A Software Toolkit for Visualizing Enterprise Routing Design

Xin Sun, Jinliang Wei, Sanjay G. Rao
ECE, Purdue University
Geoffrey G. Xie
CS, Naval Postgraduate School
Enterprise Routing Is Complex

• Routing is one of the most complex elements of large-scale enterprise networks

• Configuration errors are not uncommon...
  – 80% of IT budget in enterprises is devoted to managing enterprise networks, yet ..
  – configuration errors account for 62% of network down time, and ..
  – enable 65% of cyber-attacks (Yanke Group, USITS 2003)

• Two problems in today’s network management
  – Focusing on one device at a time
  – Manually mining through the raw configuration files
Mitigating the Complexity: A Toolkit for Visualizing Routing Design

• Leverage a set of *abstractions*, which
  – Capture the network-wide routing behavior;
  – Preserve important policy information;
  – Abstract away irrelevant & low-level configuration details.

• The toolkit is fully automated
  – Input: raw router configuration files
  – Output: a graphical representation of the routing design

• Graphs are customized for scalability & readability
Talk Outline

• An abstraction-driven framework for formulating enterprise routing design

• Framework implementation & visualization

• Case study of two large-scale campus networks

• Conclusion
Talk Outline

• An abstraction-driven framework for formulating enterprise routing design

• Framework implementation & visualization

• Case study of two large-scale campus networks

• Conclusion
Routing Instances

• **Routing instance**: a set of inter-connected routers that run the same instance of a routing protocol. [1]

• From the definition, it is easy to see that by default:
  – Routers in the same routing instance share routes freely
  – Routers in different routing instances do not share routes.

Sub-instances

- A new abstraction we introduce to model routing policies inside a routing instance.
  - All prior work has treated a routing instance as an atomic unity, with no routing policy applied inside.
  - We found that route filters do exist inside a routing instance.
  - Such route filters effectively break a routing instance into multiple “sub-instance”, each having different routing info.

Filter RIP routes originated by D
Connecting Primitive

• **Connecting Primitive**: routing mechanisms that “glue” multiple routing instances together
  – E.g., route redistribution, BGP, Static and default routes
  – *Border routers*: where the connecting primitive is implemented.
Talk Outline

• An abstraction-driven framework for formulating enterprise routing design

• Framework implementation & visualization

• Case study of two large-scale campus networks

• Conclusion
Framework Reification and Implementation

- Parser for parsing raw router configuration files.
  - Currently understands the Cisco IOS syntax.

- Algorithms for identifying the framework elements
  - Based on algorithms proposed in previous works\cite{1}, \cite{2}
  - Able to handle route filters inside routing instances;
  - Able to identify routing sub-instances;

- Implemented in Perl for cross-platform compatibility

\begin{flushleft}

\end{flushleft}
Framework Visualization

• Use GraphViz as the underlying visualization engine
  – Commercial grade, open sourced, initially developed by AT&T.
  – General purpose, but offers many customization options
  – Available on all major platforms

• Additional heuristics that customize the graphs for better scalability & readability
Talk Outline

• An abstraction-driven framework for formulating enterprise routing design

• Framework implementation & visualization

• Case study of two large-scale campus networks

• Conclusion
Network Studied

• University-1: the campus network of a large US public university.
  – Tens of thousands of students, 1000+ switches,
    ~100 routers, 600+ subnets
  – Studied two longitudinal snapshots: 2008 & 2011

• University-2: another large US public university of comparable size.
Routing instance
Border routers
External AS-es
Route redistribution
iBGP peering
eBGP peering
Static route
default route
University-2

Routing instance
Border router
External AS

Route redistribution
iBGP peering
eBGP peering
Talk Outline

• An abstraction-driven framework for formulating enterprise routing design

• Framework implementation & visualization

• Case study of two large-scale campus networks

• Conclusion
It’s All about Sharing!

• We are currently preparing the initial release of the toolkit
  – Please drop us an email if you are interested in using the tool
    sun19@purdue.edu
  – More details can be found at the following webpage:
    http://cobweb.ecn.purdue.edu/~isl/rvtool

• We are looking for more network configuration data to study.
Conclusion

• We introduced a new abstraction termed *sub-instance*  
  – Preserves important policy information within routing instances.

• We built a software toolkit to visualize the network-wide routing design.  
  – Fully automated  
  – Available on all the major platforms

• We studied two large-scale in-production campus networks, and reported on our findings.