domain knowledge. However, a problem is the lack of semantic annotation for currently available web services. In this work, we propose a web service semantic annotation method that uses lexicon-based alignment. Lexicon-based alignment considers the different senses of the words, hence can find association between the service and the ontology more accurately.

## Services Security & Privacy Workshop

### Services Security & Privacy Session 1

Session Chair: Zhixiong Chen, Mercy College, USA

#### **A Privacy Preserving Selective Authorization Enforcement Approach in DaaS (SERVICES2011-4060)**

*Xiuxia Tian, Xiaoling Wang, Aoying Zhou (Fudan University, China)*

Database as a Service (DaaS) is a practical and useful paradigm, in which the Database Service Provider (DSP) hosts the delegated database generated from the Source DB of Data Owner (DO). Due to the untrusted DSP, most of the proposed approaches were concentrated on using encryption to guarantee the privacy of delegated database and using partition based index to speed up the query. However, few papers were proposed to guarantee the privacy of delegated access control policies. In this paper, we present a privacy preserving selective authorization enforcement approach.

#### **The Evolution of Health Care IT: Are Current US Privacy Policies Ready for the Clouds? (SERVICES2011-4062)**

*Miguel Delgado (Mercy College, USA)*

The U.S. healthcare industry has been given a new mandate to expand the use of health information technology to provide better care and to help reduce costs. Equally, cloud computing is poised to become the fifth utility delivering economies of scale and cost benefits that are difficult for businesses to ignore. As the technology matures further and the healthcare industry embraces data and privacy governance programs, the chance for a successful health IT transformation with the use of the cloud significantly increase.

### Services Security & Privacy Session 2

Session Chair: Zhixiong Chen, Mercy College, USA

#### **Application of a Distributed Security Method to End-2-End Services Security in Independent**

## **Heterogeneous Cloud Computing Environment (SERVICES2011-4063)**

*Pankaj Goyal (icromega Inc.)*

Security of service usage in a heterogeneous independently-operated interoperable cloud computing environments (ICE), is a multi-faceted problem. This paper proposes a solution to the problem of trust and security of the interaction between the service requestor and service provider in an ICE, and presents its performance under various threat scenarios.

## **Enabling Data Hiding for Resource Sharing in Cloud Computing Environments based on DNA Sequences (SERVICES2011-4064)**

*Mohammad Reza Abbasy; Mahdi Sharifi; BharanidharanShanmugam; HomaMovahednejad (Universiti Teknologi Malaysia; Malaysia)*

This paper proposes an algorithm to implement data hiding in DNA sequences to increase the confidentiality and complexity by using software point of view in cloud computing environments. Based on binary coding and complementary pair rules, the algorithm selects DNA reference sequence with a secret data M hidden into it. As result of applying some steps, M' is come out to upload to cloud environments.

## **A New Paradigm to Approximate Oblivious Data Processing (ODP) for Data Confidentiality in Cloud Computing (SERVICES2011-4065)**

*Dhananjay S. Phatak, Alan T. Sherman, J. Pinkston (UMBC, USA)*

Maintaining the confidentiality of data sent to clouds is a vital issue that must be satisfactorily resolved as a pre-condition in order for the cloud computing paradigm to survive and thrive. In this paper we explore a completely new paradigm to approximately achieve the functionality implied by "Oblivious Data Processing (ODP)". Our strategy is to partition the data as well as the underlying Residue Number System (RNS) in the Residue Domain (RD) and then distribute and process the partitions independently.

## **Services Security & Privacy Session 3**

**Session Chair:** Zhixiong Chen, Mercy College, USA

## **Improving Web Service Security and Privacy (SERVICES2011-4066)**

*Xinfeng Ye, Lei Zhong (Auckland University, New Zealand)*

This paper proposes a scheme that allows the web service providers to carry out fine-grained access control on the data hosted by them. Through data tracking, the scheme also automatically detects the data flows that might lead to attacks on online services. Compared with existing schemes, the proposed scheme is more flexible in managing the data on the service provider. The scheme relieves the programmers from enforcing access control and detecting data flow violation in their applications.

## **Semantic Security Policy Matching in Service Oriented Architectures (SERVICES2011-4067)**

*Giuseppe Di Modica, Orazio Tomarchio (Universit' a di Catani, Italy)*

Cloud computing poses several new security and privacy challenges, mainly related to resource sharing, interoperability and dinamicity among different providers. In this work we propose a semantic approach that, by means of semantic annotations to WS-Policy documents, allows for an improved matching of security requirements and capabilities based on their actual meaning. The proposed approach has been validated through a case study.

## **ITGRC Workshop**

### **ITGRC Session 1**

## **IT Governance, Compliance and Auditing Curriculum "C A Pedagogical Perspective (SERVICES2011-4068)**

*Zhixiong Chen, Jong Yoon, Christopher M. Frenz, Kenneth Compres (Mercy College, USA)*

Designing sound IT governance, compliance and auditing curriculum is a rewarding as well as challenging task. In this paper, we share our experiences from teaching IT governance, compliance and auditing both in the undergraduate and graduate level and examine lessons learned. We also provide curriculum design strategy, student assessment and outcomes.

## **A Business Viewpoint for Integrated IT Governance, Risk and Compliance (SERVICES2011-4069)**

*Pedro Vicente, Miguel Mira da Silva (Universidade T'ecnica de Lisboa, Portugal)*

IT requirements, standards and best practices play a crucial role in IT organizations/departments. In this paper we propose a business architecture that describes the integration of the main processes for IT Governance, IT Risk Management and IT Compliance (IT GRC). Based on a process model for IT GRC and a conceptual model for GRC, we use ArchiMate to model the behavioural, structural and informational structure of the business viewpoint – business processes, roles and business objects.

## **IT Governance, Risk & Compliance (GRC) Status Quo and Integration (SERVICES2011-4070)**

*Nicolas Racz, Edgar Weippl, Riccardo Bonazzi (TU Vienna, Austria; University of Lausanne, Switzerland)*

The integration of governance, risk, and compliance (GRC) activities has gained importance over the last years. This paper presents an analysis of the GRC integration efforts in IT departments of three large enterprises. Action design research is used to organize the research to assess IT GRC activities based on a model with five dimensions. Five key findings explain the main commonalities and differences observed.

## **WSHA Workshop**

## WSHA Session 1

### Interoperability and Integration Considerations for a Process-Oriented Clinical Decision Support System (SERVICES2011-4071)

*Hemant Shah, Prakash Nadkarni, Patricia Williams, Ganesh Krishna, Arthur Vogler, Raymond David Allard (Henry Ford Health System Detroit, Yale University Medical School, USA)*

Electronic medical record systems (EMRs) can be made more attractive to the clinicians if Clinical Decision Support Systems (CDSS) are integrated with them. However, CDSS have to be developed with integration in mind. Web services-based integration has to allow two-way data exchange between the CDSS and the EMR. In the semantic data capture initiative (SDCI) project, we integrated Proteus, an open source, process-oriented clinical decision support system with Henry Ford Health System's EMR, CarePlus.

### Minimum Steiner Tree for Automatic SQL Query Generation Applied on a Medical Record Database (SERVICES2011-4072)

*Christofer E. Gillies, Nilesh Patel, Gautam B. Singh, Serge G. Kruk Eddie Cheng, George Wilson (Oakland University; William Beaumont Hospitals, USA)*

The size and complexity of medical record databases makes extracting information challenging. This paper presents a case study of our initial method of finding minimum Steiner trees in the Epic Clarity Reporting database to solve this problem. In addition, we present a web service architecture that can be used to extend our approach to multiple databases.

### A Web Enabled Health Information System for the Neonatal Intensive Care Unit (NICU) (SERVICES2011-4073)

*Saikat Roy, Debi Prosad Dogra, Sourya Bhattacharya, Biswanath Saha, Arun Kumar Majumda Jayanta Mukherjee, Bandana Majumdar, Arun Singh, Angshuman Paria, Suchandra Mukherjee, Sangeeta Das Bhattacharya, (IIT Kharagpur, India; IPGIMER and SSKM Hospital)*

Information Systems are needed for modernization of ICUs to deliver better health care services. This work proposes a secure web enabled system based on a multi-tier architecture for carrying out routine and special operations of Neonatal Intensive Care Unit (NICU). Based on SOA, the system facilitates decision support systems for a number of critical tasks of NICU. A prototype of the system has been installed.

## FM-S&C Workshop

### FM-S&C Session 1

#### Probabilistic Timed Model Checking for Atomic Web Service (SERVICES2011-4074)

*Honghao Gao, Huaikou Miao, Shengbo Chen, Jia Mei (Shanghai University; Shanghai Key Laboratory of Computer Software Evaluating&Testing, China)*

In this paper, we apply probabilistic timed model checking to model and verify the behaviors of atomic service by extending interface automata, and propose a technique to formally estimate software performance. Second, the probabilistic timed computation tree logic (PTCTL) formulae are used to express the reliability properties. Third, we present an internal interaction model, based on which we can dynamically pick out a highest reliable execution sequence for Web services composition. Finally, a case study is proposed.

#### Towards Functional Dynamic Reconfiguration for Service-Based Applications (SERVICES2011-4075)

*Ying Li, Xiaorong Zhang, YuYu Yin, Yuanlei Lu (Zhejiang University; Hangzhou Dianzi University, China)*

The approach tries to replace each faulty service firstly. If the attempts fail, it will construct regions for each faulty service and tries to replace the region. In order to ensure the correctness of dynamic reconfiguration, we use services-behavioral type to formally describe services and propose subtype rule services-behavioral type to judge the substitutability between services. A case study is given.

#### Formal Specification and Verification of Transactional Service Composition (SERVICES2011-4076)

*Iman Saleh, Gregory Kulczycki, M. Brian Blake (Virginia Polytechnic Institute and State University; University of Notre Dame, USA)*

Research in transactions planning has recognized the evolvement of Web Services as an industry standard to implement transactional business processes. We proposed a data modeling and contracting framework for Web services and in this paper we are exploring how our framework can help formally verify data integrity properties in an ad-hoc transaction.

### FM-S&C Session 2

#### Web Service Composition using Service Suggestions (SERVICES2011-4077)

*Rui Wang, Chaitanya Guttula, Maryam Panahiazar, Haseeb Yousaf, John A. Miller, Eileen T. Kraemer, Jessica C. Kissinger (University of Georgia, USA)*

This paper presents a semi-automatic Web service composition approach. This approach ranks all available candidate Web service operations based on semantic annotations and suggests service operations. The ranking scores are based on data mediation, functionality and formal service specifications. A formal graph model, an IODAG, is defined to formalize an input/output schema of a Web service operation. A typed representation for our data mediation approach, which formalizes the data mediation problem as a subtype-checking problem, is presented. An evaluation is performed.

#### Scaling-up Item-based Collaborative Filtering Recommendation Algorithm based on Hadoop (SERVICES2011-4078)

*Jing Jiang, Jie Lu, Guangquan Zhang, Guodong Long (University of Technology Sydney, Australia)*

Collaborative filtering (CF) techniques have achieved widespread success in E-commerce nowadays. In this paper, we developed and

implemented a scaling-up item-based collaborative filtering algorithm on MapReduce, by splitting the three most costly computations in the proposed algorithm into four Map-Reduce phases, each of which can be independently executed on different nodes in parallel. We also proposed efficient partition strategies not only to enable the parallel computation in each Map-Reduce phase but also to maximize data locality to minimize the communication cost.

## FoSeC Workshop

### FoSeC Session 1

#### **The IEEE International Workshop on the Future of Software Engineering for/in the Cloud (FoSEC 2011) (SERVICES2011-4079)**

*Rami Bahsoon, Ivan Mistrík, Subramanian Mohan, Nour Ali (The University of Birmingham; Infosys Technologies; Lero-The Irish Software Engineering Research Centre, Ireland)*

Though the fundamentals of engineering software in both paradigms exhibit resemblance, software engineering for the cloud require novel approaches, which address the interplay between technical, economics-driven considerations and shifts software engineering towards a utility-based engineering in cloud – for infrastructure-, data storage-, platform- and software- as a service.

#### **Satisfying Cloud Computing Requirements with Agile Service Networks (SERVICES2011-4080)**

*Damian A. Tamburri, Patricia Lago (VU University Amsterdam, The Netherlands)*

We argue that Agile Service Networks can be used as a paradigm for software engineering in the cloud, since they are indeed able to deliver solutions which are both compliant to the cloud's needs and able to harness it, bringing about its full potential. In this paper we identify requirements for the cloud, and show how these can be satisfied using Agile Service Networks.

#### **Software Engineering Challenges for Migration to the Service Cloud Paradigm - On-going Work in the REMICS Project (SERVICES2011-4081)**

*Parastoo Mohagheghi, Thor Sæther (SINTEF ICT Oslo; DI Systemer AS Trondheim, Norway)*

This paper presents on-going work in a research project on defining methodology and tools for model-driven migration of legacy applications to a service-oriented architecture with deployment in the cloud; i.e. the Service Cloud paradigm. We have performed a comprehensive state of the art analysis and present some findings here. In parallel, with two case studies, we present software engineering challenges in the context of one of the industrial cases in the project.

### FoSeC Session 2

#### **Transaction Level Economics of Cloud Applications (SERVICES2011-4082)**

*Kevin Buell, James Collofello (Arizona State University, USA)*

Since cloud computing operates on a pay-as-you-go model, application developers must understand the economics of their software in finer detail. They must understand how much their software costs to run and how much revenue they earn as their software runs. This understanding comes from knowing how the application uses infrastructure and services for which costs accumulate. We explore some fundamental concepts of cloud application economics at the transaction level.

#### **Modelling as a Service (MaaS): Minimizing the Environmental Impact of Computing Services (SERVICES2011-4083)**

*Colin Atkinson, Thomas Schulze, Sonja Klingert (University of Mannheim, Germany)*

Existing research projects have mainly focused on increasing the efficiency of cloud computing services at the relatively low platform and infrastructure levels of abstraction. In this paper we argue that to maximize the environmental benefits of cloud computing, both from the demand as well as the supply point of view. To this end, we introduce the vision of Modelling as a Service (MaaS) and explain how it provides an essential foundation for reducing the environmental impact of computing services.

#### **Cloud Computing Security - Trends and Research Directions (SERVICES2011-4084)**

*Shubhashis Sengupta, Vikrant Kaulgud, Vibhu Saujanya Sharma (Accenture Technology Labs, India)*

In this paper, we take a holistic view of cloud computing security - spanning across the possible issues and vulnerabilities connected with virtualization infrastructure; software platform; identity management and access control; data integrity; confidentiality and privacy; physical and process security aspects; and legal compliance in cloud. We present our findings from the points of view of a cloud service provider, cloud consumer, and third-party authorities such as Govt.

#### **Healing Web-based Services on Cloud Using Strategies (SERVICES2011-4085)**

*Markus Lachat, Yan Liu, Anna Liu (Hochschule Mannheim University of Applied Sciences, Germany; Pacific Northwest National Laboratory, USA; National ICT Australia Ltd., Australia)*

In this paper, we propose a middleware-based approach that encompasses a healing process that links available strategies to exceptions. Our solution is implemented as an embedded middleware called Exception Healing Manager (EHM). The EHM ensures non-intrusive service recovery and improves overall service response time.

## CloudPerf Workshop

### CloudPerf Session 1

#### **Formal Verification of SLA Transformations (SERVICES2011-4086)**

*Vatche Ishakian, Andrei Lapets, Azer Bestavros, Assaf Kfoury (Boston University, USA)*

The mapping between what constitutes desirable performance and SLAs is not unique: multiple SLA expressions might be

functionally equivalent. Having the flexibility to transform SLAs from one form to another in a manner would enable hosting solutions to achieve significant efficiencies. This paper demonstrates the promise of such an approach by proposing a type-theoretic framework for the representation and safe transformation of SLAs, mappings of periodic, real-time tasks to the physical and virtual hosts that constitute a hierarchical scheduler.

### **Modeling and Performance Analysis on Network Virtualization for Composite Network-Cloud Service Provisioning (SERVICES2011-4087)**

*Qiang Duan (Penn State University, USA)*

Networking and Clouding computing systems should be modeled and analyzed as a composite service provisioning system to obtain higher performance. Network virtualization is one of the latest developments in the networking area, which decouples networking services from network infrastructures. We investigate application of SOA in network virtualization for composing network and cloud services, and analyze the achievable performance of composite network-Cloud service provisioning.

### **Performance and QoS in Service-Based Systems (SERVICES2011-4088)**

*R. William Maule, William C. Lewis (Naval Postgraduate School, USA)*

We present a systematic method of measuring performance risk for specific implementations of an Enterprise SOA within a Cloud computing framework, in the context of a U.S. DOD application. Such architectures are essential for highly reliable and life critical Cloud applications. We provide baseline performance for an architecture comprised of service components from the service interfaces provided by several major commercial software vendors. Transition from legacy systems into SOA systems necessitates an infrastructure of federated components. This paper documents a means to measure such an infrastructure.

### **CloudPerf Session 2**

#### **A Threat Free Architecture for Privacy Assurance in Cloud Computing (SERVICES2011-4089)**

*Thamada Srinivasarao, Prasadreddy P.V.G.D, Saripalli Phani Venkat (Andhra University; Gitam University, India)*

Cloud Computing is a boon to IT industry that can help its clients to grow with minimal investment in technology. But users deter the adoption of cloud services with apprehensions on data leakage and loss of privacy if their sensitive data is processed in the cloud. The paper aims to provide maximum security and privacy to the data stored on cloud by using Double Authentication and Hybrid Obfuscation Technique with the use of a plug-in for the internet browser as an application software with multiple functionalities. The novelty of this method is to place data and keys separately on different clouds which have no direct communication between them by following the policy of 'Divide and Rule'.

#### **Balava: Federating Private and Public Clouds (SERVICES2011-4090)**

*Audun Nordal, Åge Kvalnes, Joseph Hurley, Dag Johansen (University of Tromsø, Norway)*

Balava is a new system for managing computations that span multiple clouds and involve data with confidentiality constraints. This paper describes the design, implementation and initial performance evaluation of Balava building-blocks. We detail the run-time developed to interconnect private and public clouds, and present a storage overlay built on top of this run-time. To support low-overhead execution of Balava computations, we are investigating alternative approaches to virtualization.

## **IEEE Cloud Forum for Practitioners (ICFP)**

### **ICFP Session 1**

**Session Chair:** Liqiang Wang, University of Wyoming, USA

#### **TrustCloud - A Framework for Accountability and Trust in Cloud Computing (SERVICES2011-4091)**

*Ryan K. L. Ko, Peter Jagadpramana, Miranda Mowbray, Siani Pearson, Markus Kirchberg, Qianhui Liang, Bu Sung Lee (HP Labs, Singapore)*

The key barrier to widespread uptake of cloud computing is the lack of trust in clouds, especially detective controls related to cloud accountability and auditability. The complexity resulting from large-scale virtualization and data distribution carried out in current clouds has revealed an urgent research agenda for cloud accountability. This paper discusses key issues and challenges in achieving a trusted cloud through the use of detective controls, and presents the trustCloud framework, which addresses accountability in cloud computing via technical and policy-based approaches.

#### **Cloud Computing Support for Collaboration and Communication in Enterprise-wide Workflow Processes (SERVICES2011-4092)**

*Jason S. Bolin, James Bret Michael, Man-Tak Shing (US Army Redstone Arsenal; Naval Postgraduate School, USA)*

This paper discusses the use of social media and cloud computing technologies to facilitate the collaboration and communication in enterprise-wide workflow processes, as a use case analysis of the US Army Test and Evaluation Command (ATEC) test program. The resulting optimizations to the monitoring, reporting, and control aspects will lead to situational awareness information being available to senior leadership with far fewer intermediary, human-in-the-loop steps.

#### **NIST Cloud Computing Reference Architecture (SERVICES2011-4093)**

*Robert B. Bohn, John Messina, Fang Liu, Jin, Tong, Jian Mao (NIST; Knowcean Consulting, Inc., USA)*

This paper presents the first version of the NIST Cloud Computing Reference Architecture (RA). This is a vendor-neutral conceptual model that concentrates on the role and interactions of the identified actors in the cloud computing sphere. A primary goal was to give the United States Government (USG) a method for understanding and communicating the components of a cloud computing system.

## ICFP Session 2

### **Leveraging the Cloud for Big Data Biometrics: Meeting the Performance Requirements of the Next Generation Biometric Systems (SERVICES2011-4094)**

*Edmund Kohlwey, Abel Sussman, Jason Trost, Amber Maurer (Booz Allen Hamilton, Inc., USA)*

This paper presents a prototype system for generalized searching of cloud-scale biometric data as well as an application of this system to the task of matching a collection of synthetic human iris images. First, we discuss growth trends in the biometric technology market. Next, we discuss the considerations that motivated our decisions. We then discuss the underlying open source components that we selected for the prototype, its API design, and the relationship between the API and the underlying architecture. We provide details of our implementation of human iris matching within our prototype framework.

### **Rapid 3D Seismic Source Inversion using Windows Azure and Amazon EC2 (SERVICES2011-4095)**

*Vedaprakash Subramanian, Hongyi Ma, Liqiang Wang, En-Jui Lee, Po Chen (University of Wyoming, USA)*

Cloud computing has been increasingly adopted by scientists for large-scale scientific computation, because it is elastic in the support of real-time computation and more powerful in the management of large-scale datasets. This paper presents our experience on designing and implementing seismic source inversion on both cluster (specifically, PI-based) and cloud computing (specifically, Amazon C2 and Microsoft Windows Azure).

## ICFP Session 3

### **An Approach to Enable Cloud Service Providers to Arrange IaaS, PaaS, and SaaS Using External Virtualization Infrastructures (SERVICES2011-4096)**

*Antonio Celesti, Francesco Tusa, Massimo Villari, Antonio Puliafito (University of Messina, Italy)*

Cloud computing ecosystem is more and more distributed and heterogeneous. Cloud service providers build services using cloud-based services offered by other service providers. This raises issues due to integration between services and provider themselves. In this paper, we propose a practice addressing such a concern in a “Vertical Supply Chain” scenario of distributed Clouds.

### **A Cloud Computing Application for Synchronized Disaster Response Operations (SERVICES2011-4097)**

*Shawn Kelly, Corey Mazyck, Karl Pfeiffer, Man-Tak Shing (Naval Postgraduate School, USA)*

During disaster response, key resources are supplied from a variety of channels. While these entities have efficient internal methods of communication and coordination, interorganizational collaboration has often been hindered by political, social, and technological challenges. This paper examines the challenges and proposes a technology-enabled self-synchronization framework for sharing information using a distributed, highly scalable, web application based on the cloud computing technologies.

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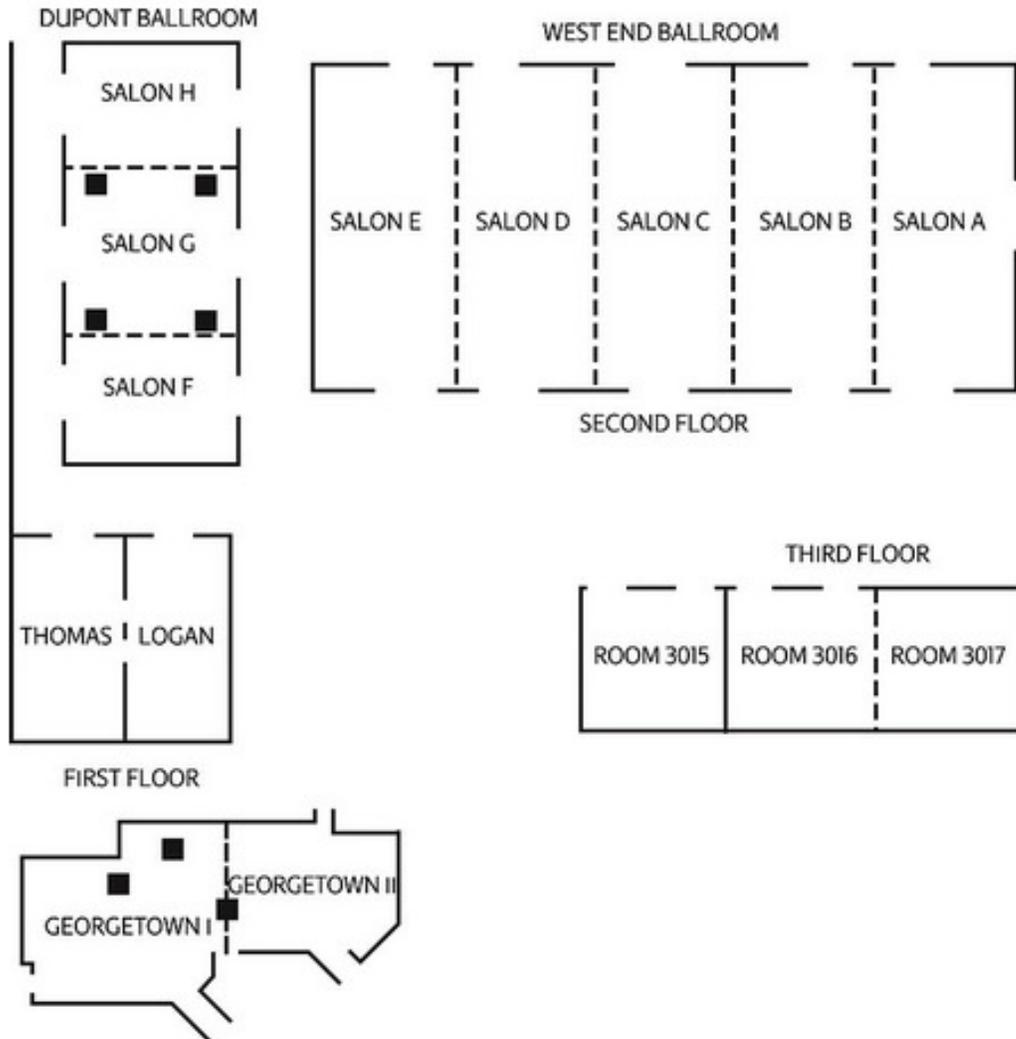
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