Automating Network Security Assessment

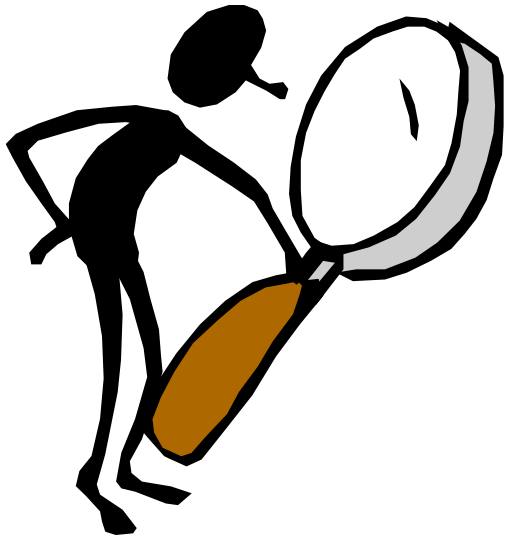
NW2011 BRKSEC-1065

What we will cover

- Traditional approach
- What's new: Automation
- Case study: Network modeling
  - Cisco's global infrastructure
- Case study: Defending critical assets
  - Isolating PKI
- Case study: Zone defense
  - Scrub down of border PoP's
- Case study: Automating Perimeter Assessment
  - Passive Penetration Testing the Global Enterprise
- Case study: Managing change day to day
  - The Carnac moment

Today's network security audits

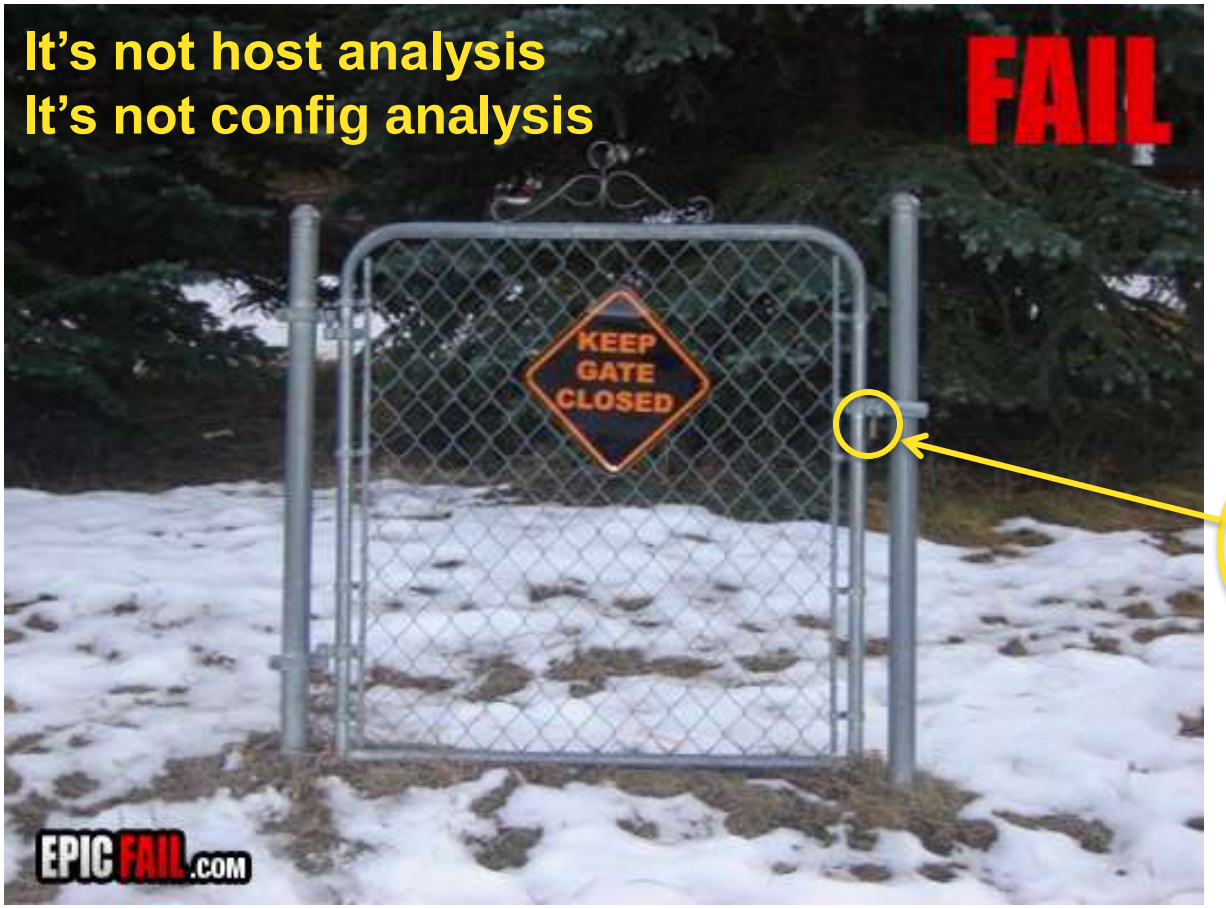
- Typically, network and hosts treated separately
- Network:
  - Elbow grease and eye strain
    - Gather configs; print configs; read configs
    - Similar to proof-reading the phone book
- Hosts:
  - Level 1: Leave the admins to patch
    - Problem: hope is not a strategy
  - Level 2: Scan for unpatched systems
    - Problem: more data than you can handle
  - Level 3: Drive cleanup based on risk
    - Problem: prioritization easier said than done



What needs to change

- Typical teams:
  - Host exploit gurus
    - Working without network or business context
  - A few network specialists
    - Critical “how’s & why’s” in the heads of a few gurus
- Audit treadmill
  - Like painting more bridges than you have crews
- Need to:
  - Finish each audit in less time
  - Increase accuracy
  - Capture the rules for next time
  - Integrate across specialties – put issues in context

Why network assessment is different

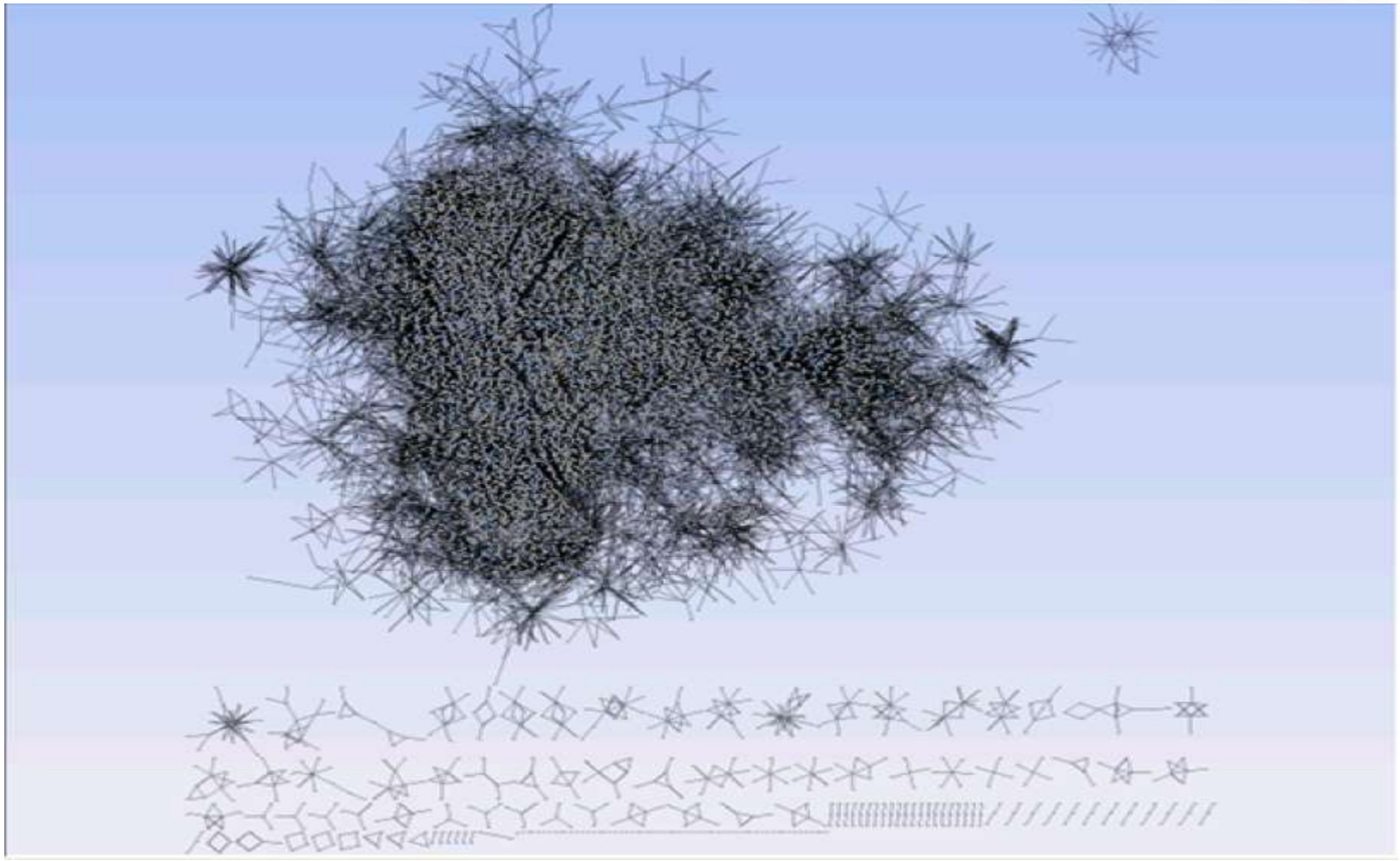


You can't detect a route around the firewall by reading the firewall

Case study: “Project Atlas”

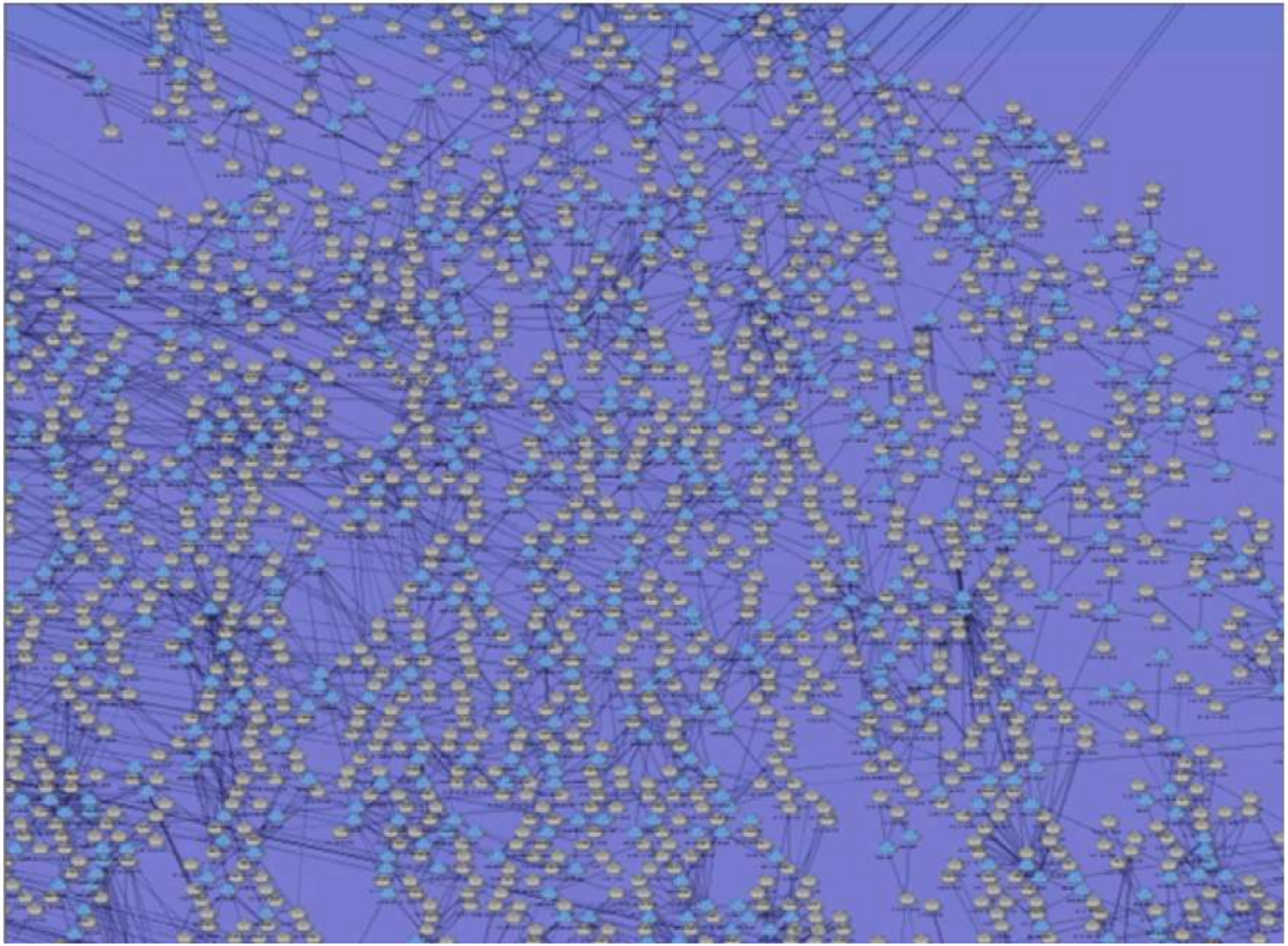
- Objective:
  - Map the entire global Cisco environment
  - Review major site interconnections
  - Audit access to sensitive locations
- Resources:
  - Installed Network Modeling software
  - Two weeks
  - 27,000 configuration files
  - Originally on ~$5K server (quad core, 32G RAM)
  - Now running on Cisco UCS – much faster!

Raw network (aka “The Bug Splat”)

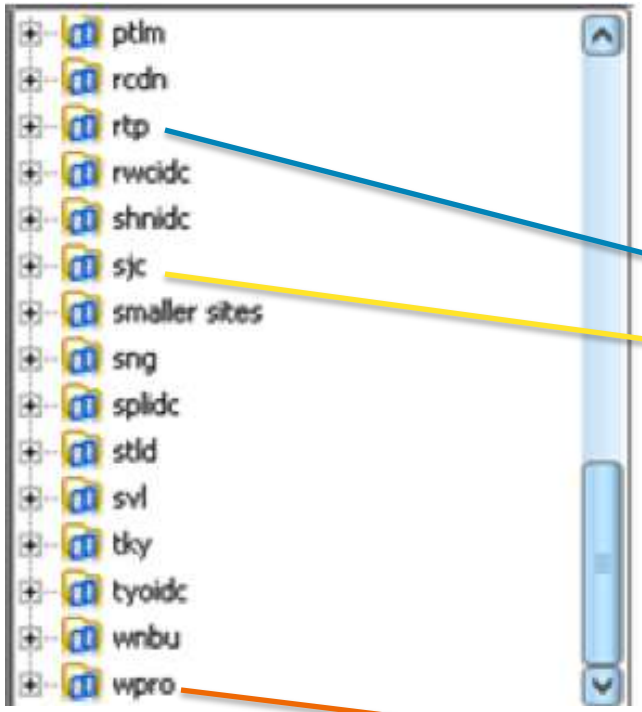


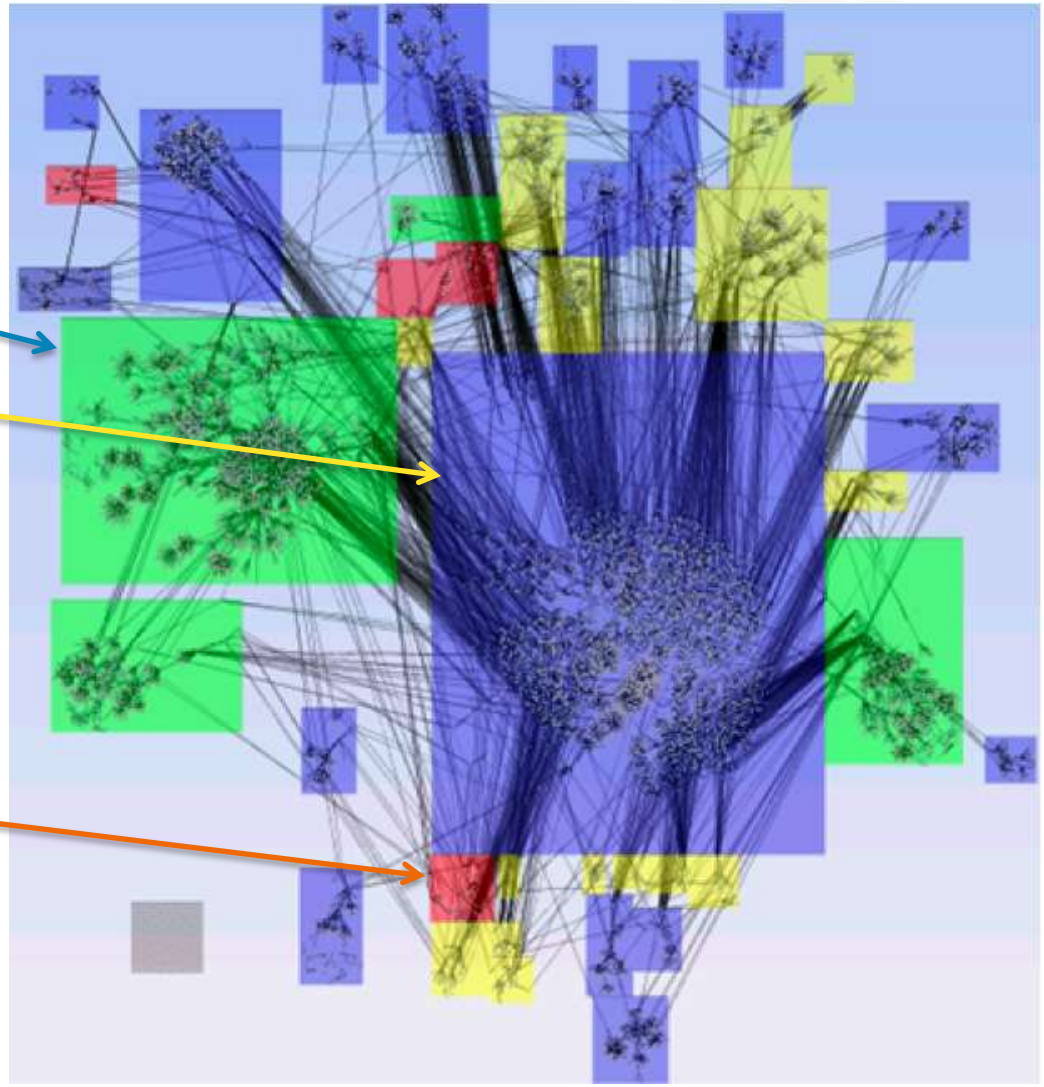
Lesson #1: You need a config repository

Complexity level is high



Organizing Cisco's worldwide network

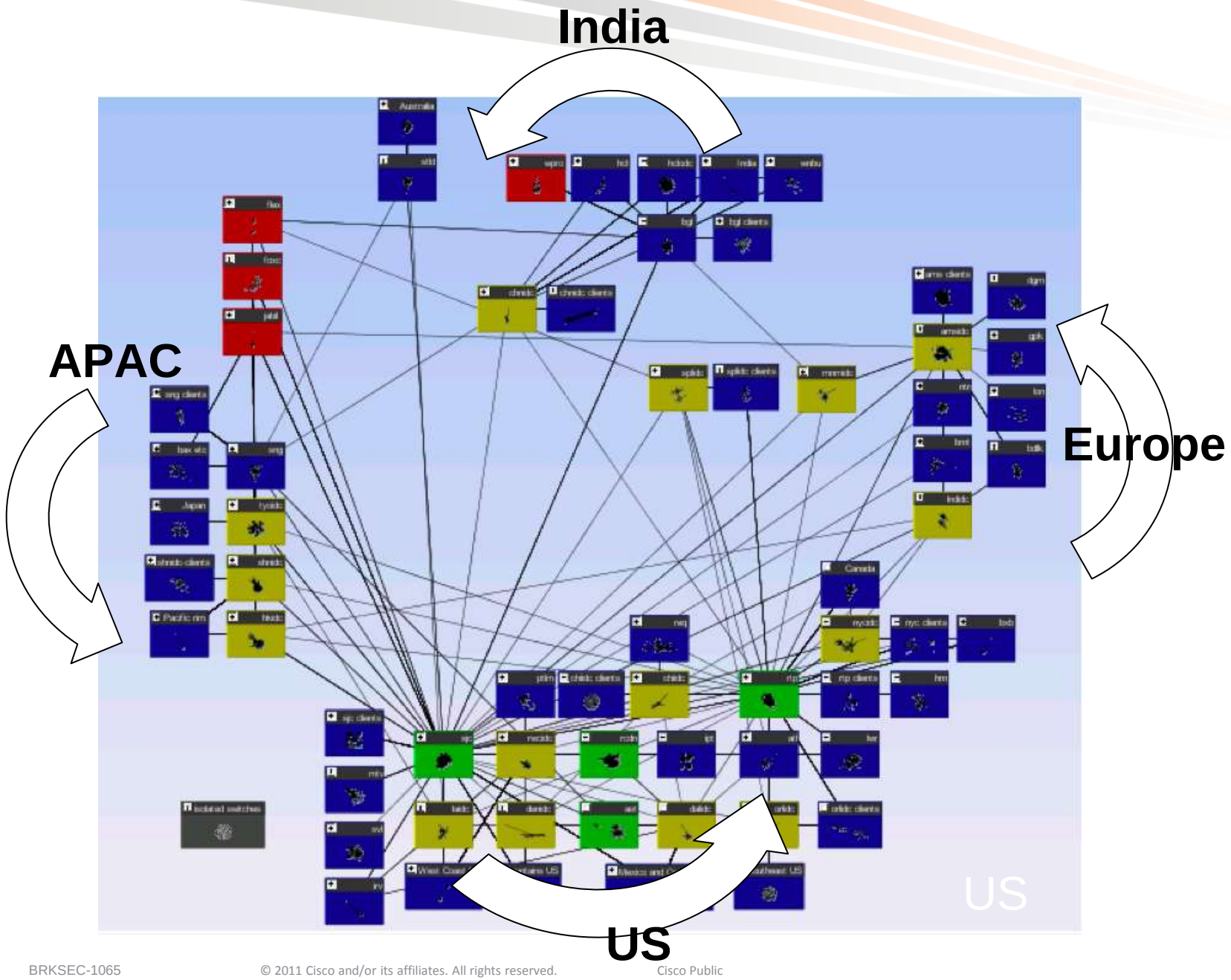




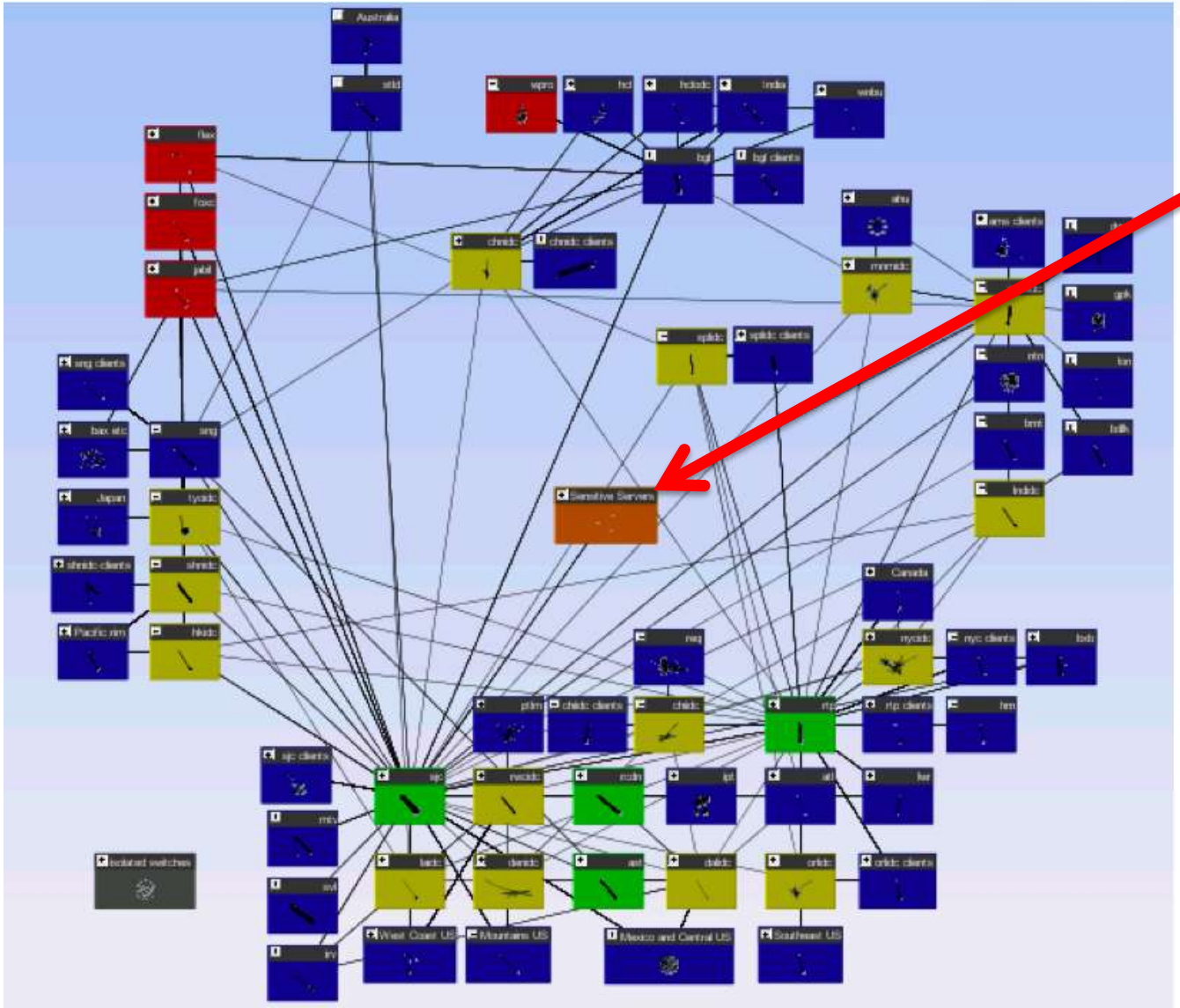
- Zoning from location codes, without input from Cisco

Lesson #2: Naming conventions are your friend

Final “circumpolar” zoned view

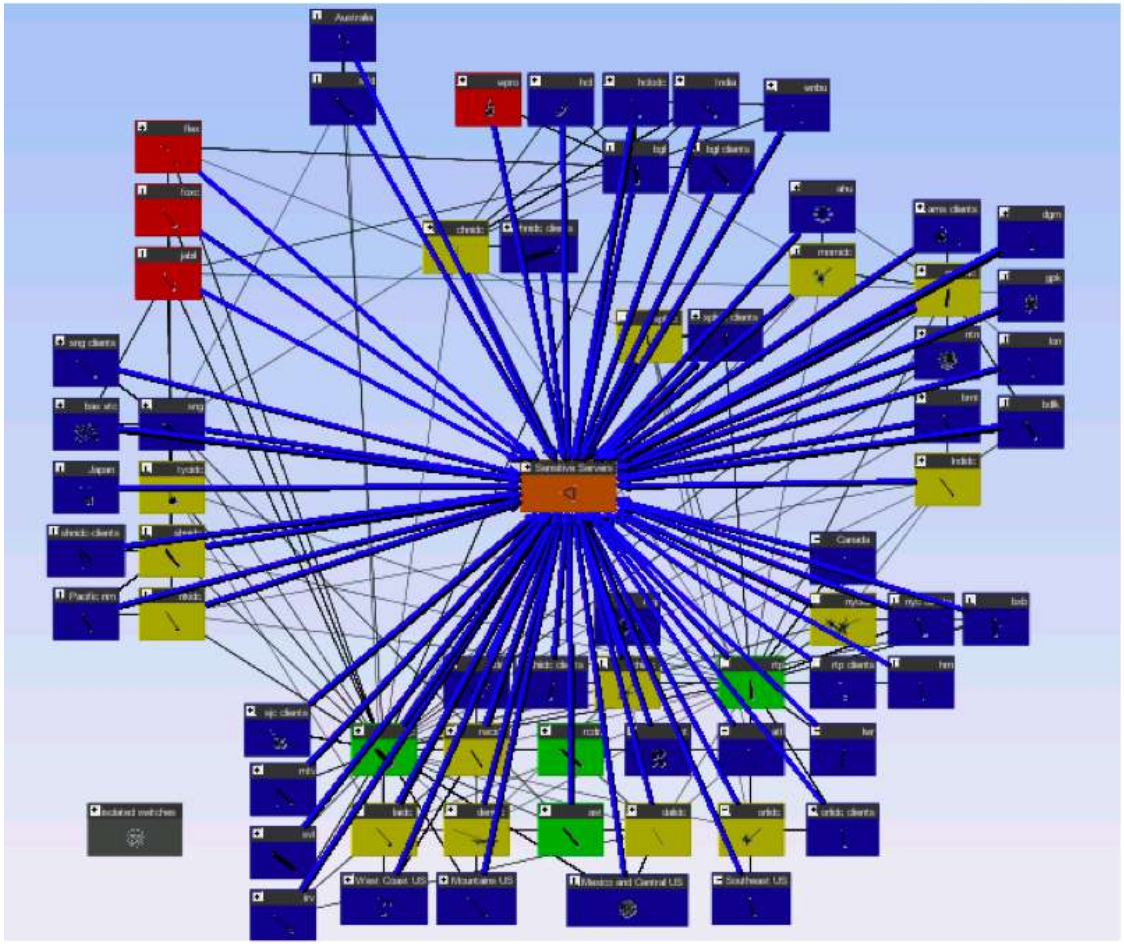


Connectivity to three sensitive servers



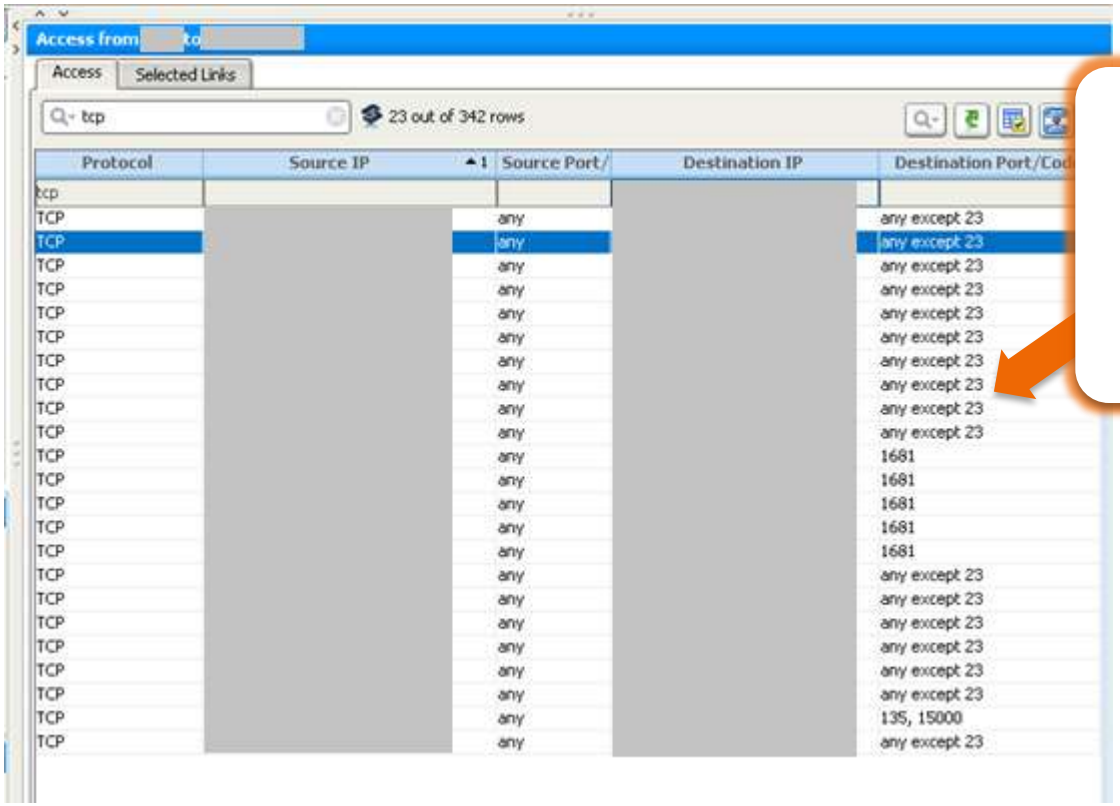
Automatic calculation of connectivity

- Blue lines show access paths to sensitive servers
- Clearly shows the need for segmentation



Lesson #3: Pictures easily explain difficult concepts

Access specifics – “Is it just ping?”



Source	Destination Port
any	any except 23
any	any except 23
any	any except 23
	…

- Detailed drill-down from one blue arrow
- Well, at least we blocked telnet
  (Specifics hidden, for obvious reasons)

Before vs. After

- Before:
  - No way to visualize global infrastructure
- After:
  - Map of record in an “Atlas”
  - Has become a working platform for further projects
  - Graphics to explain security issues to non-experts

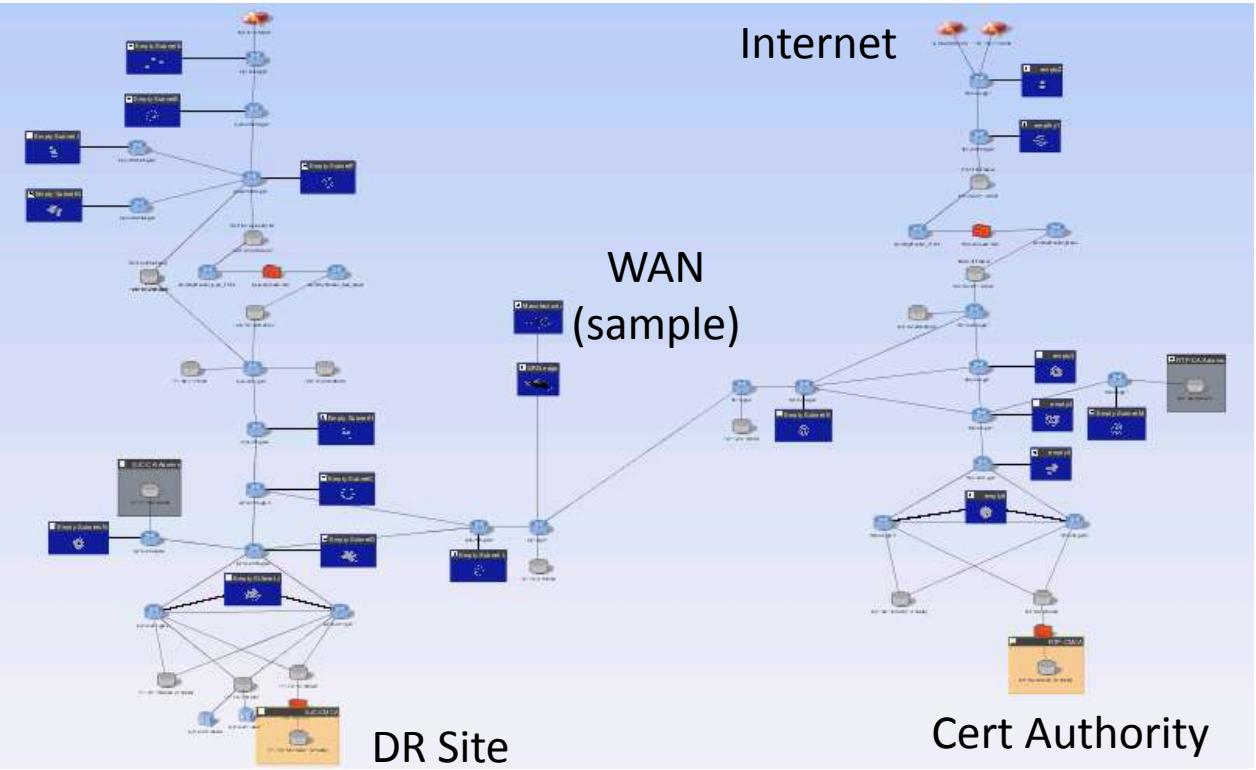
Case Study: Defending critical assets

- PoP audits work outside in
  - Broad scope, hunting major gaps
  - Problem: lots and lots of access to review
  - Can’t quickly capture all rules for all incoming access
  - Some assets deserve focused attention
- For critical assets, work inside out
  - Start from known target
  - Limit scope, increase focus
  - Continuous re-assessment

Distributed public key infrastructure

- Main site, plus disaster recovery site

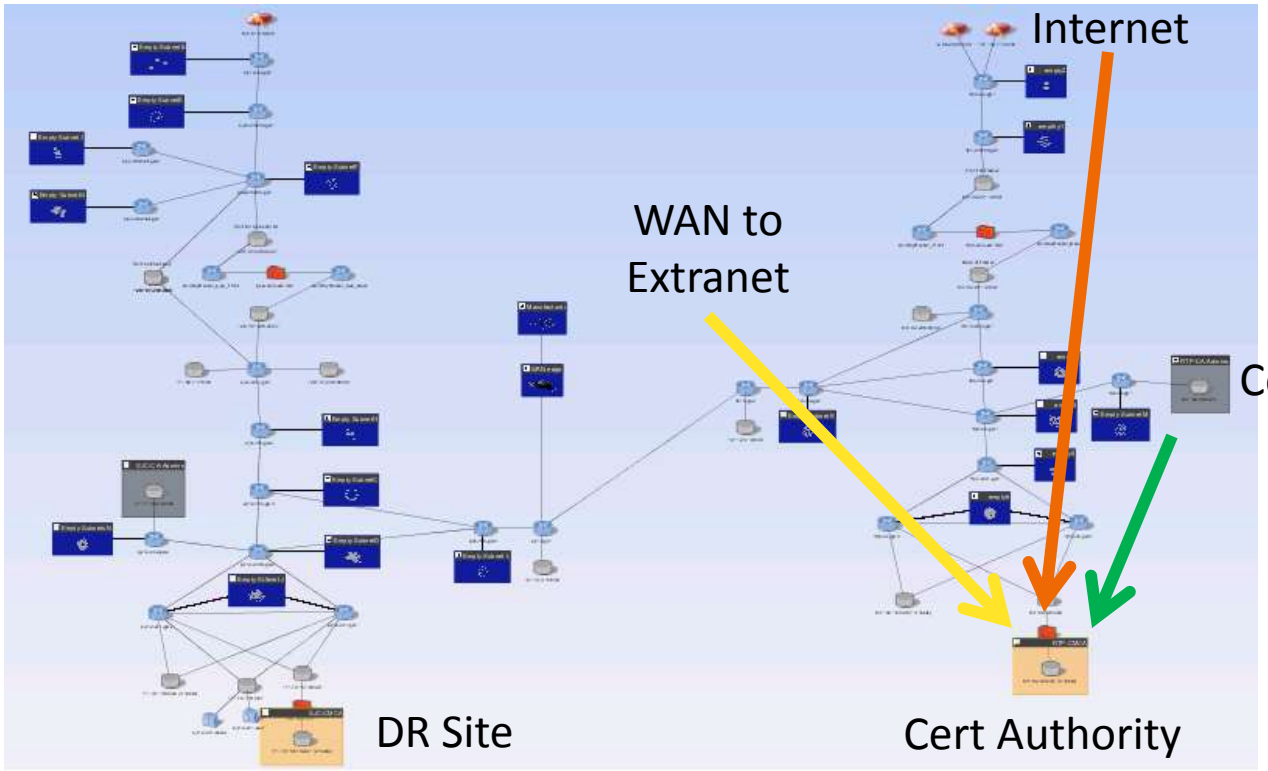
  Building the “crossbar” was easy – we sampled from Atlas



Lesson #4: A reference atlas is your friend

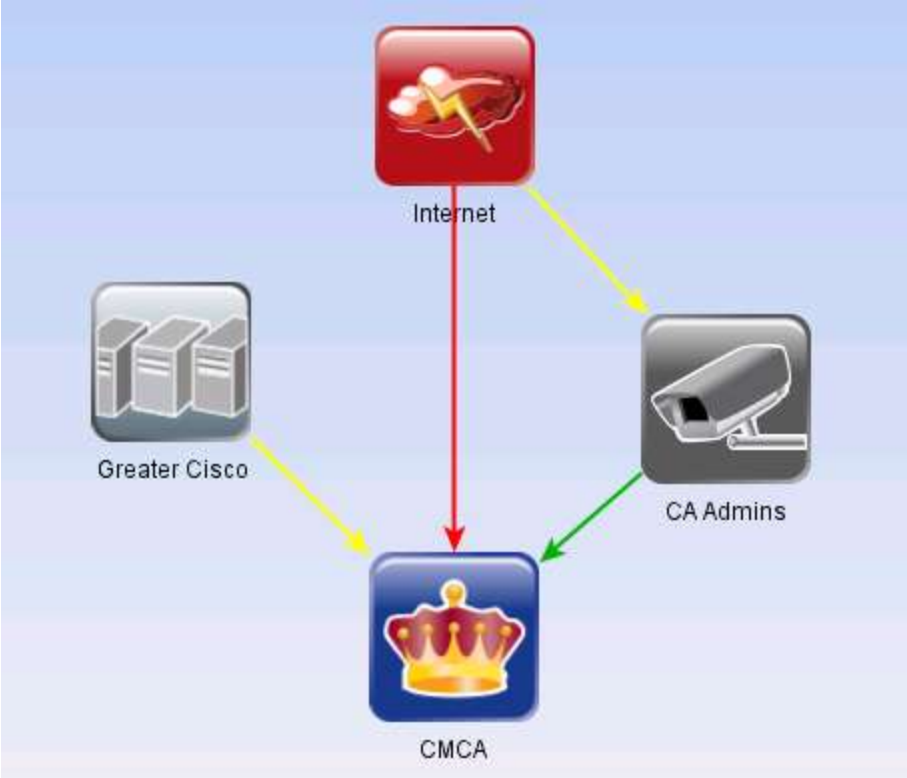
Distributed public key infrastructure

- Access strictly controlled
  - Untrusted 3rd party manufacturers need to request certs
  - Only cert admins should have general access



Capture high level rules

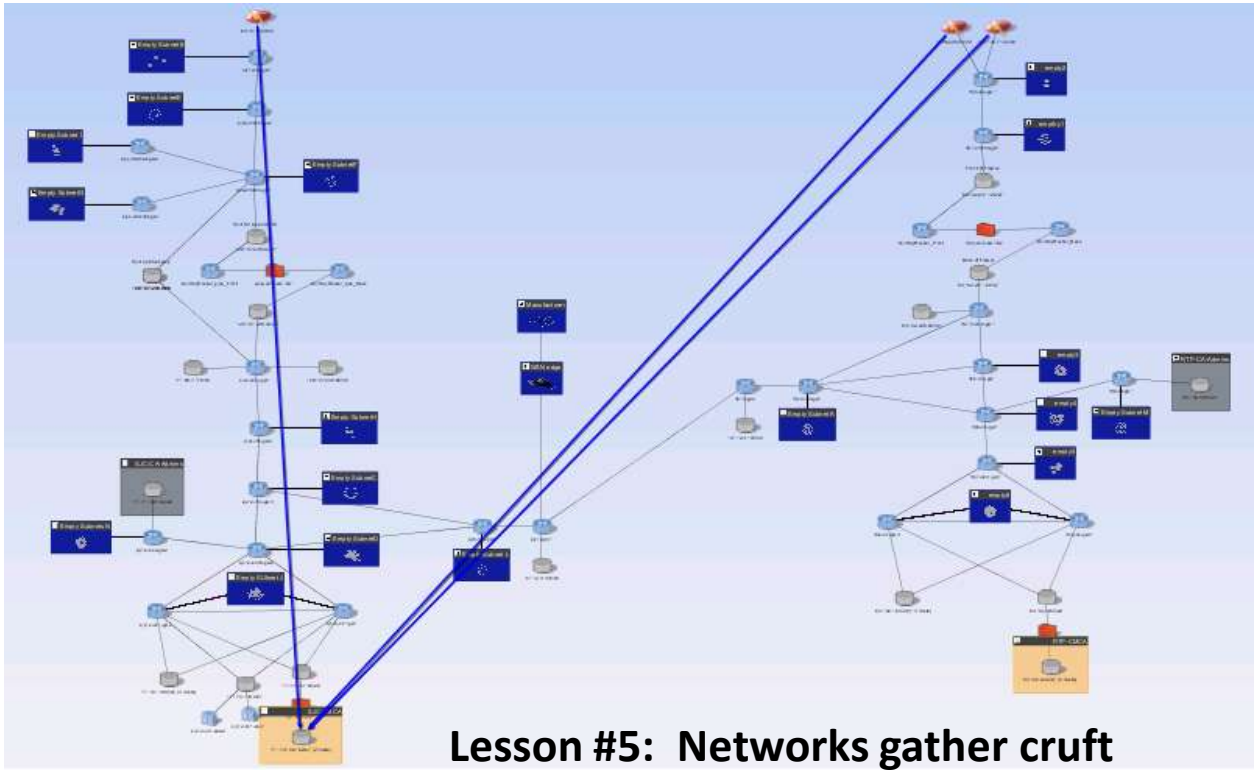
- Capture relationships of major zones
- Arrows show there is some unwanted access



Investigate unexpected access

- Note: no flow into primary
- Only DR site had unexpected Internet access

  Even that was for limited sources, but still unexpected



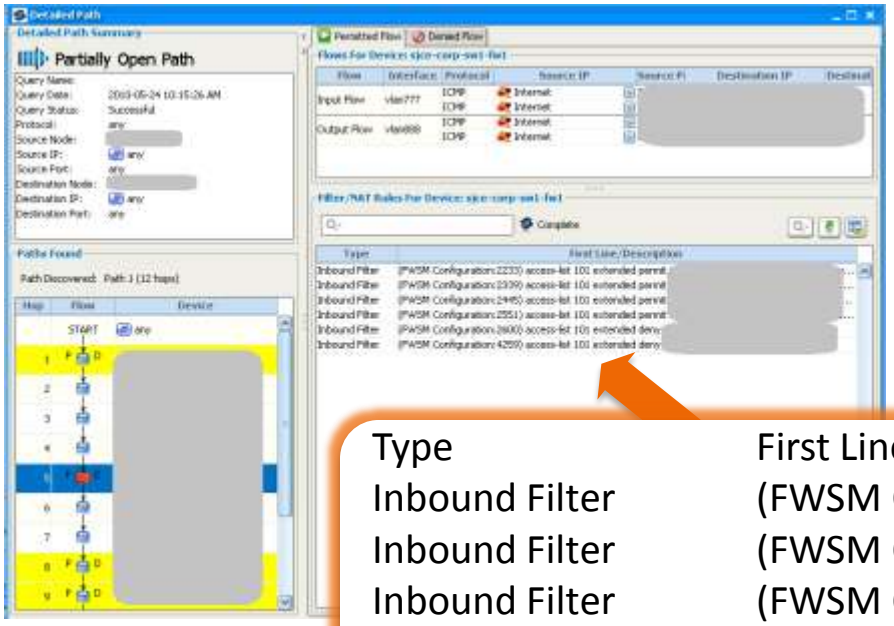
Remove unwanted access

- Drill down to detailed path for unexpected access
- Identify exact cause

  In this case, an out of date group definition on firewall

Access Found

"Subway Map" showing path



Flow through one hop

Type	First Line/Description
Inbound Filter	(FWSM Configuration:2233)
Inbound Filter	(FWSM Configuration:2339)
Inbound Filter	(FWSM Configuration:2445)
Inbound Filter	(FWSM Configuration:2551)
Inbound Filter	(FWSM Configuration:2600)
Inbound Filter	(FWSM Configuration:4259)

Before vs. After

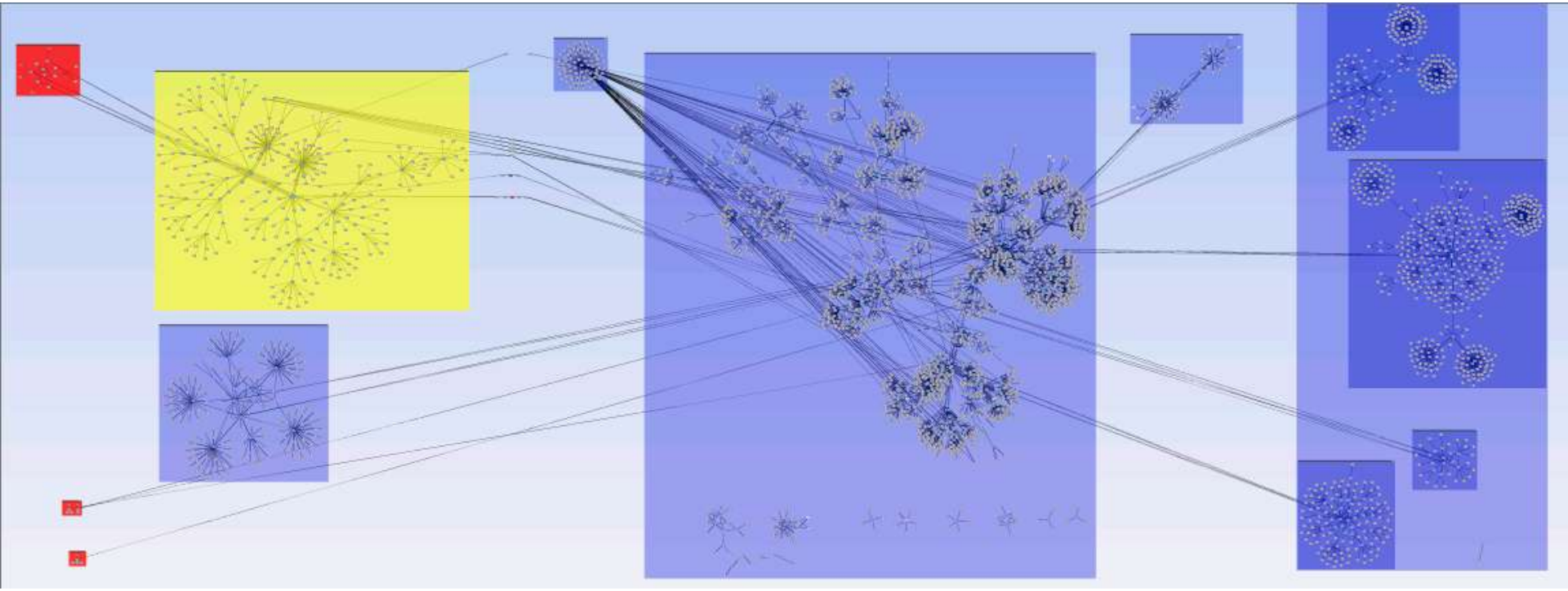
- Before:
  - Important details buried in large, complex network
- After:
  - Focused rule-set to test defenses
  - Built out over 2 days
  - Daily re-evaluation as network changes come and go
  - Automatic mail summarizing status

Case Study: Zone defense

- Cisco has 15 major PoP's for external connections
- Typical manual assessment: 90 days per PoP
- Target:
  1. Build map
  2. Record major zones
     - Internet, DMZ, Inside, Labs, etc
  3. Analyze for Best Practice violations
  4. Add host vulnerabilities from scans
  5. Run penetration test

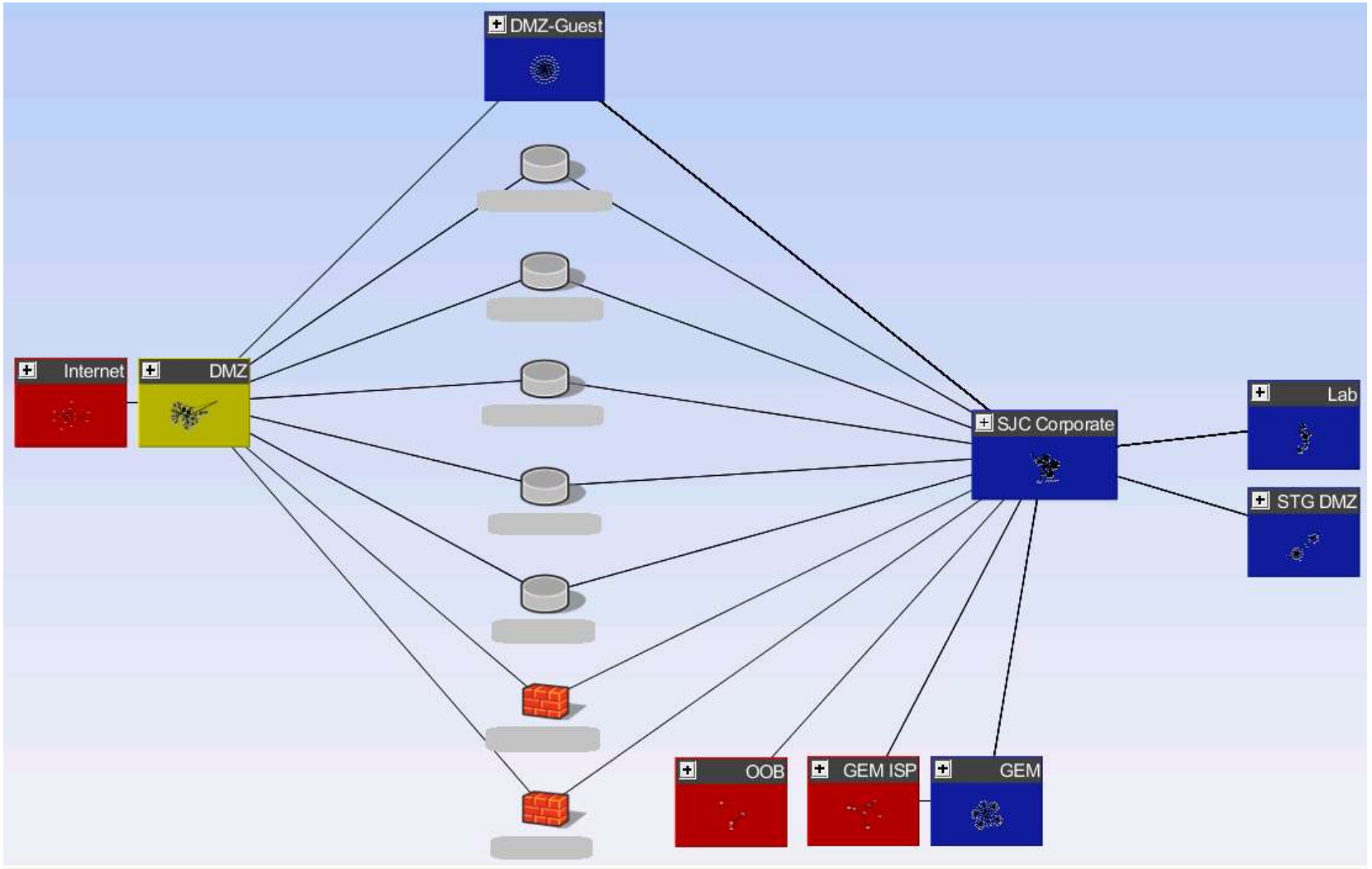
San Jose Campus Network Map

- Map of one PoP
- Zoning done “semi-automatically”



Internet DMZ Main Site Labs

San Jose Campus Network Map



Example of Best Practice Checks

- Automatic evaluation of 100+ rules
- Weak or missing passwords, redundant rules, etc

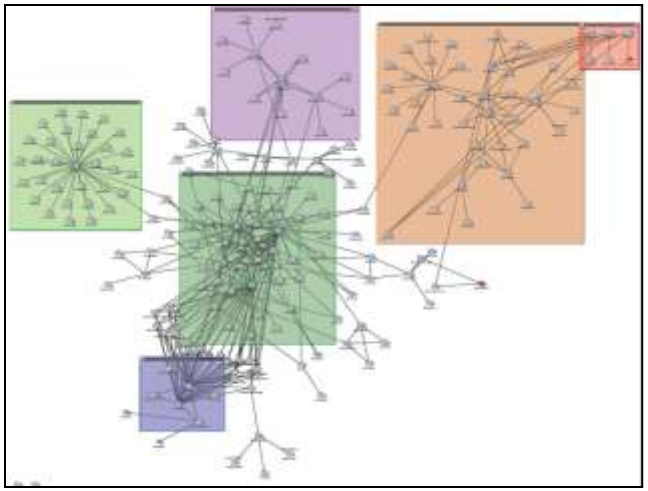
Check ID	Title	Severity
RS-16	Unencrypted Passwords	HIGH
RS-25	Default Enable Password	HIGH
RS-26	Default Password	HIGH
RS-29	No Password for User	HIGH
RS-38	Weakly Encrypted Password	HIGH
RS-41	Superfluous Enable Password	HIGH
RS-55	No Password on Console	HIGH

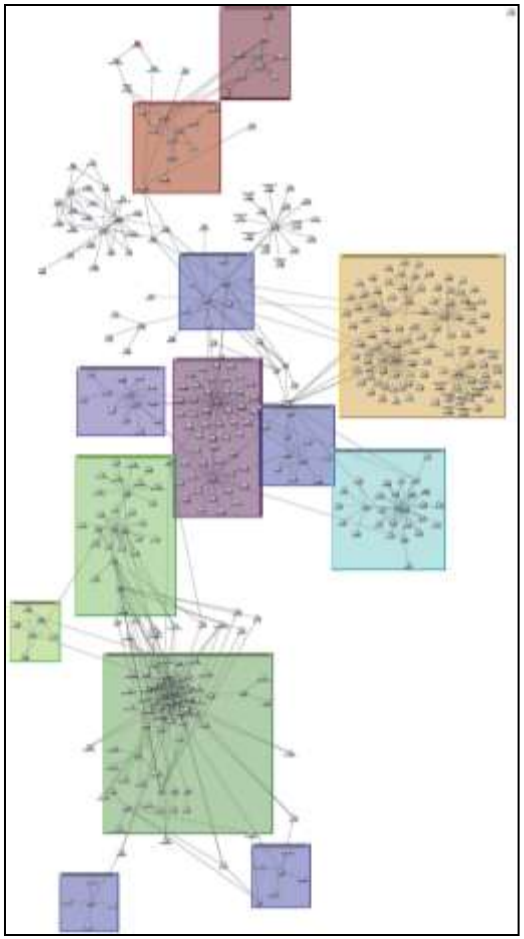
- Unlike rolling stones, changing networks gather moss …

Lesson #6: 'Best Practices' are called 'Best Practices' for a reason.

More sample maps

- 9 PoP maps built out & zoned in one morning
- Export to Visio and PDF

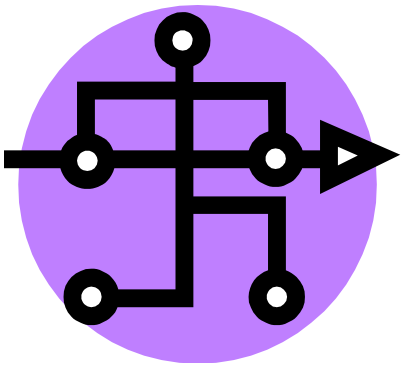




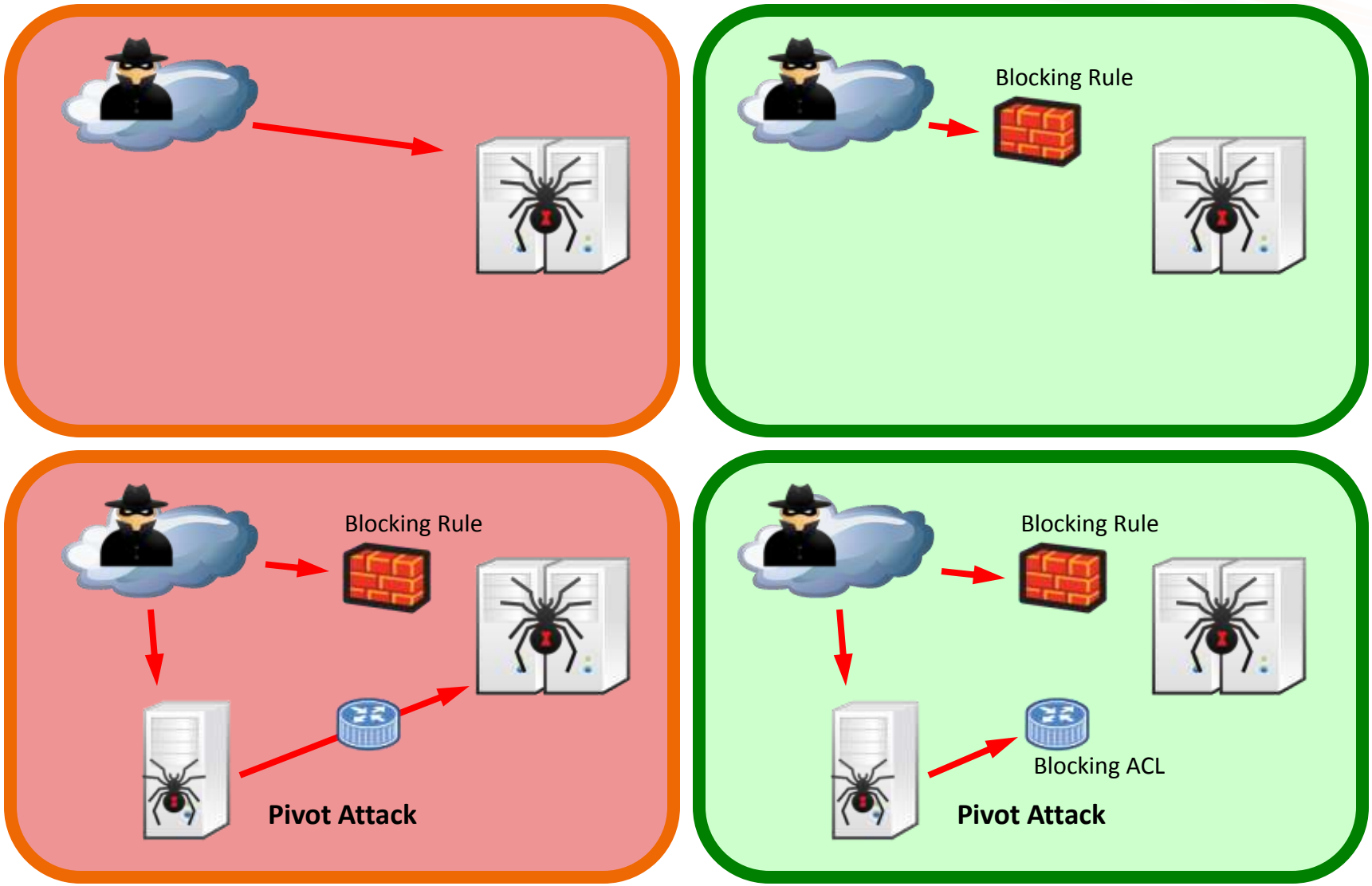
Lesson #7: 'Regular' people can do this.

Offline penetration testing

- Next level of analysis is penetration testing
- Combine network map with host scans
- Add access calculation
- Software automatically evaluates attack paths
- Identify high risk defensive weaknesses



Risk from Network-Based Attacks



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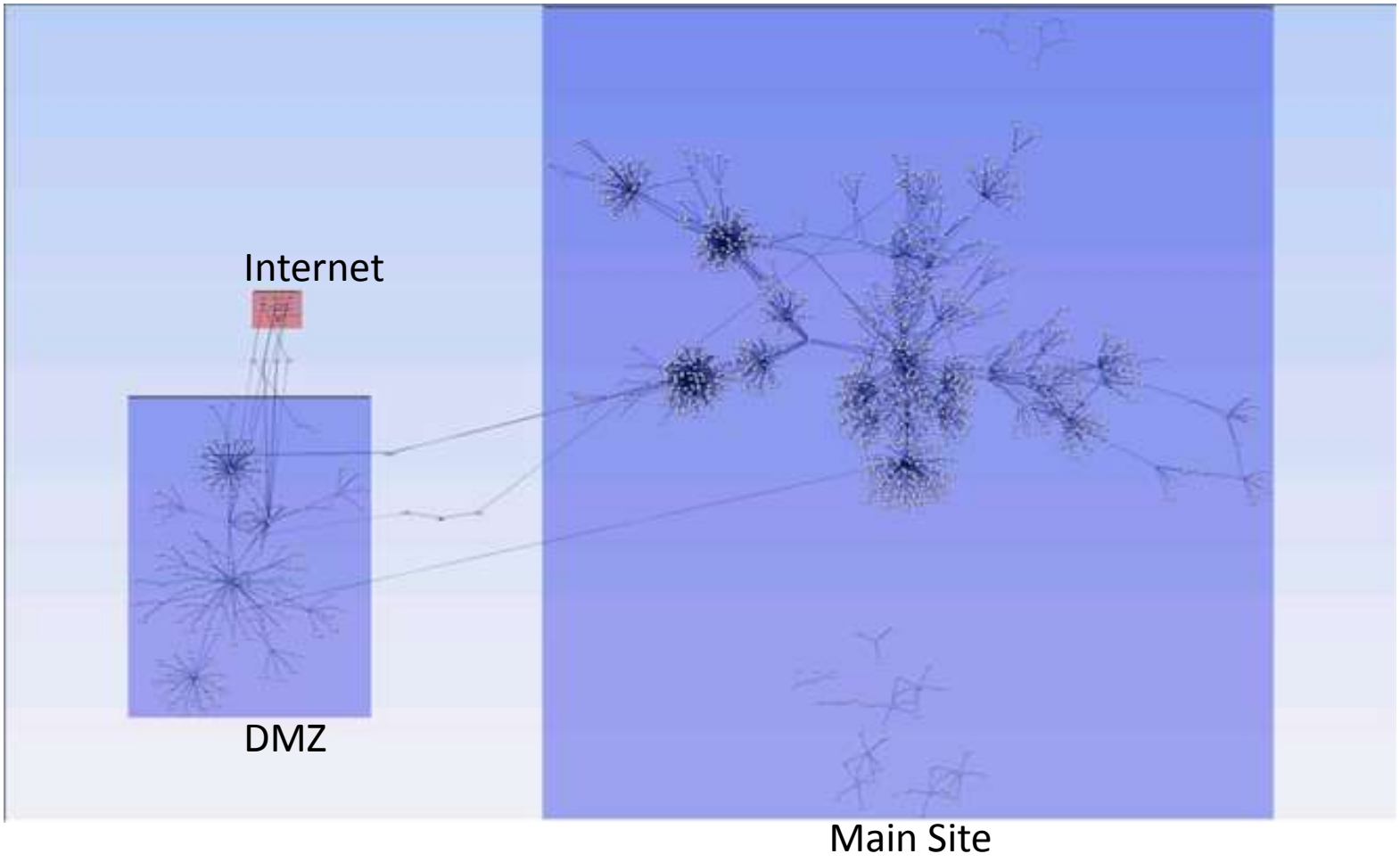
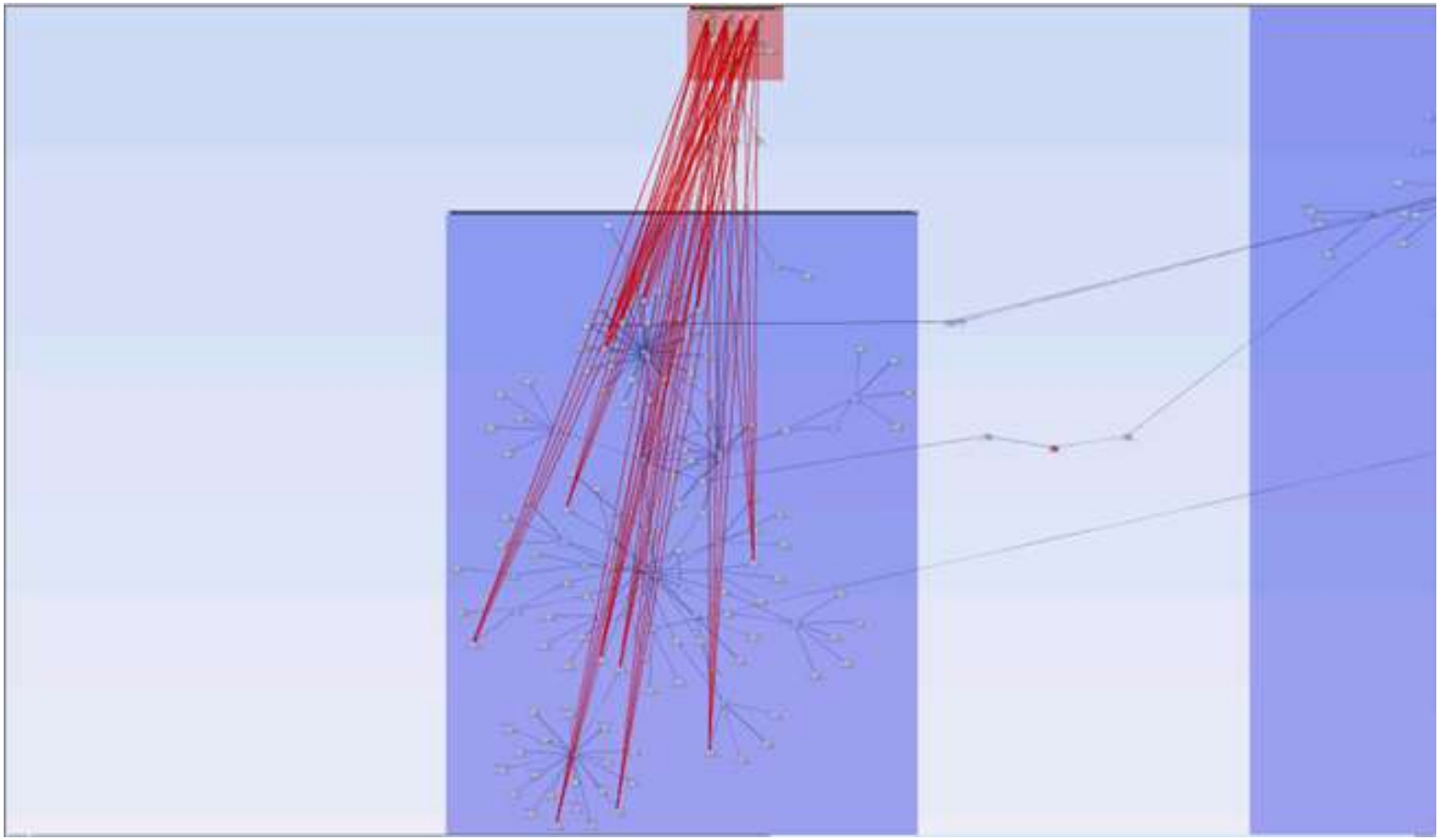
Sample attack chain – Before



Step 1 – Vulnerabilities exposed in DMZ

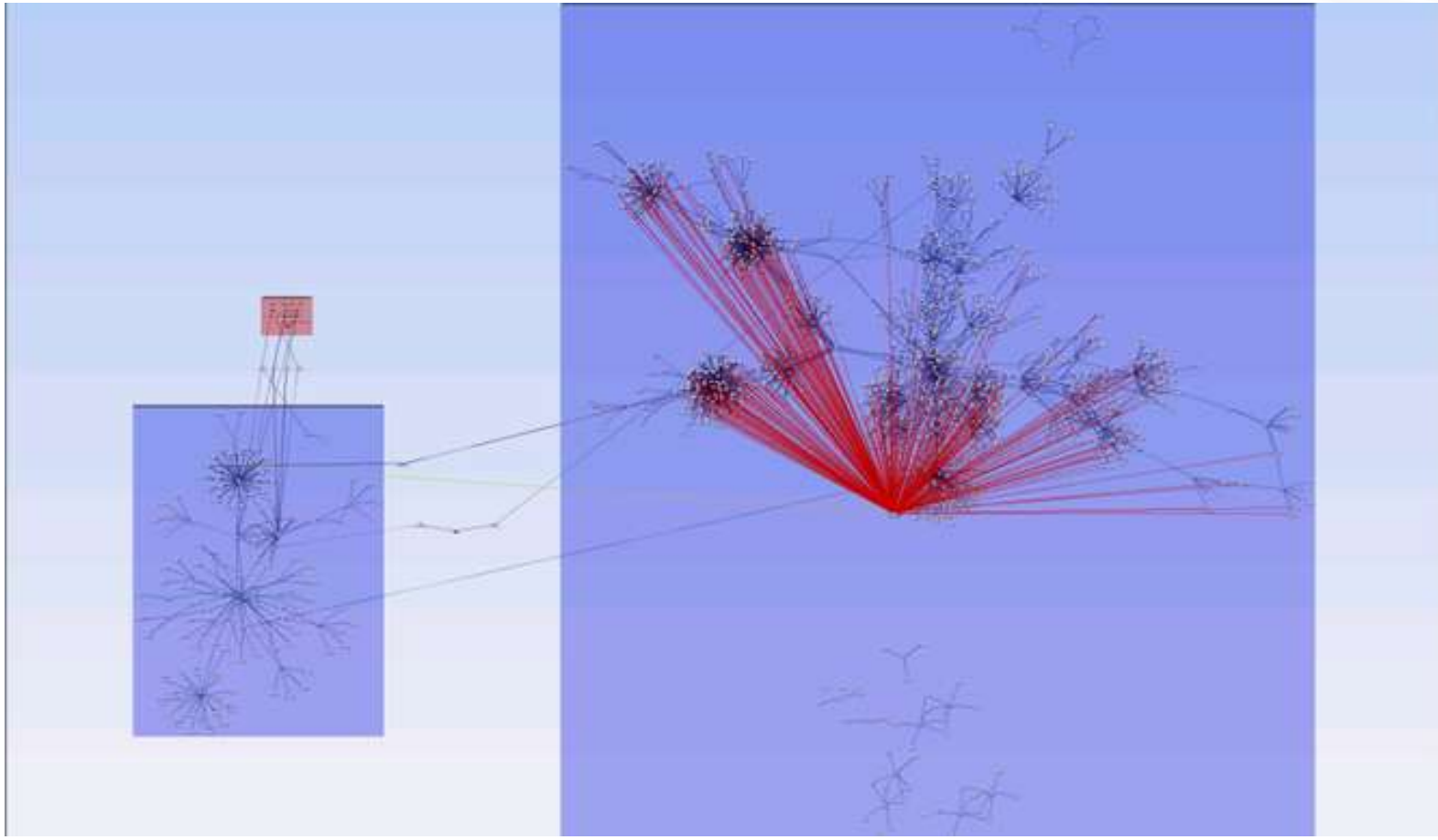


- Attackers can reach these Internet-facing servers

Step 2 – Some attack paths sneak in

- Just a few pivot attacks are possible

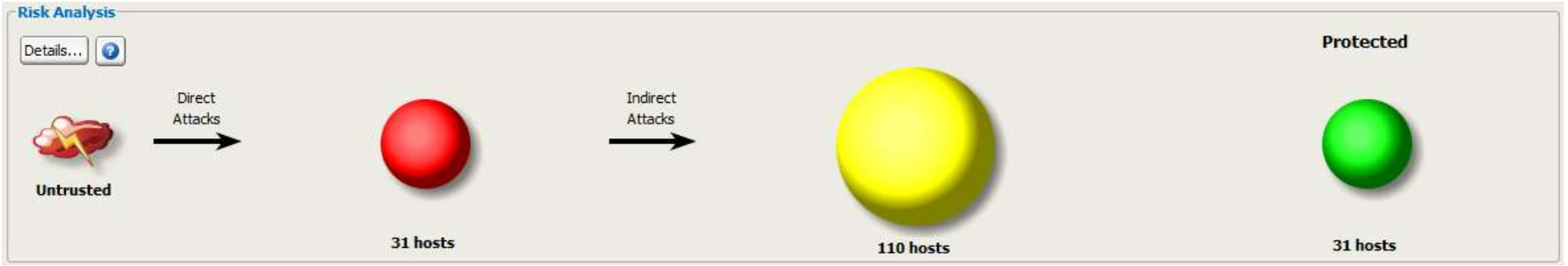
Step 3 – Attack fans out



- An attacker can get in if they find this before you fix it

Penetration test results

- Sample result:



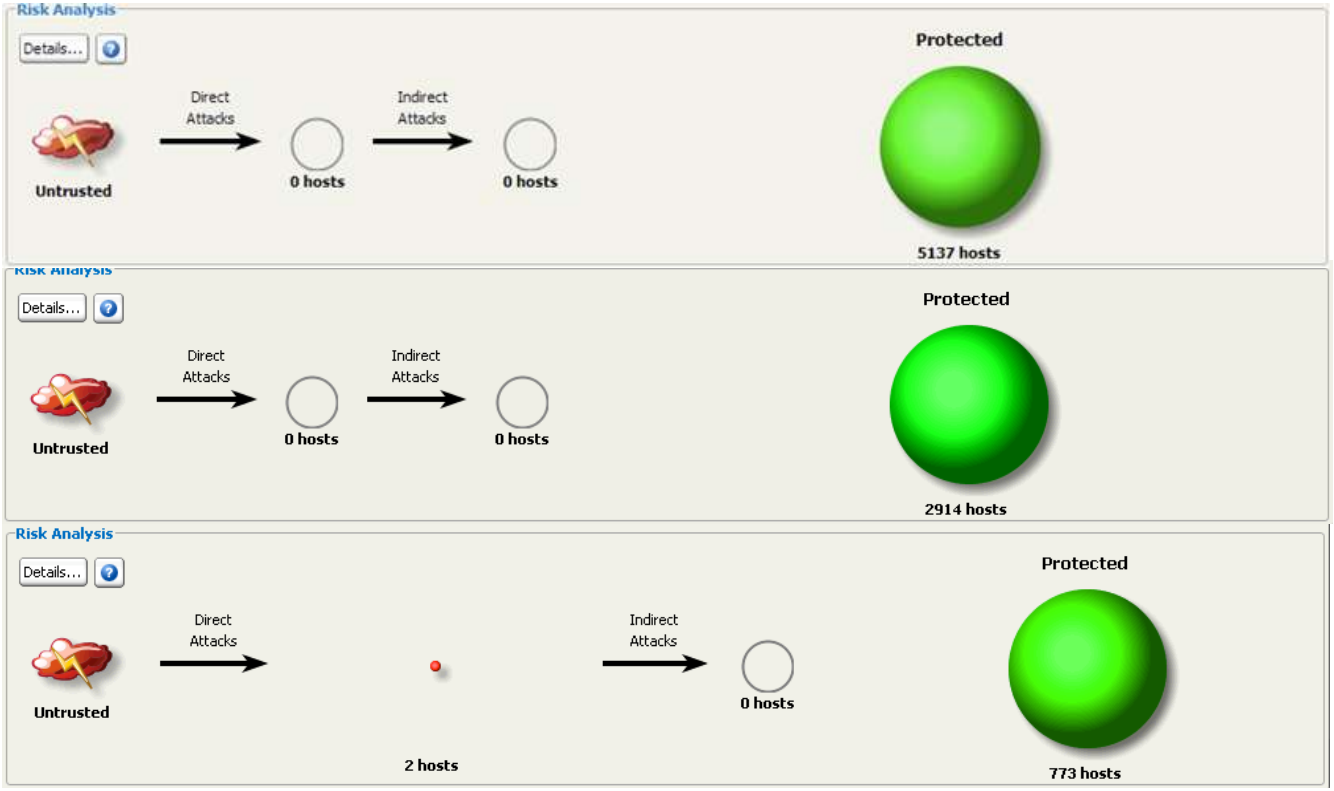
External attackers can reach red hosts

Then pivot to attack yellow hosts

But no attack combination reached green hosts

Results of recent PoP analysis

- Three PoP's out of nine analyzed
- These are very clean – small attack surface



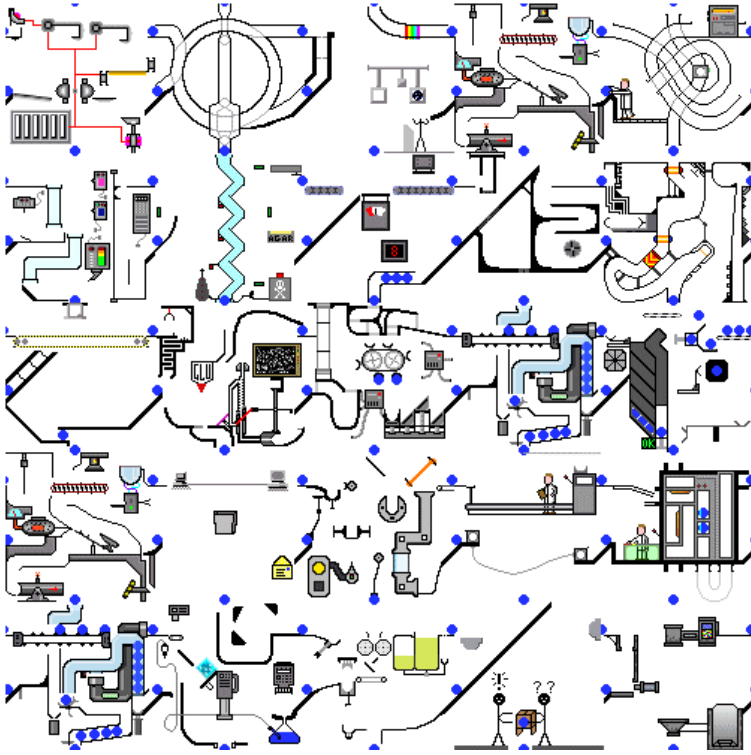
Before vs. After

- Before:
  - Each PoP audit took 90 days
  - Did not consider host vulnerability data
- After:
  - Team executed 9 PoP audits in one day
  - Integrated assessment
    - Network configuration analysis
    - Zoned map
    - Host vulnerabilities
    - Attack path analysis
  - Bonus: map and results re-usable on next visit

Lesson #8: Network data + Vuln data + Attack path = GOLD

Case Study: Automated Perimeter Assessments

- Assess 9 PoPs in a day? How about all 15 every night?
  - Assessments get stale with age
  - Fresh data is best
  - Automation is the only answer

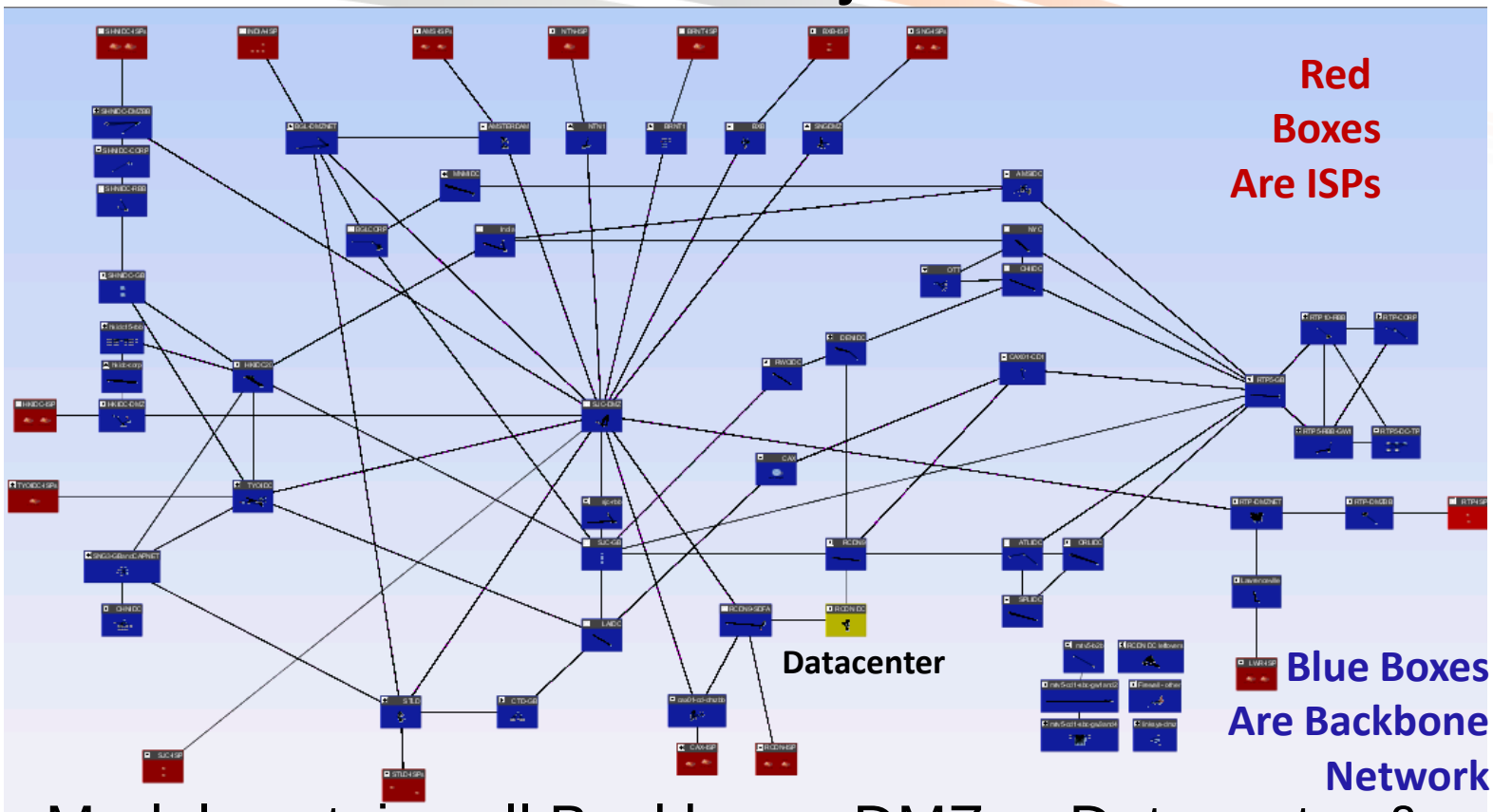


Risk Evaluation Object Model (Project REOM)

[aka Rotating Eye Of Mordor]

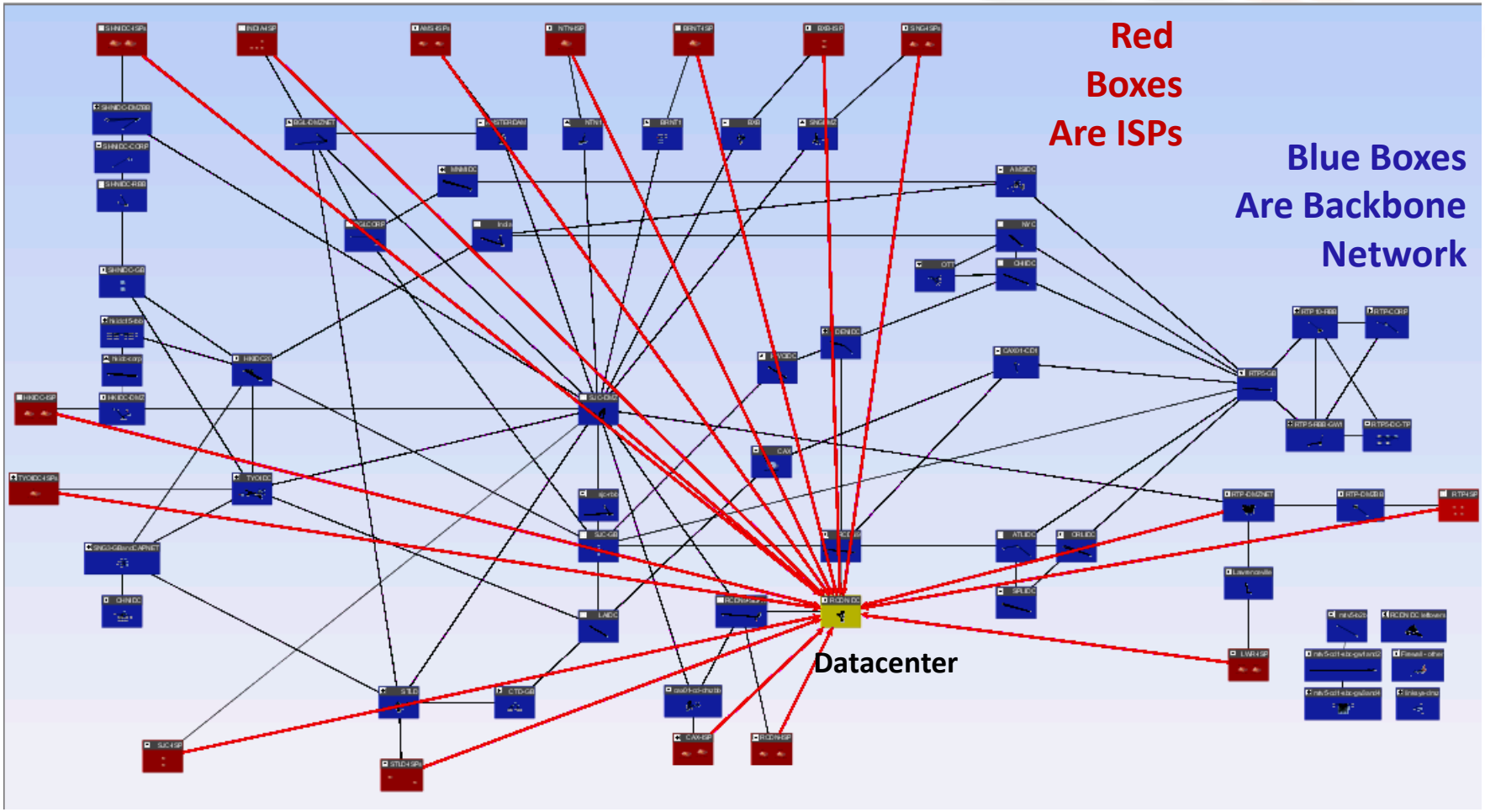
- Project to Passively Penetration Test all Cisco PoPs
  - Network Modeling Software pulls network configuration data and integrates it with scanner vulnerability data
- Global Enterprise view of
  - Cisco ISPs - Scoped to evaluate all 15 PoPs (SJC, RTP, et. al.)
  - Entire Backbone Network (CAPNET)
  - All DMZs
  - Richardson Datacenter (i.e. something to attack)
- Goal
  - Everything Automatic; Minimal Human Involvement
  - Reporting that shows what appears vulnerable
  - Trending that shows how we're addressing issues

Risk Evaluation Object Model



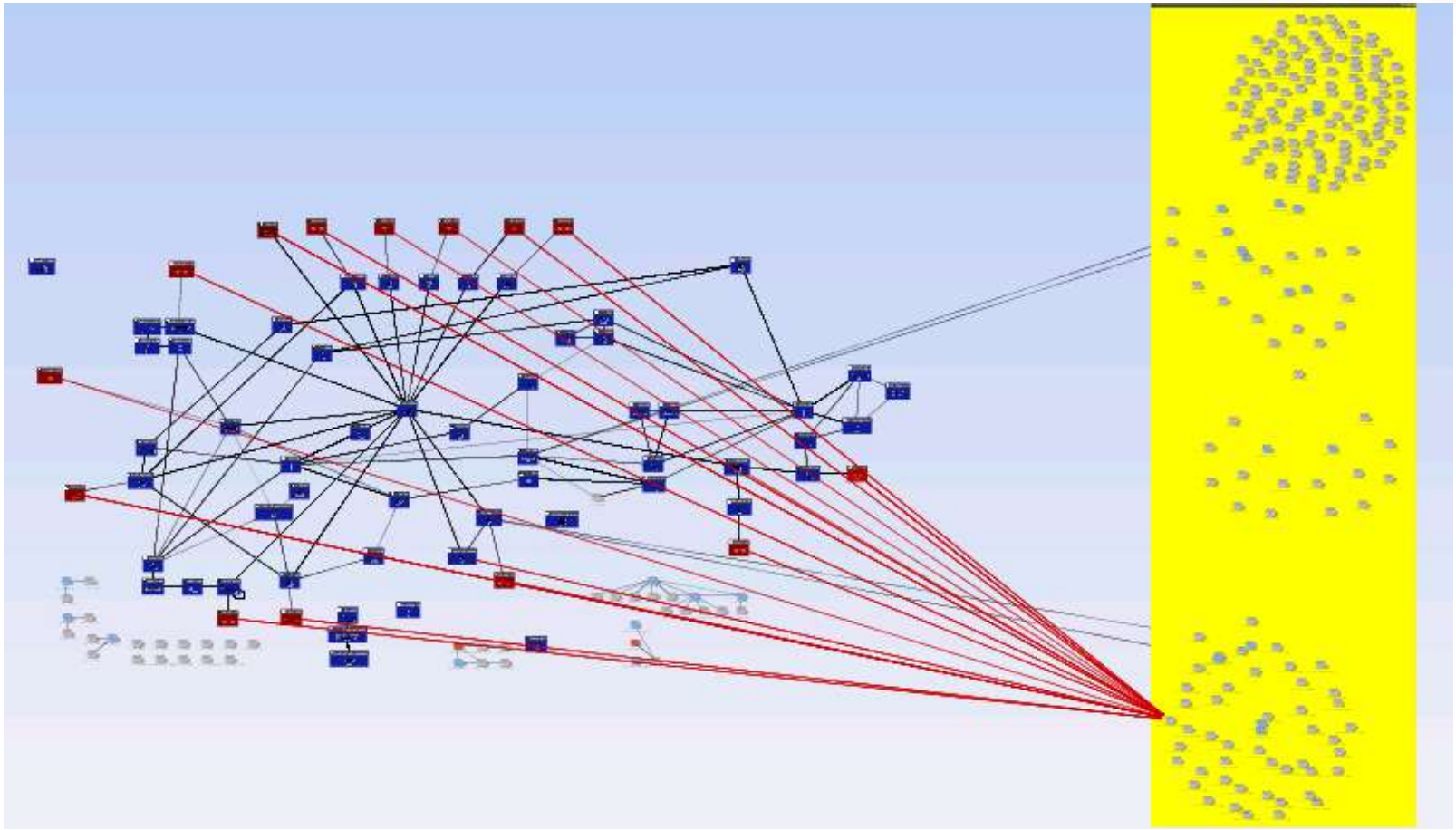
- Model contains all Backbone, DMZ, a Datacenter & Vulnerability data
  - ~750 NW configs; ~9K hosts w/vulns; NW configs update daily; vulnerability scans take 3-5 days; weekly report
- Completely Automated

REOM with Attack Paths



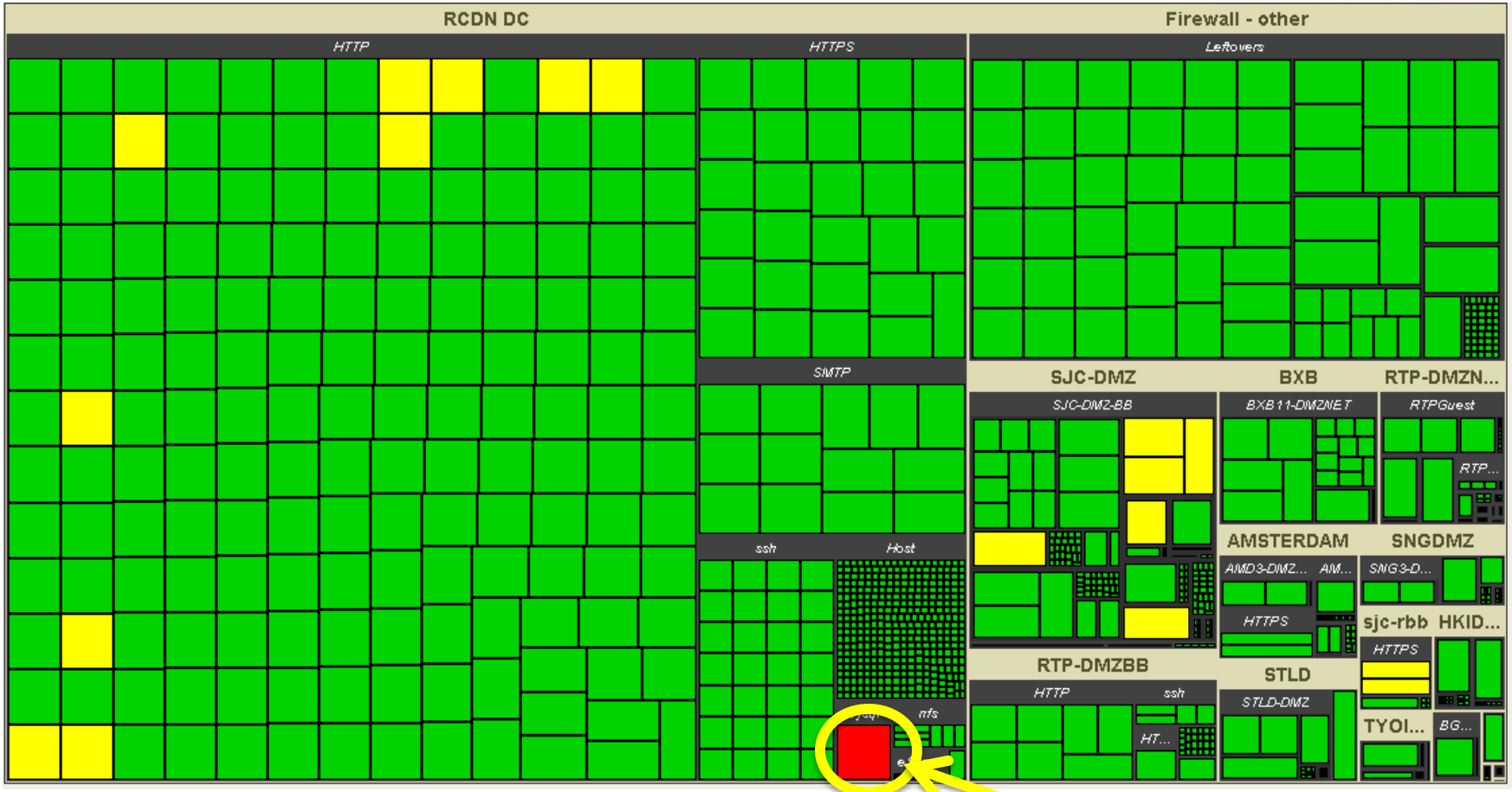
- Automatic attack path calculation based on connectivity and vulnerability data

The Datacenter in more Detail



- Attacks land in one subnet (oddly, that is good news)
- Notice network segmentation within the DC?

So what is open to attack and purportedly vulnerable?



- Multiple views to hosts, services, and topology
- Pinpoints highest priority remediation

Here's the culprit!

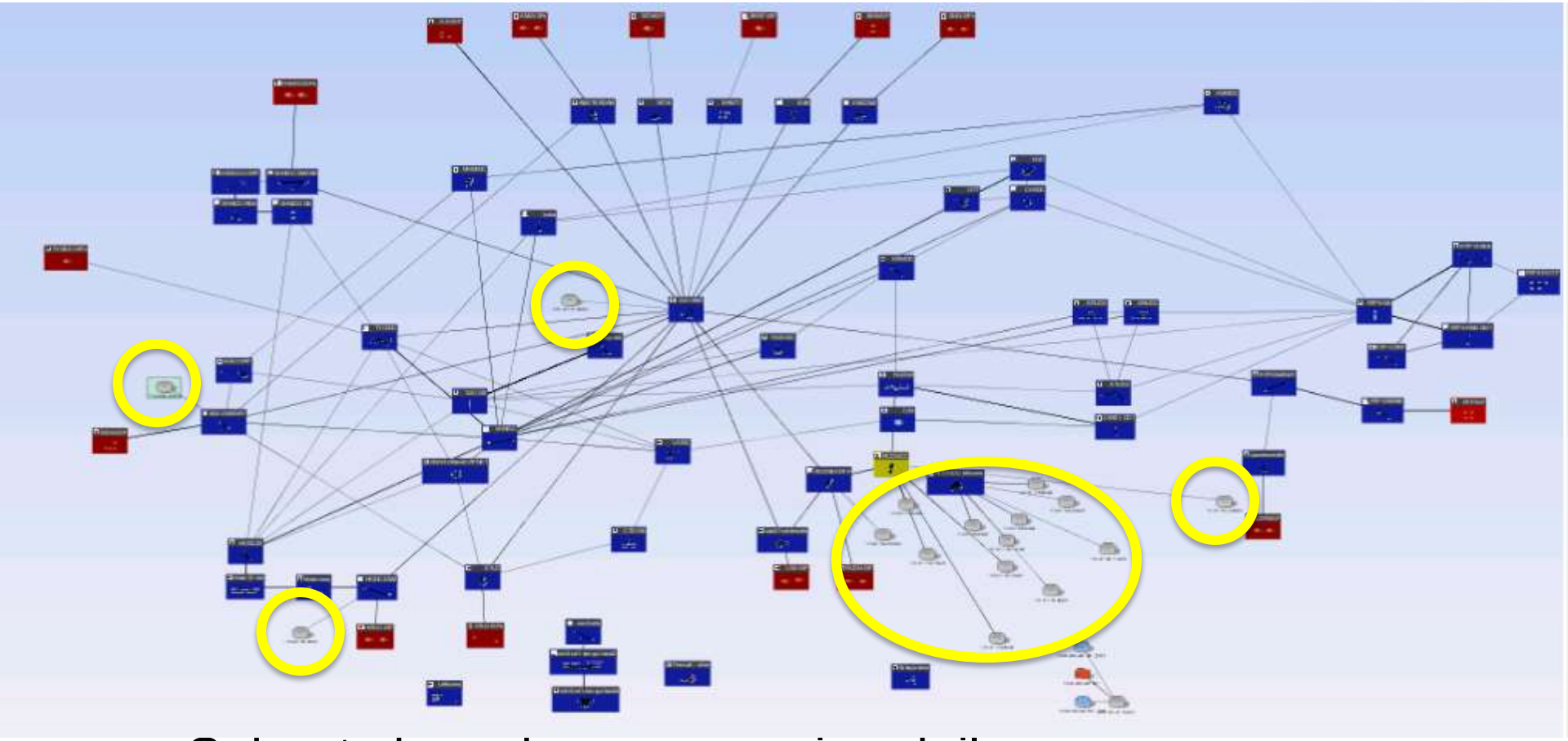
Reporting

Standard ‘Top 10’ Style Reporting

Topology > Topology|RCDN DC

Host	IP Address	Primary Service	Value	Attack Depth	Leapfrog	DSR	Risk ▼
[redacted].cisco.com	[redacted]	mysql	75	1	Yes	0	74
[redacted]		HTTP	50	1	Yes	0	39
		HTTP	50	1	No	0	38
		HTTP	50	1	No	0	38
		HTTP	50	1	Yes	0	35
		HTTP	50	1	Yes	0	35
		HTTP	50	1	Yes	0	35
		HTTP	50	1	Yes	0	33
		HTTP	50	1	Yes	0	33
		HTTP	50	1	Yes	0	33
		HTTP	50	1	Yes	0	33
		HTTP	50	1	Yes	0	31
		HTTP	50	1	Yes	0	31
		HTTP	50	1	Yes	0	31
		HTTP	50	1	Yes	0	31
		HTTP	50	1	Yes	0	31
		HTTP	50	1	Yes	0	31

Daily Change – New Subnets



- Subnets have been appearing daily
- As subnets are added, hosts and vulnerabilities are automagically integrated into the model

Best Practice Checks

- The dreaded Non-contiguous Wildcard

Non-contiguous Wildcard — Severity: low — Check ID: RS-21

Description: A wildcard in the configuration references a set of non-contiguous IP addresses. This is frequently done by mistake—0.0.0.240, which addresses 16 non-contiguous hosts, might easily get set instead of the intended 0.0.0.15 wildcard. (If the ***redundant-security-rule*** test has also failed for the same block of addresses, fix the non-contiguous problem first. It may be producing a false-positive ***redundant-rule*** warning.)

Remediation: If not intentional, the wildcard should be replaced with a contiguous wildcard.

Primary Capability > Router — 1 of 5 network devices have at least 1 issue

Device ▾	Summary	Violation ID
[redacted]	Non-contiguous wildcard found Line 2673 permit tcp any [redacted] 0.0.0.32 eq www	119
	Non-contiguous wildcard found Line 2790 permit ip any [redacted] 0.0.0.128	124
	Non-contiguous wildcard found Line 2827 permit ip any [redacted] 0.0.0.128	126

Inverted Mask in Access List — Severity: medium — Check ID: RS-92

Description: An inverted subnet mask was found in an access list rule. An inverted mask can inflate a range of 255 addresses to as many as 16.7 million, causing severe performance degradation of the RedSeal analysis engine. RedSeal ignores rules containing inverted masks, since they are almost certainly configuration errors.

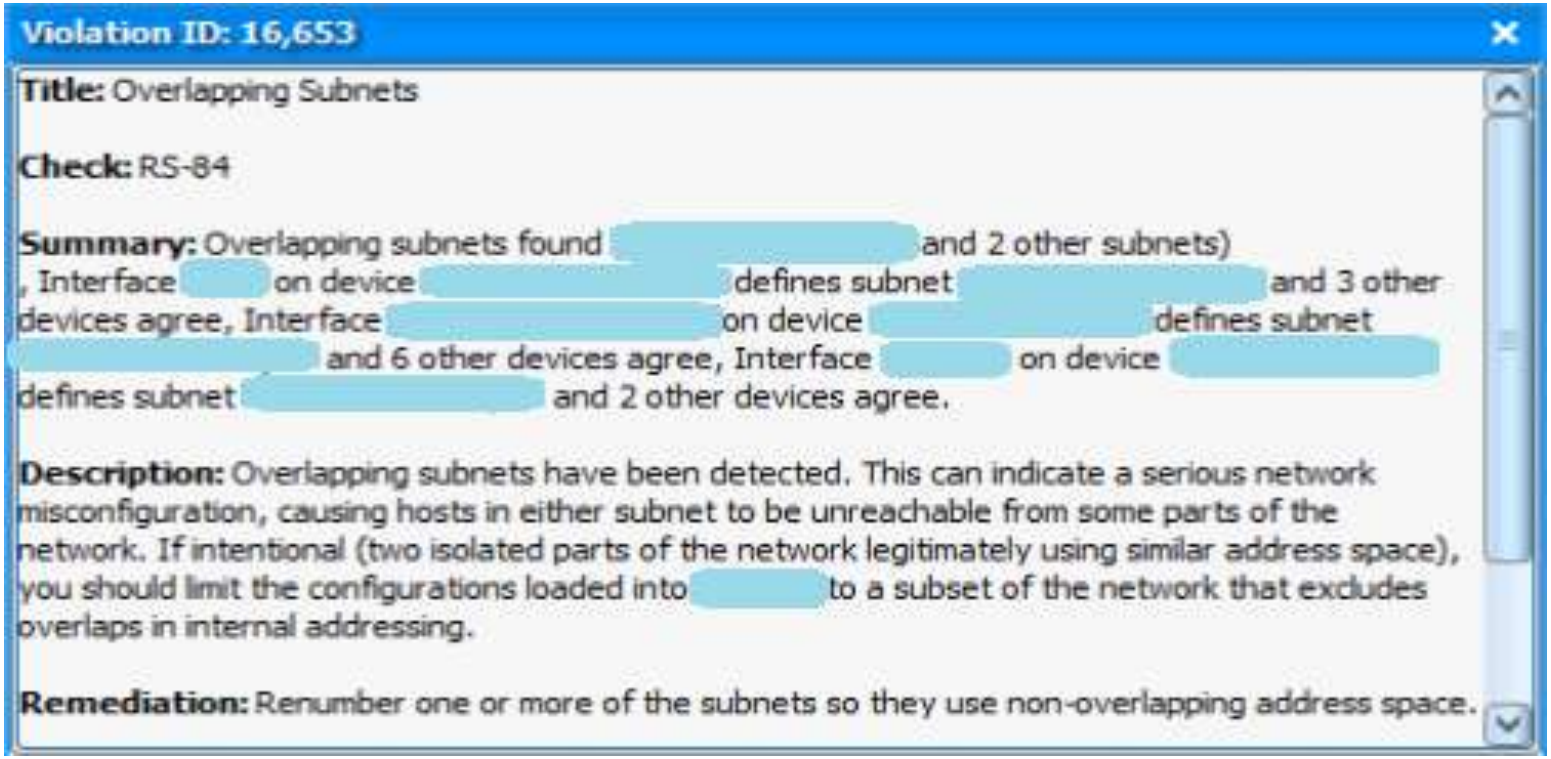
A common mistake when configuring access lists is to specify the mask using ***do care*** bits when the platform expects ***don't care*** bits. That is, for example, to match hosts of the form 172.16.1.*, the correct form for IOS and Foundry is 172.16.1.0 0.0.0.255. An operator may sometimes enter 172.16.1.0 255.255.255.0 by mistake. Since the mask uses ***don't care*** bits, this actually matches hosts of the form *.*.*.0. Also note that the router can remove any values covered by ***don't care*** bits, so the incorrect entry will show up as 0.0.0.0 255.255.255.0 instead of what the operator typed originally. Permitting every address that ends in zero is almost certainly not the intended filter, since *.*.*.0 specifies 16.7 million distinct permissible addresses.

Remediation: Verify the original intent of this line and replace with the correct host and mask.

Lesson #9: Computers are better at reading phone books than you are. Get over it.

Best Practice Checks

- The fierce Overlapping Subnet



Risk Evaluation Object Model - Quick Summary

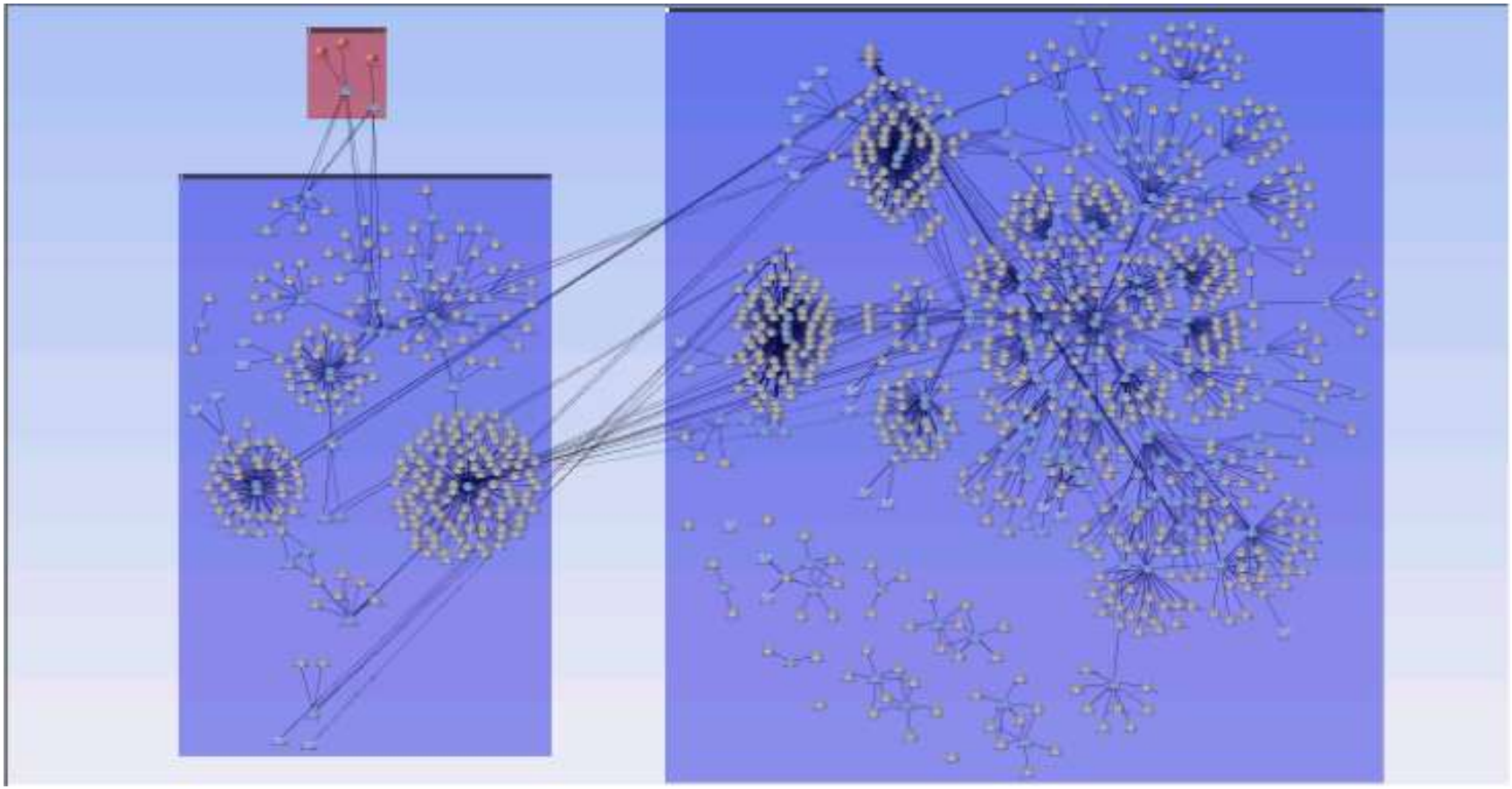
- Many other benefits (Acquisition tie-in, Extranet, Labs, CSIRT, Architecture Planning, et.al)
- What we're getting
  - Full pentest of all 15 PoPs every night
  - A model of 'All Cisco' to use as the basis for other projects
- Why it's important
  - Now we know how they can get in – and we can fix it first
- We're partnering with
  - Global Network Operations (GNO owns Backbone/DMZ) and the PM for the GNO remediation team
- Continually working with teams to address issues

Case Study: Managing daily change

- Business change requests come thick & fast
- Security teams are asked to approve
- No standard basis to approve
- Can't position security team as "Dr No"
  - Need clear, unequivocal reasons when rejecting changes
- Causes "the Carnac moment"

RTP Campus Network Map

Internet

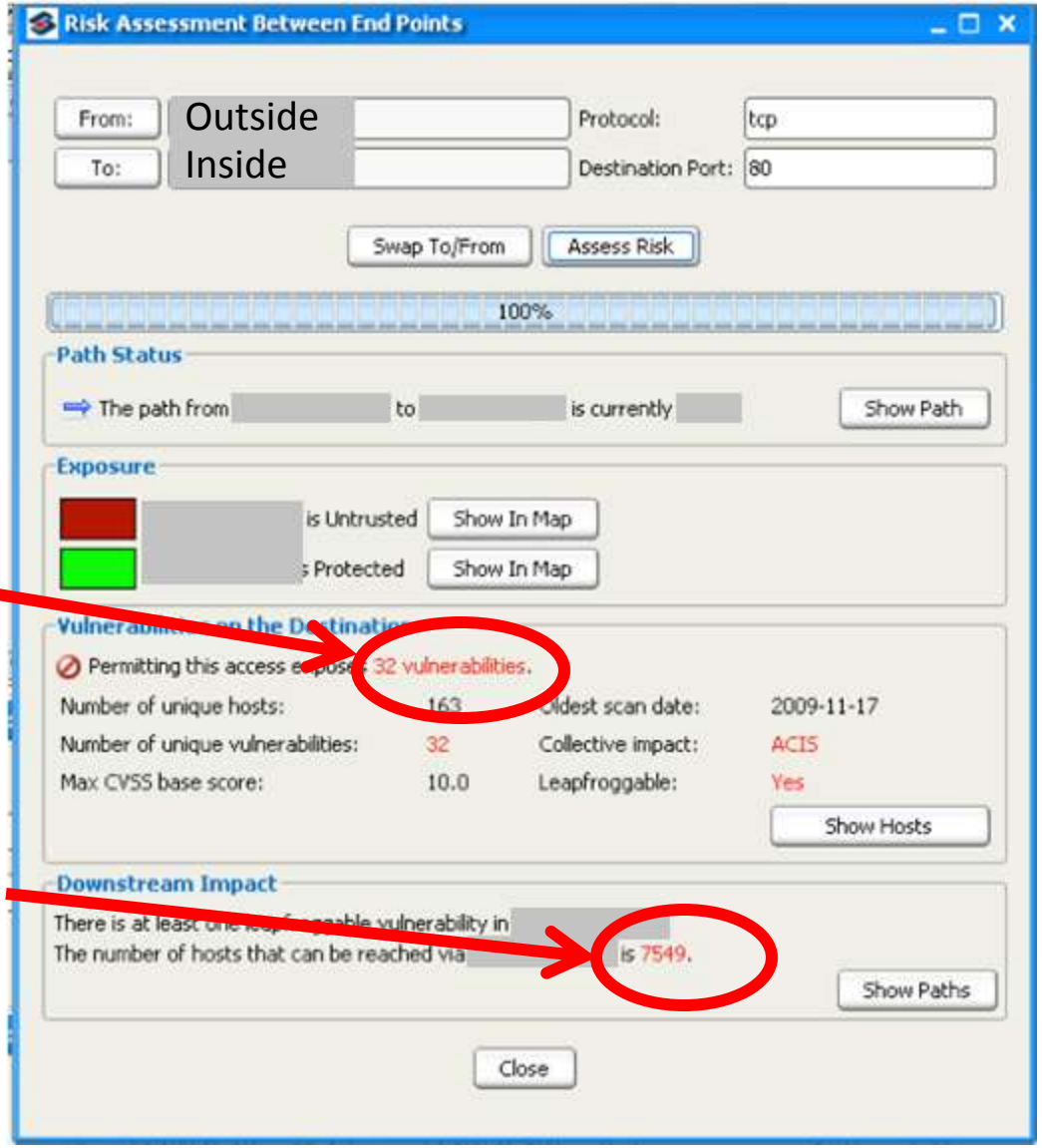


DMZ **Cisco Campus**

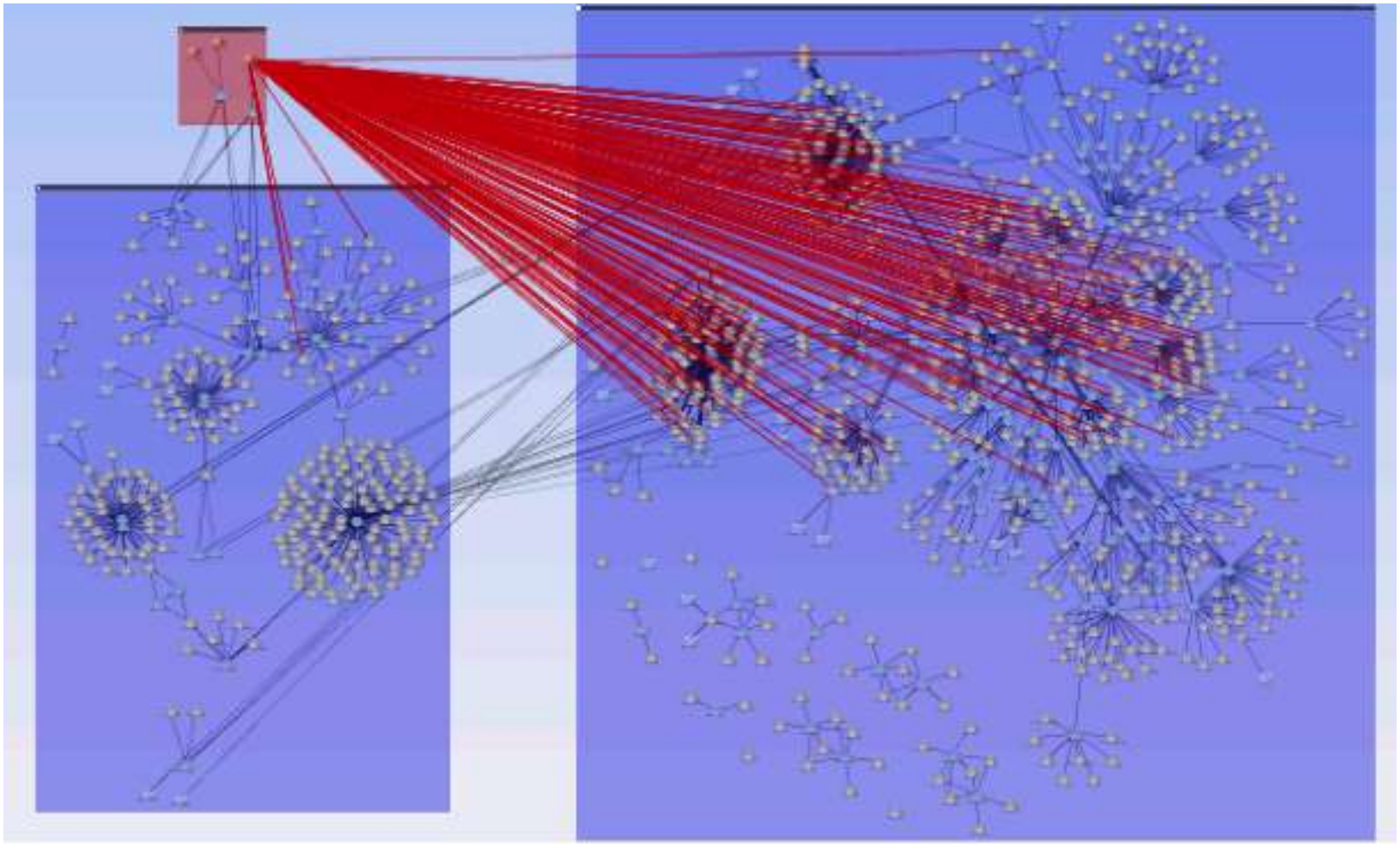
Client Connection Request

- Create Network Model
- Input Vulnerability Data
- Business need: Open one Class C network :80
  - Connection exposes 32 vulnerabilities

Downstream Effect?
Exposes 7,549 Vulnerabilities

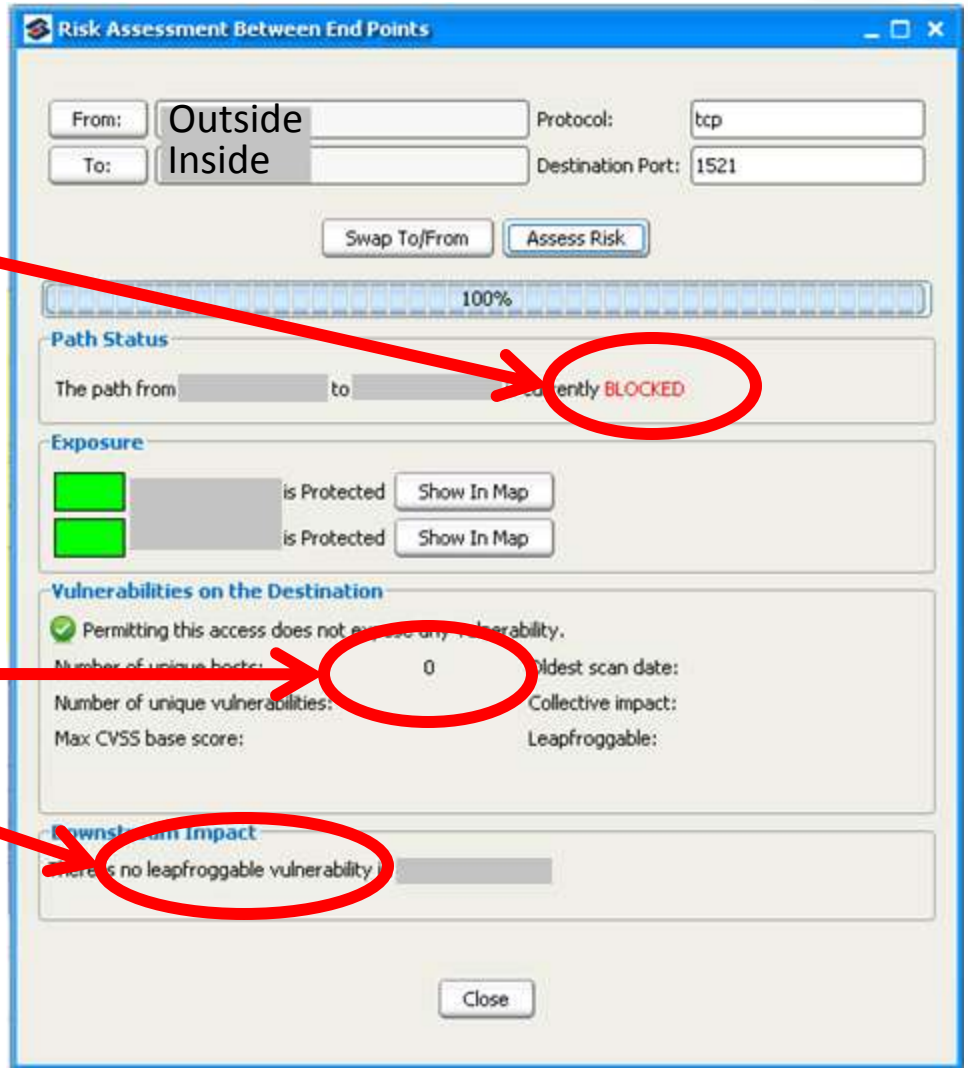


Client Connection Exposure



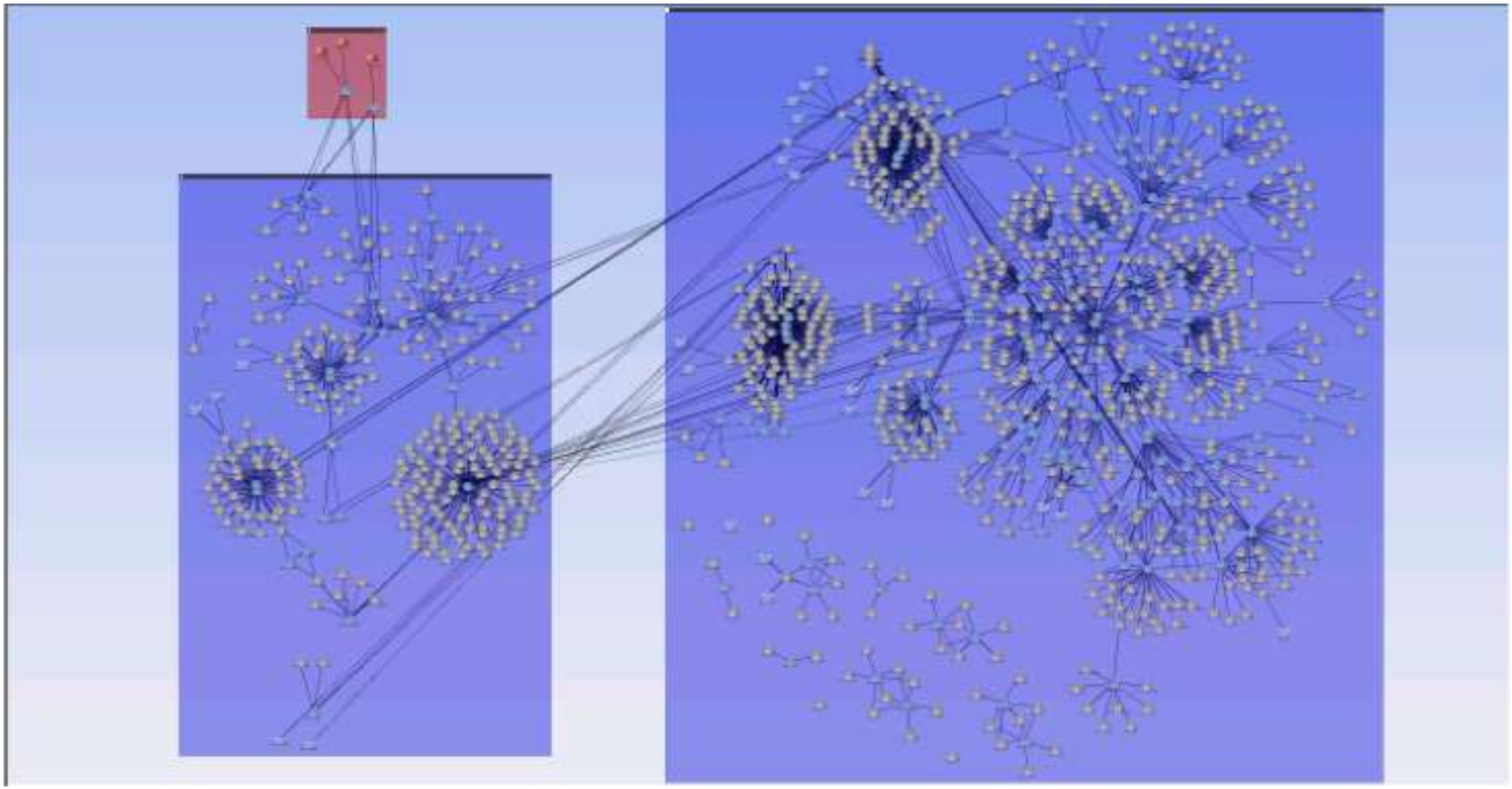
Acceptable Risk Assessment

- Access is BLOCKED
- No hosts vulnerable; nothing Leapfroggable



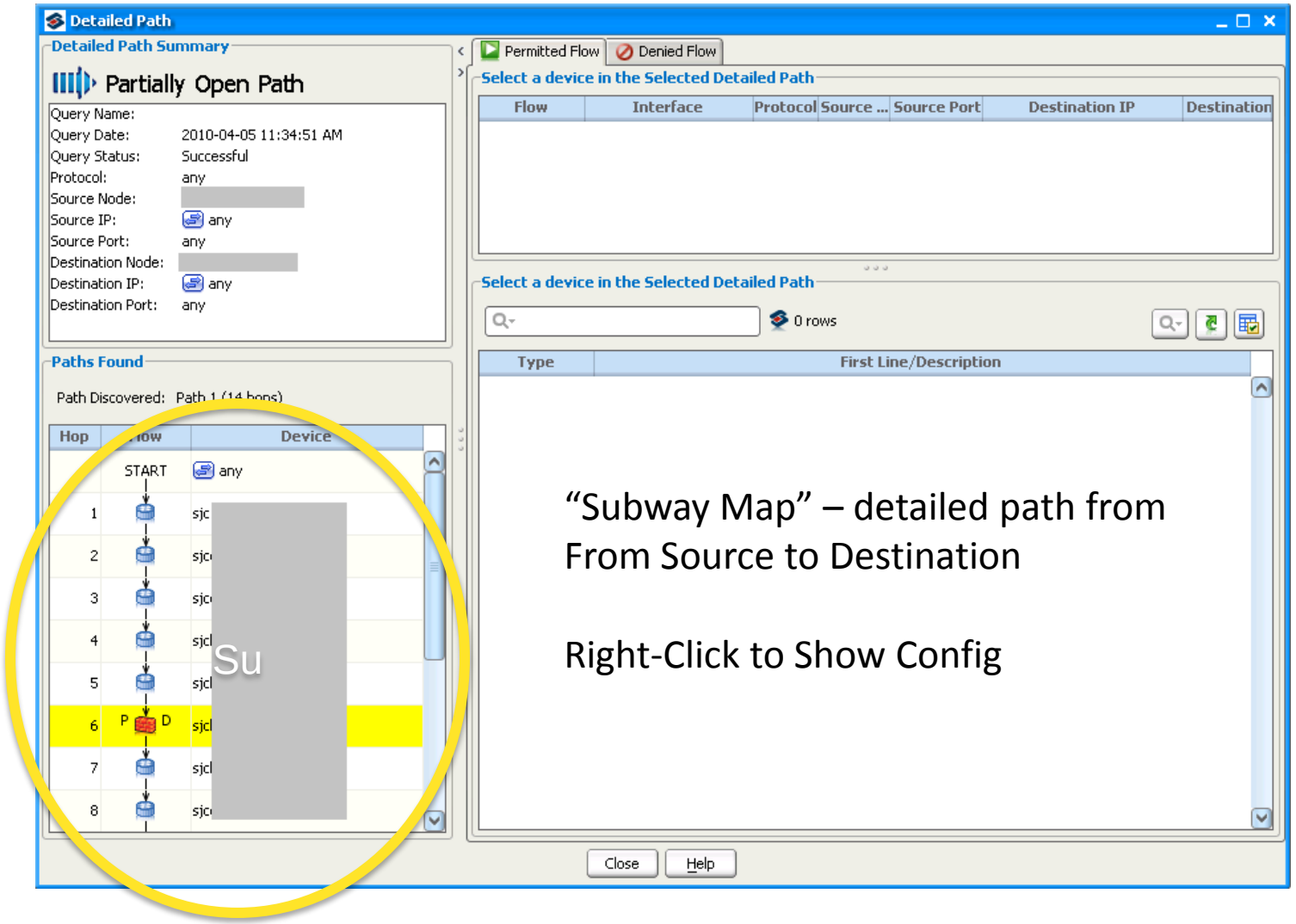
RTP Campus Network Map

Internet

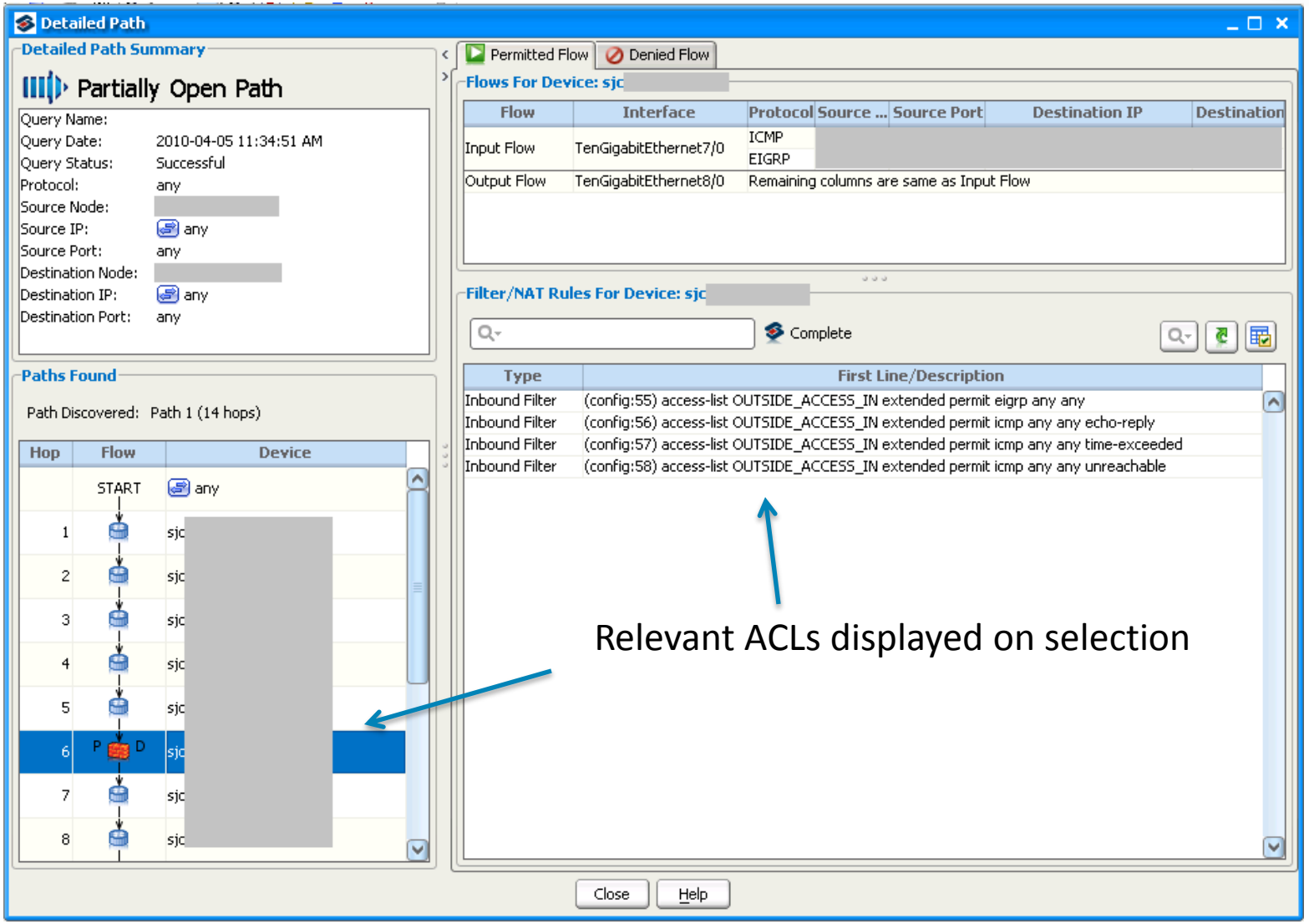


DMZ **Cisco Campus**

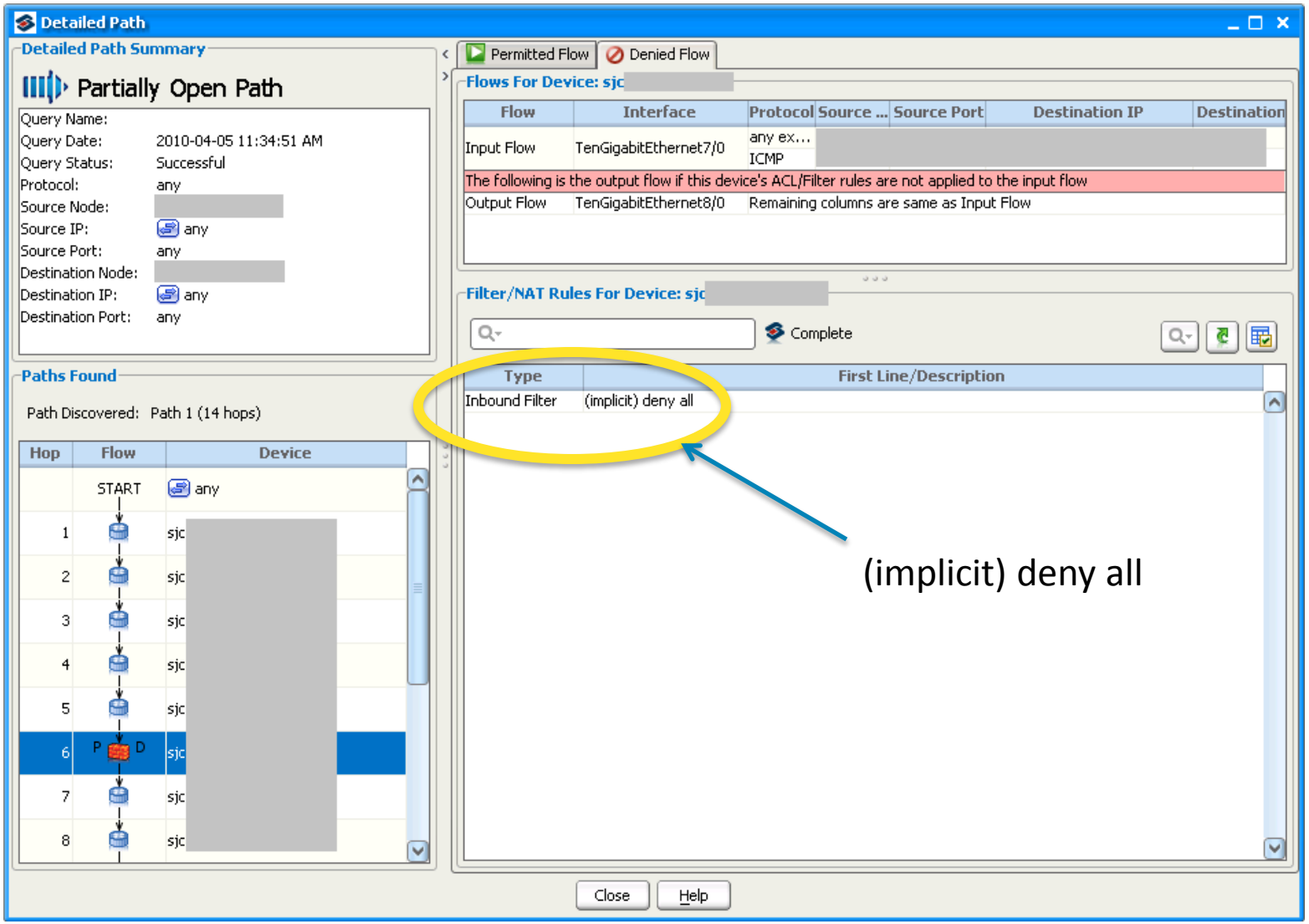
Isolate Partially Blocked Access Path



Pinpoint Firewall Permissions



Isolate Blocking Rule



Before vs. After

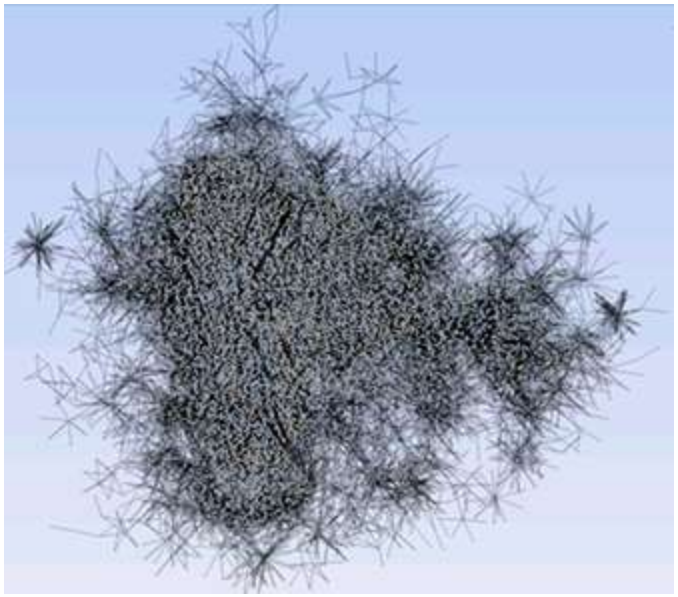
- Before
  - The Carnac moment
  - Could only enforce general best practices (“spell checking”)
  - Exceptions granted based on need, no real risk evaluation

- After
  - Push-button assessment of impact
  - Visuals to demonstrate nature of exposure
  - Automatic pin-pointing of rules needing to change

Lesson #10: We can finally have a coherent discussion with the business

Automating network audit

Before:



After:

What we covered

- Large Topology (the Bug Splat) – very useful, but too big to handle
- Tactical Target (PKI) – Take something small and critical and fix it
- Perimeter Assessment with Vulnerabilities – Nine PoPs in a day
- Passive Perimeter Penetration Testing – Automated, Everywhere, Daily
  - Risk Evaluation Object Model
  - All PoPs, Networks, and Vulnerabilities
- Change Management – Enabling a coherent discussion with the business

About Cisco and RedSeal

- RedSeal is the technology behind these case studies
- We are an end user of Redseal
  - We use 20 copies of their software
  - In InfoSec, Webex, Telepresence and advanced engineering
- We have signed a new, multi-year distribution partnership
  - Between RedSeal and our Advanced Services division
- We will be announcing service offerings

  Based on RedSeal, bundled with Cisco AS personnel

  For the federal and major enterprise marketplace

  Please stay tuned – announcement due shortly

Lesson Summary

- Lesson 1 – You need a config repository.
- Lesson 2 – Naming conventions are your friend.
- Lesson 3 – Pictures easily explain difficult concepts.
- Lesson 4 – A reference atlas is your friend.
- Lesson 5 – Networks gather ‘cruft’.
- Lesson 6 – “Best Practices’ are called ‘Best Practices’ for a reason.
- Lesson 7 – ‘Regular’ people can do this.
- Lesson 8 – Network data + Vuln data + Attack path = GOLD.
- Lesson 9 – Computers are better at reading phone books than you are. Get over it.
- Lesson 10 – We can finally have a coherent discussion with the business.

Thank you.

- Questions?
- Contact:

  ddexter@cisco.com