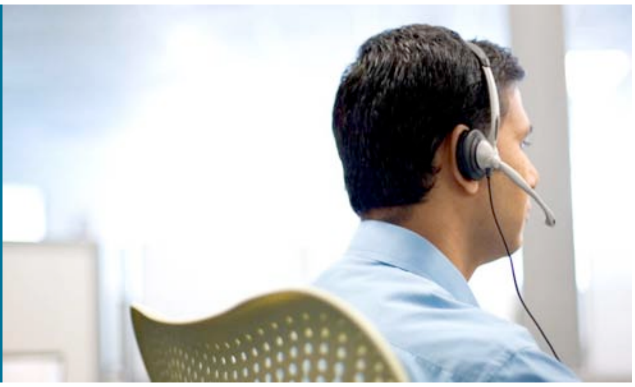
Security and Complexity in Networks



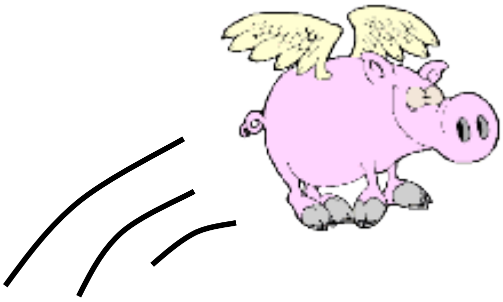
Michael Behringer <mbehring@cisco.com>

Distinguished Engineer

ReSIST Summer School, 27 Sep 2007

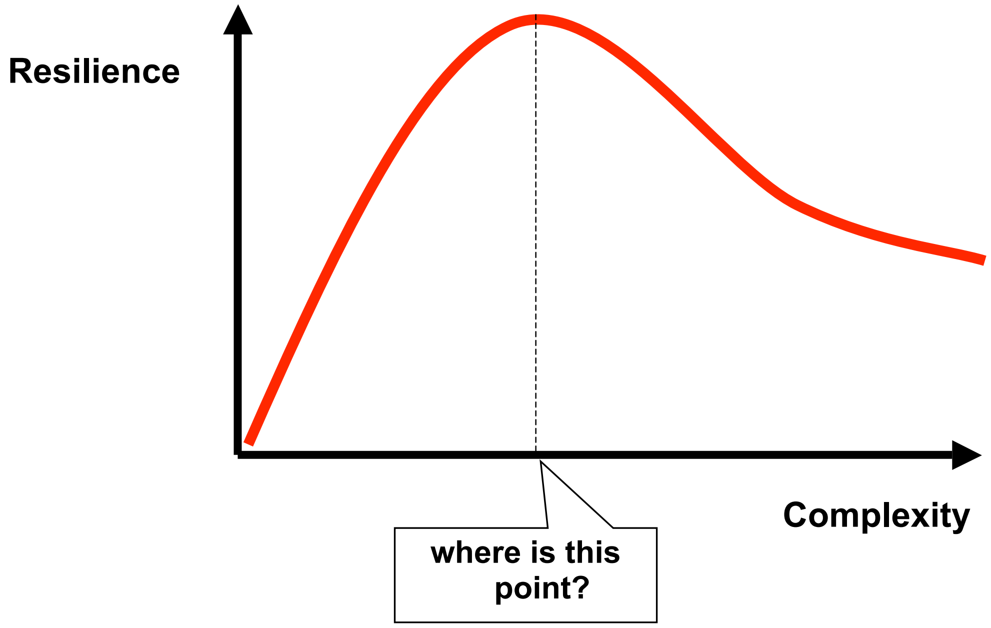
RFC 1925: The Twelve Networking Truths

- “With sufficient thrust, pigs fly just fine.”



“However, this is not necessarily a good idea.”

The Resilience-Complexity Trade-Off



where is this point?

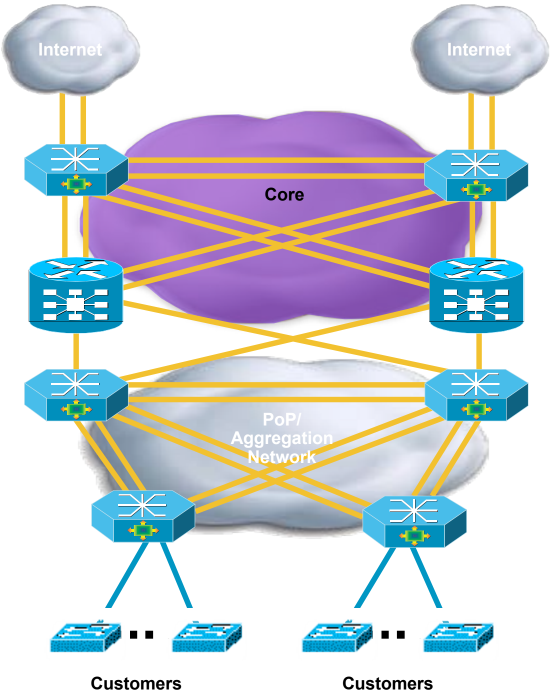
General Networking Recommendations

- Keep it simple
- Single resilience generally sufficient

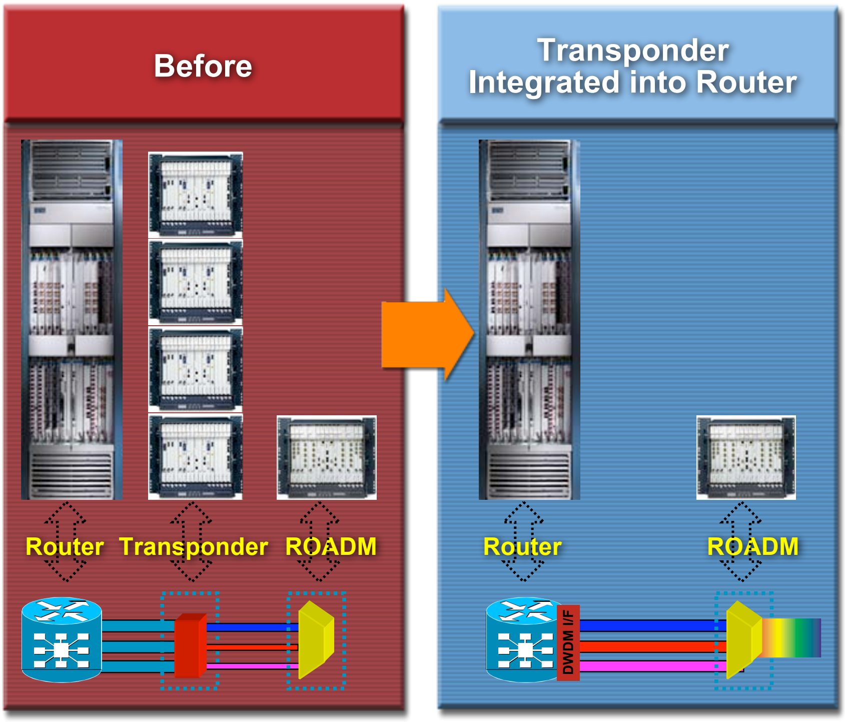
  3: Often too complex!
- Layering

  Do a job in *one* layer, and do it well

  Example: Failover



IP over DWDM - Simplicity



- Increased Performance

  4x increase in throughput for *existing* 10G DWDM systems

- Lower CapEx

  50% optics reduction

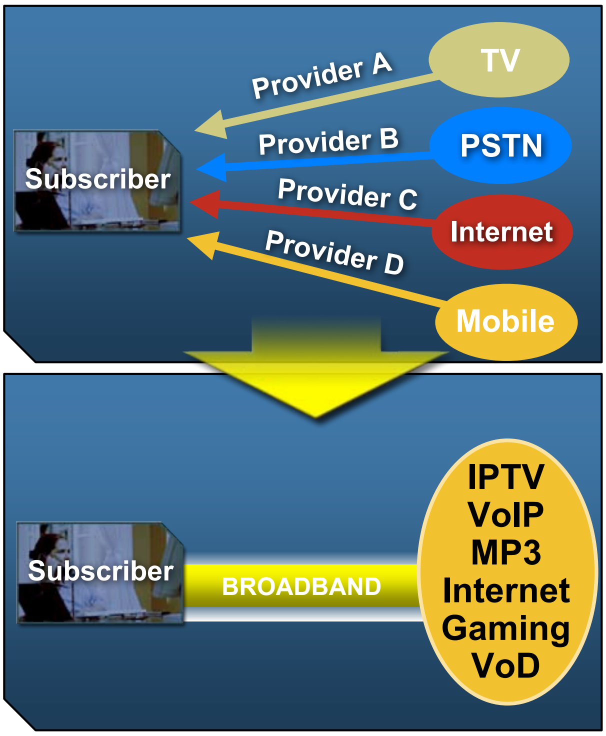
- Lower OpEx

  Fewer shelves (space, cooling, power, management), fewer interconnects

- Enhanced resiliency

  Fewer devices, fewer active components, fewer interconnects

2010 – The SP Nightmare – IP Works



Dedicated access for each service

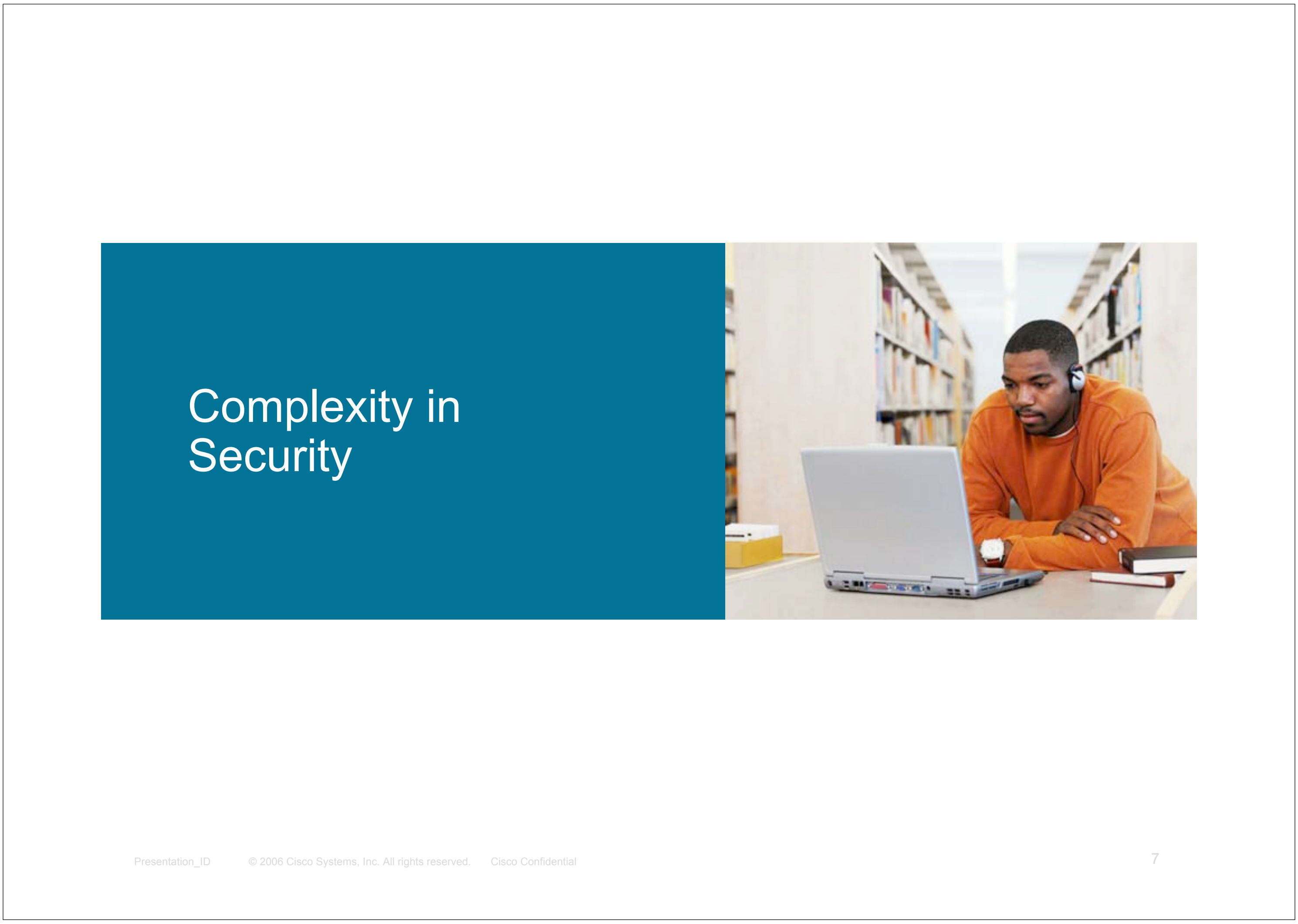
Trust within service

Reliability per service

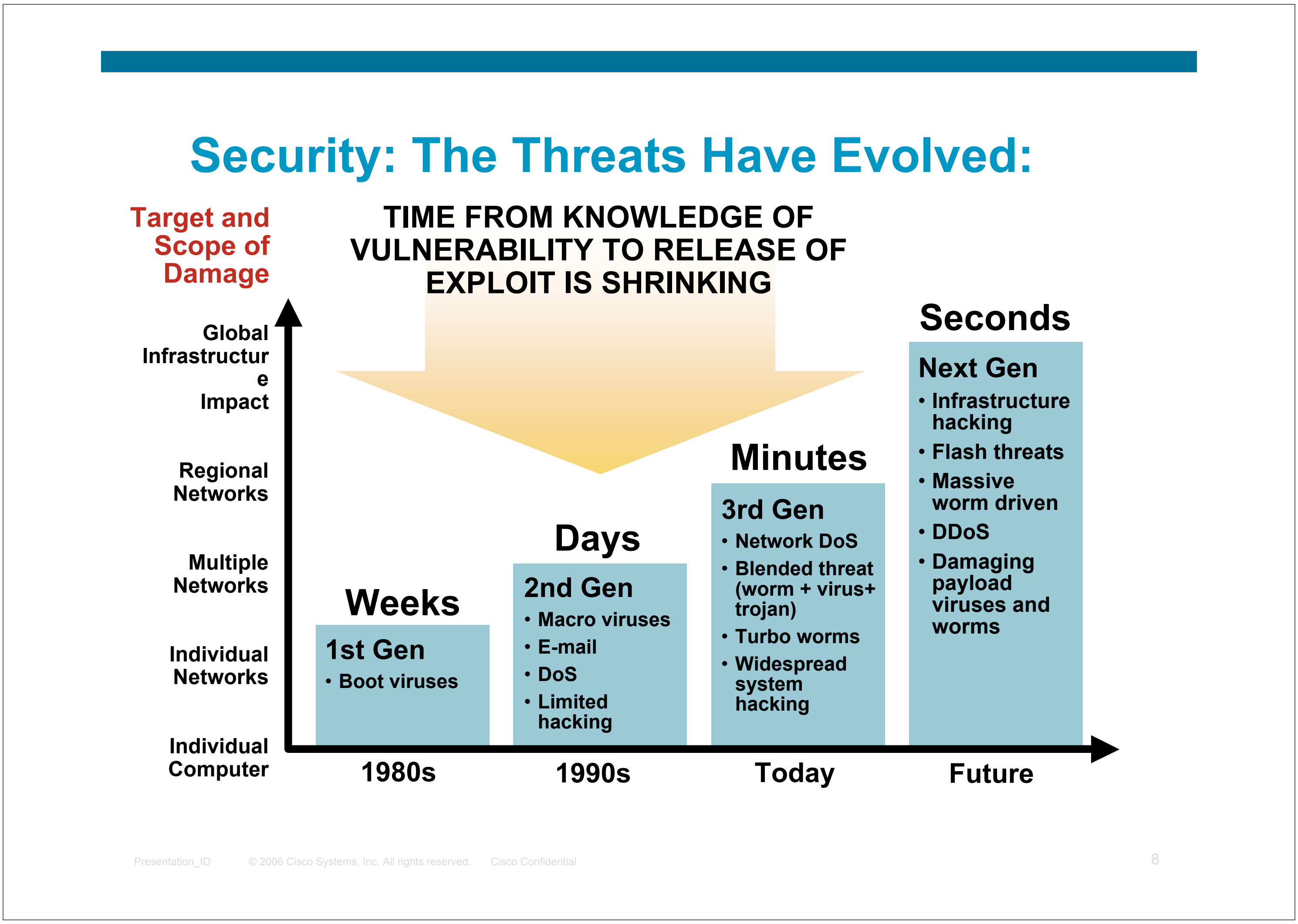
One access for all

Trust no one / everyone

Overall reliability



Complexity in Security



Security: The Threats Have Evolved:

TIME FROM KNOWLEDGE OF VULNERABILITY TO RELEASE OF EXPLOIT IS SHRINKING

Target and Scope of Damage

Global Infrastructure Impact

Regional Networks

Multiple Networks

Individual Networks

Individual Computer

1980s – Weeks

1st Gen
- Boot viruses

1990s – Days

2nd Gen
- Macro viruses
- E-mail
- DoS
- Limited hacking

Today – Minutes

3rd Gen
- Network DoS
- Blended threat (worm + virus+ trojan)
- Turbo worms
- Widespread system hacking

Future – Seconds

Next Gen
- Infrastructure hacking
- Flash threats
- Massive worm driven
- DDoS
- Damaging payload viruses and worms

Example Intrusion Protection: The Problem Space

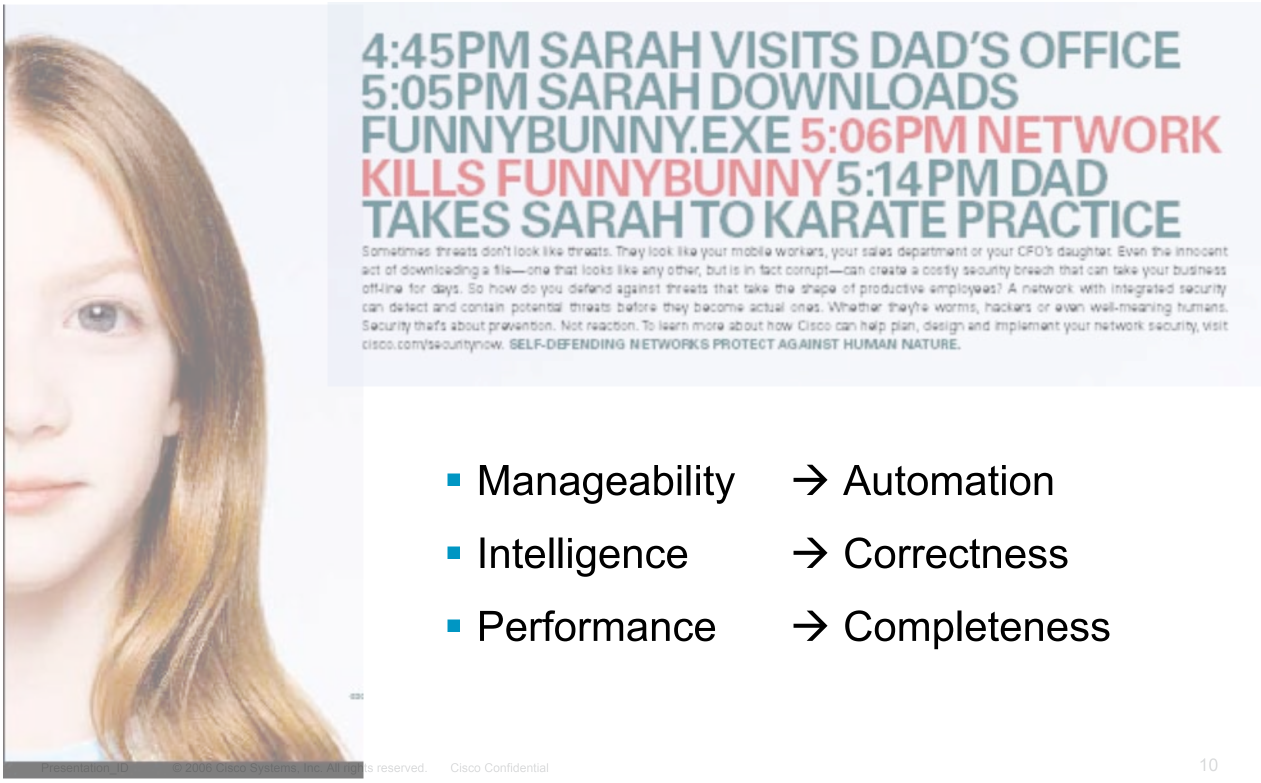
- Signature management
- Many different IDS approaches
- False positives
- Day-0 recognition
- Scale of alerts
- Complexity of decision
- Network scale
- Visibility (encryption, location, …)
- …

Manageability

Intelligence

Performance

The Goal



4:45PM SARAH VISITS DAD'S OFFICE 5:05PM SARAH DOWNLOADS FUNNYBUNNY.EXE 5:06PM NETWORK KILLS FUNNYBUNNY 5:14PM DAD TAKES SARAH TO KARATE PRACTICE

Sometimes threats don't look like threats. They look like your mobile workers, your sales department or your CFO's daughter. Even the innocent act of downloading a file—one that looks like any other, but is in fact corrupt—can create a costly security breach that can take your business off-line for days. So how do you defend against threats that take the shape of productive employees? A network with integrated security can detect and contain potential threats before they become actual ones. Whether they're worms, hackers or even well-meaning humans. Security that's about prevention. Not reaction. To learn more about how Cisco can help plan, design and implement your network security, visit cisco.com/securitynow. **SELF-DEFENDING NETWORKS PROTECT AGAINST HUMAN NATURE.**

- Manageability → Automation
- Intelligence → Correctness
- Performance → Completeness

IDS: Approaches

- Signature based (define “bad”)

  Needs to know attack up front; hard to manage

- Behaviour based

  Complex to manage; up front config

+ quite precise
- complex
- slow

- Honeypots

  Good for worms and scanning, not much else

- Statistical Analysis

  Only detects big changes

+ performant
- not precise enough

Two Generic Approaches

1. Full packet / session inspection

   Precision!!!

   But: Mostly signature based, see next section

   But: Performance required, see later

2. Header inspection: Flow based, honeypot

   Statistics based → heuristics are simple

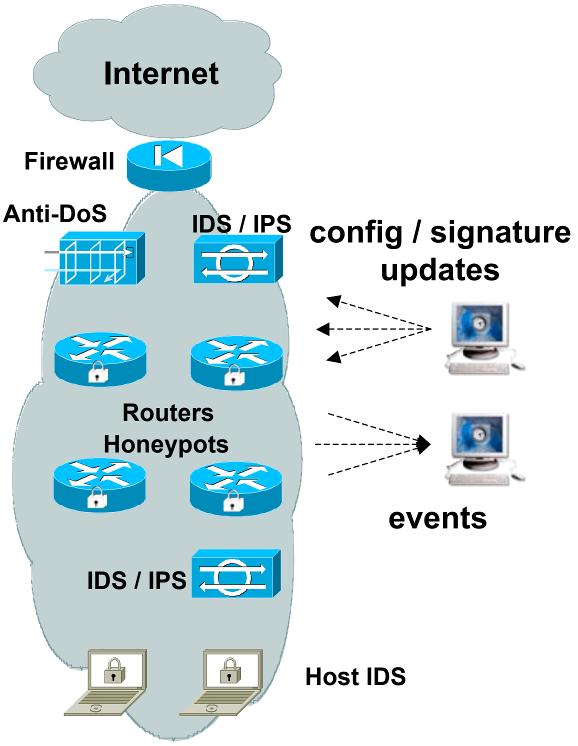
   Can catch day-zero, quite efficient

   But: Not precise enough!!!

Probably both required!

Manageability

Manageability Challenges: Overview



- Different device types
  - Router, firewall, IDS, HIDS, DDoS protection, honeypot, …
  - → Different IDS capabilities
  - → Different management
  - → Different signatures
  - → Different event types
- Scaling issues:
  - Updating N devices
  - Receiving lots of events
  - Correlation

Number of Events, Network Wide

Model	Performance Events/Sec*	Performance NetFlows/Sec
	50	7,500
	500	15,000
	1000	30,000
	3000	75,000
	5000	150,000
	10,000	300,000

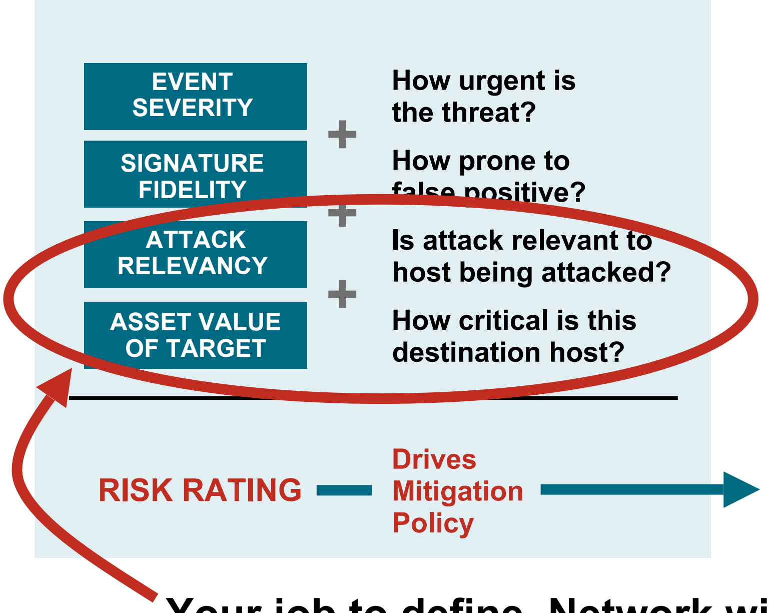
Marketing Stuff irrelevant here

1000s of events per second
10,000s of flows per second

Intelligence

Process for Accurate Threat Mitigation:

Rating Alarms for Threat Context



EVENT SEVERITY + How urgent is the threat?

SIGNATURE FIDELITY + How prone to false positive?

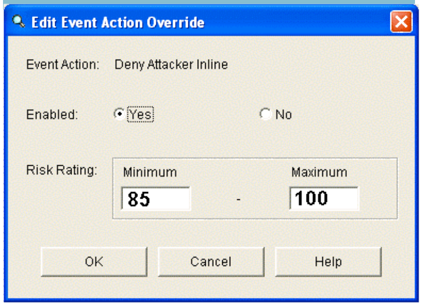
ATTACK RELEVANCY + Is attack relevant to host being attacked?

ASSET VALUE OF TARGET How critical is this destination host?

RISK RATING — Drives Mitigation Policy →

Your job to define. Network wide.

Decision Support Balances Attack Urgency with Business Risk



Edit Event Action Override

Event Action: Deny Attacker Inline

Enabled: ● Yes ○ No

Risk Rating: Minimum 85 - Maximum 100

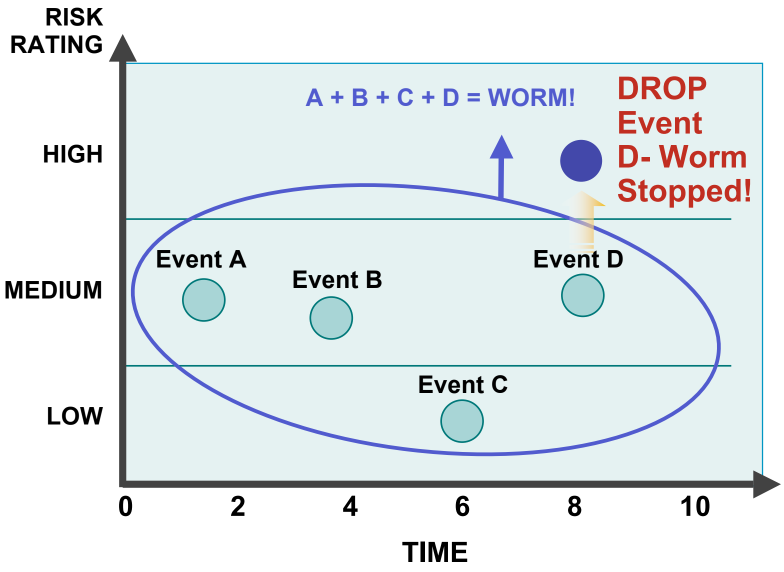
Customizable Risk Rating Thresholds :

0 < RR < 35	Alarm
35 < RR < 85	Alarm & Log Packets
85 < RR < 100	Drop Packet

Process for Accurate Threat Mitigation:

Integrated Event Correlation

On-Box Correlation Allows Adaptation to New Threats in Real-Time without User Intervention



- Links lower risk events into a high risk meta-event, triggering prevention actions
- Models attack behavior by correlating:

  Event type

  Time span

Example for Increasing Complexity: Obfuscation

IDS looking for "..\" to detect attacks like:

...\WINNT\SYSTEM32\CMD.EXE

IDS needs to look for "\":

- \ or /
- %5c (%5C is hexa code for \ )
- %255c (%25 is hexa code for %)
- %%35c (%35 is hexa code for 5)
- %%35%63 (%63 is hexa code for c)
- %c0%af (using Unicode)
- ....

} Double decode !

→ **IDS must parse! → Complex!**

Performance

Performance: Goal

- Inspect:
  - Each packet header
  - Each packet payload
  - At full line rate
- Checks:
  - against 1000s signatures
  - do virtual reassembly
  - be stateful (track connections)
  - application awareness

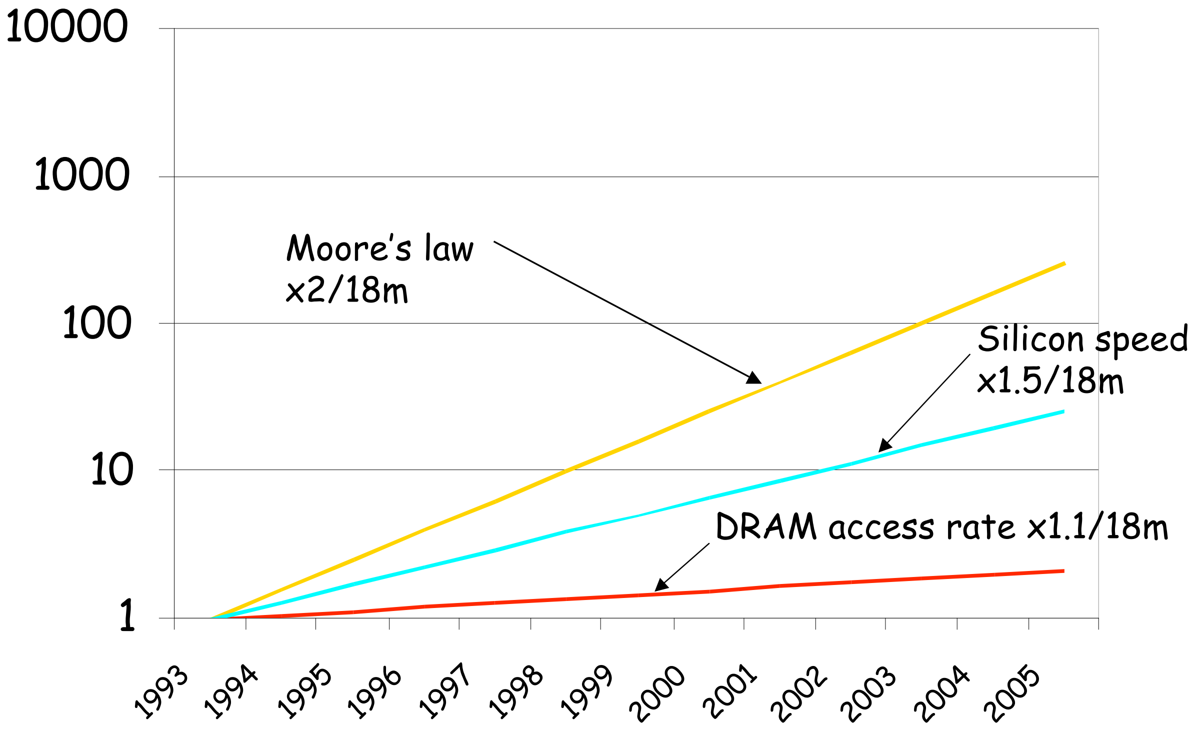
BUT:

Network Speed Development: ↗

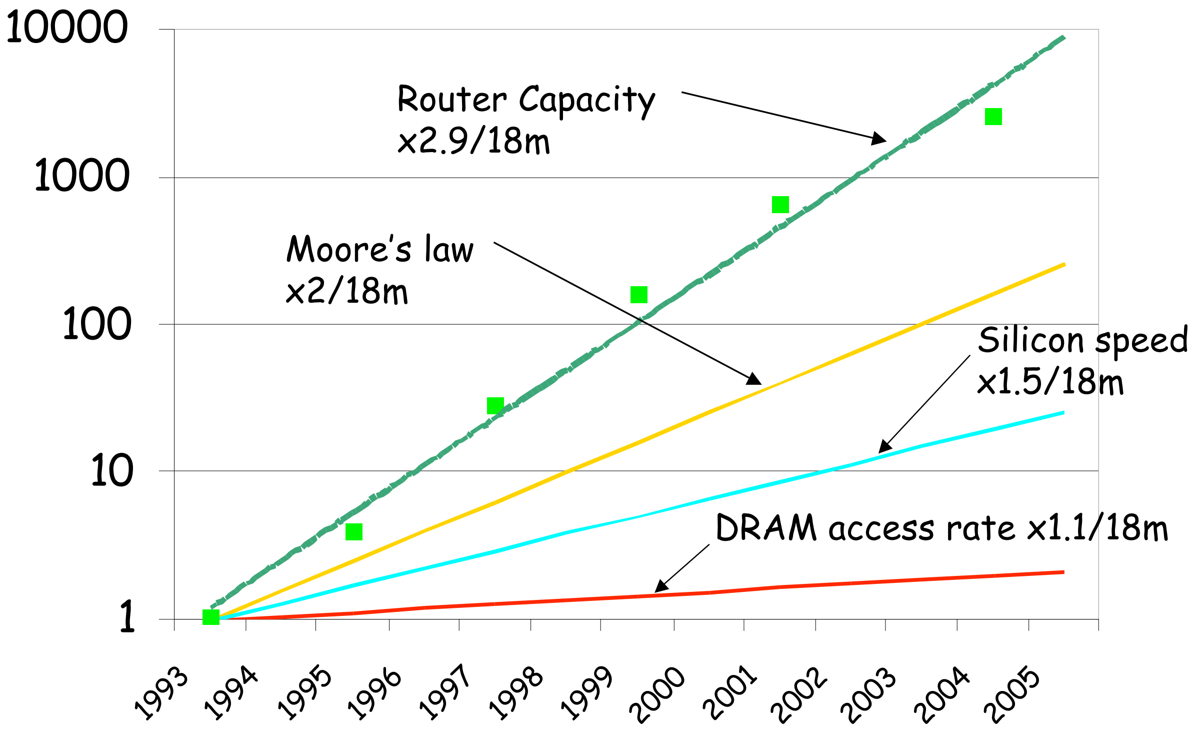
Complexity Development: ↗

… so: “just build faster chips!”

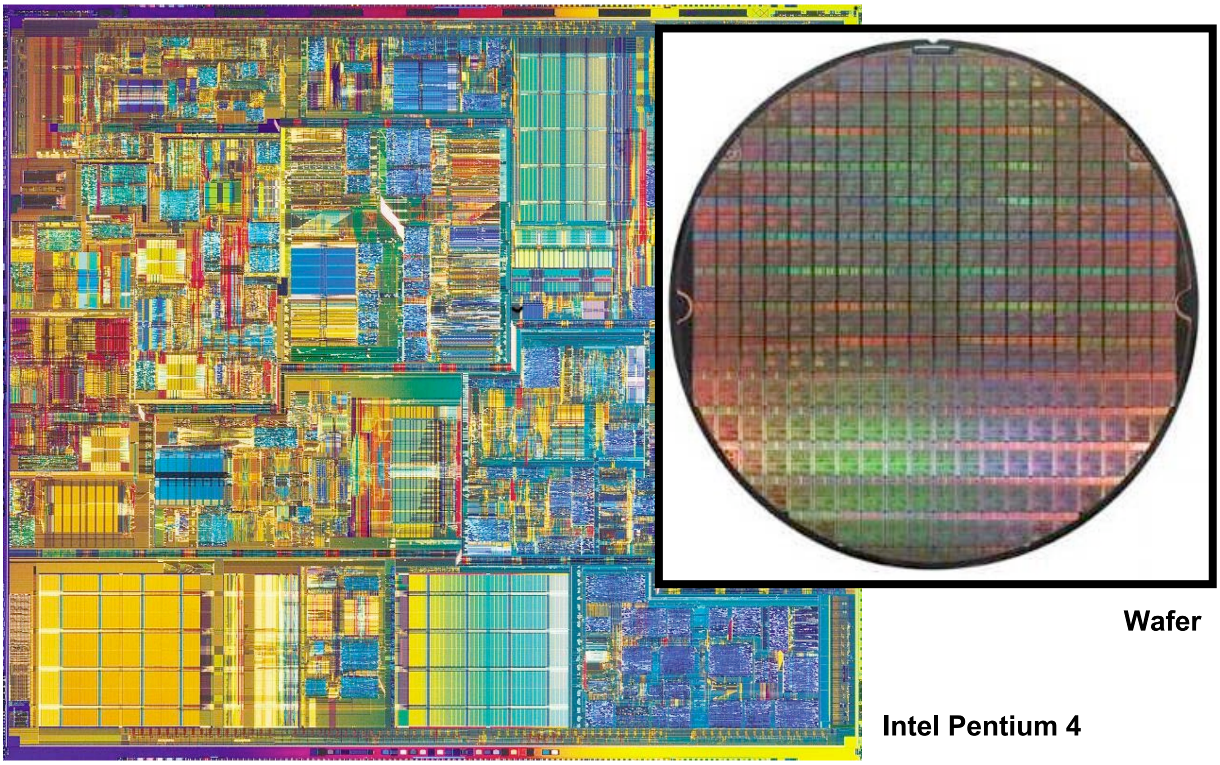
Silicon Industry Challenge



Silicon Industry Challenge



Silicon Density – Touching the Limits

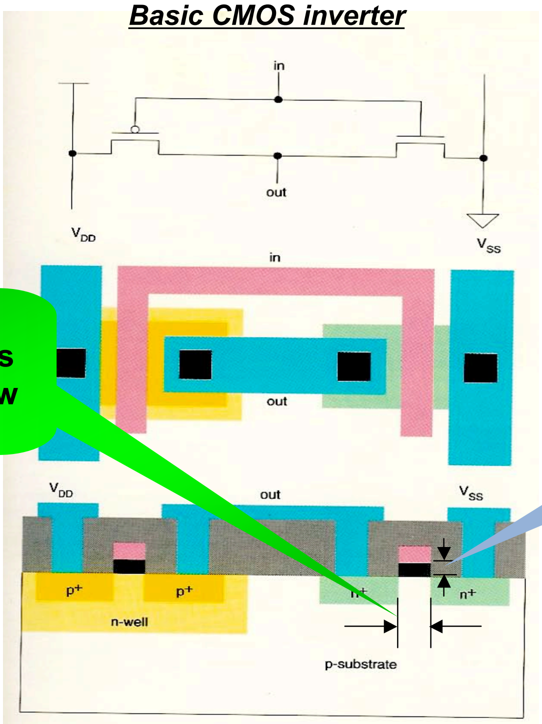


Wafer

Intel Pentium 4

Silicon Density and Moore’s Law

Basic CMOS inverter



“Feature size”
This dimension is what Moore’s Law is all about!

Gate Oxide Layer
For 90nm process, this is approx 1.2nm = 5 Atoms!

ASIC Feature Size Evolution

Feature size (drawn) (μm)	Qual. Year	Usable Gates (M)	DRAM density (Mbit/mm^2)	Gate delay (ps)	Power (nW/MHz/gate)	Core Voltage	Metal layers
0.25	1999	10	-	?	50	2.5/1.8V	5/Al
0.18 (0.15)	2000	24	0.81	23	20	1.8V	6/Cu
0.13 (0.10)	2002	40	1.5	20/15	9	1.2V/1.5V	7/Cu
0.09 (0.07)	2004	72	2.9	11/7	6	1.0V/1.2V	8/Cu
0.065	2005	120	?	6/8	4.5/5.0	1.0V/1.2V	9/Cu

Source: IBM SA-12E, SA-27E, Cu-11, Cu-08, Cu-65

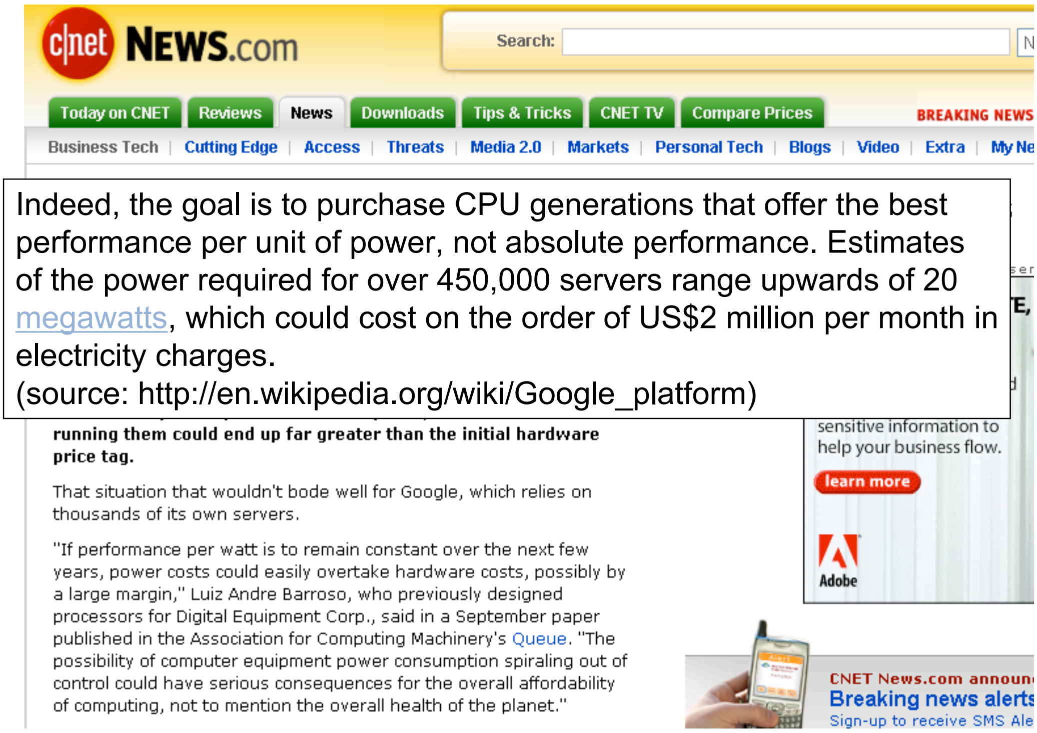
Biggest Scaling Issue: Power!

The constraints of ‘standard’ cooling and packaging of networking systems are very significant…

Device	Power
‘486	< 5W
Pentium	10W
Pentium II (400MHz)	28W
Pentium III (1.33GHz, 0.13um)	34W
Pentium IV (3.2GHz, 0.09um)	103W
Pentium “Extreme Edition 840” 3.2GHz, HyperThreading	180W

Source: Intel datasheets

Power is Becoming an Issue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Indeed, the goal is to purchase CPU generations that offer the best performance per unit of power, not absolute performance. Estimates of the power required for over 450,000 servers range upwards of 20 megawatts, which could cost on the order of US$2 million per month in electricity charges.
(source: http://en.wikipedia.org/wiki/Google_platform)

running them could end up far greater than the initial hardware price tag.

That situation that wouldn't bode well for Google, which relies on thousands of its own servers.

"If performance per watt is to remain constant over the next few years, power costs could easily overtake hardware costs, possibly by a large margin," Luiz Andre Barroso, who previously designed processors for Digital Equipment Corp., said in a September paper published in the Association for Computing Machinery's Queue. "The possibility of computer equipment power consumption spiraling out of control could have serious consequences for the overall affordability of computing, not to mention the overall health of the planet."

CRS-1 System Mechanical

Line Card Chassis Overview—Full Rack Unit

- Slots (Midplane design):

  Front

  16 PLIM slots

  2 RP slots + 2 Fan Controllers

  Back

  16 LC Slots

  8 Fabric cards

- Dimensions:

  23.6” W x 41*” D x 84” H

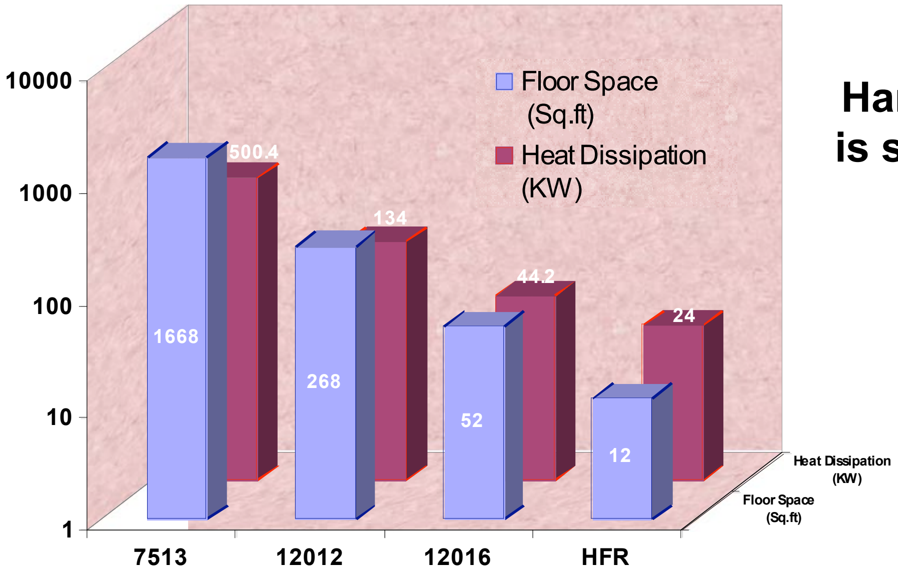
  (60 W x 104.2 D x 213.36H (cm))

- Power: ~12 KW (AC or DC)
- Weight: ~ 707kg
- Heat Dis.: 33000 BTUs (AC)

***For standalone Chassis Depth = 35” (no fabric chassis cable management)**

But: Efficiency is Still Increasing!!

Resources for a 1 Terabit Router



Hardware design is still improving!!

Scaling Performance

- Not just “faster, faster, faster”
- Need new approaches for h/w and s/w
- Distribute processing:
  - Host – switch – edge router – core router
  - Each device what it knows best
- But: Challenge in Management!

The Way Forward

So, Host Based Security is “the” Solution, right?

- Performance distributed
- Encryption not an issue
- Stateful
- Application awareness

Sounds ideal, doesn’t it?!?

BUT:

Can you trust the host?
- may be subverted
- User might switch host secuirty off / bypass it
- Service Provider Case: no control over host!

Ways Forward

- Distribute processing

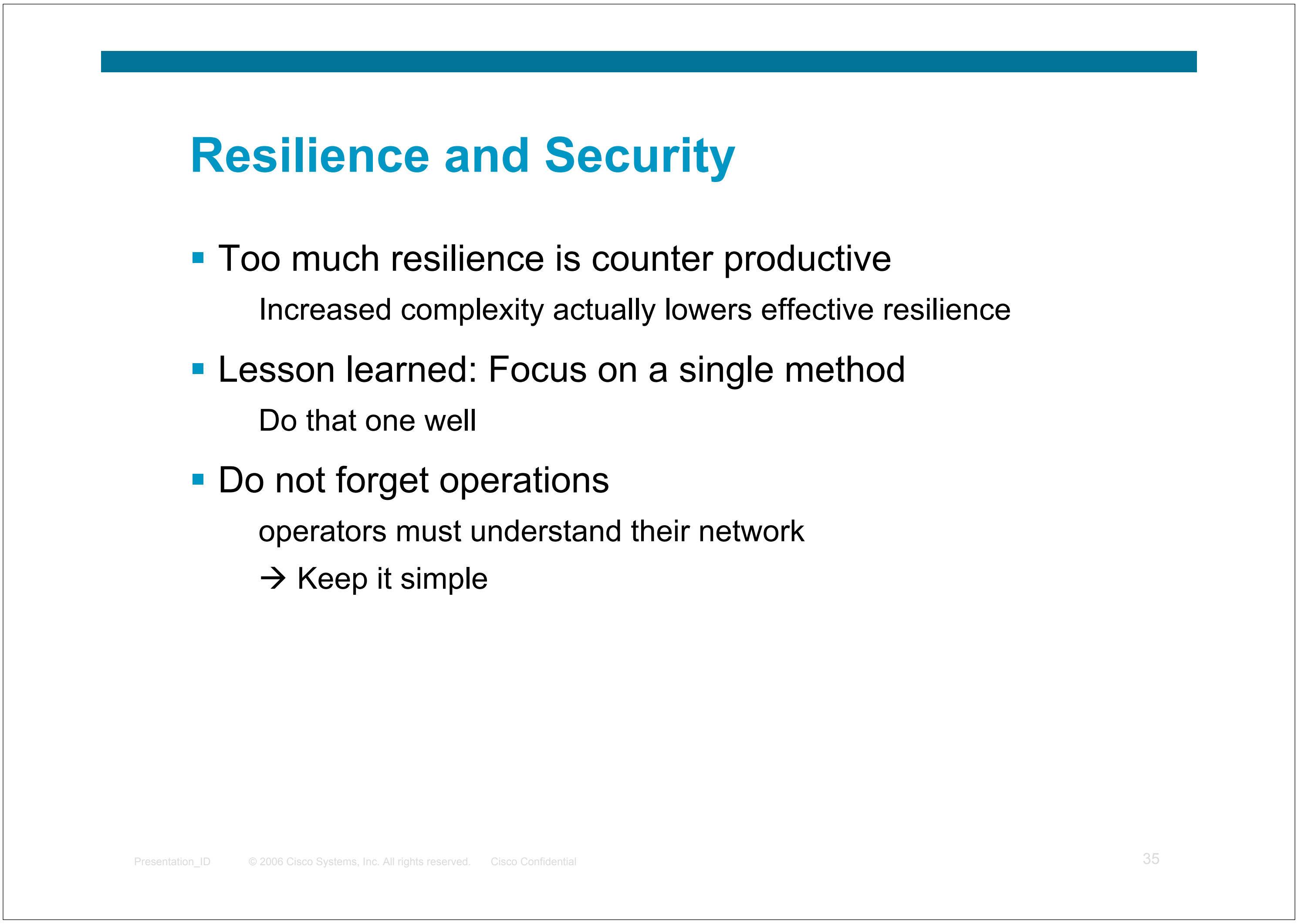
  Host, router, access switch, honeypot, …
- More “intelligence”

  Innovative, simple, approaches
- Evolve management

  Distributed, “intelligent”
- Combine approaches

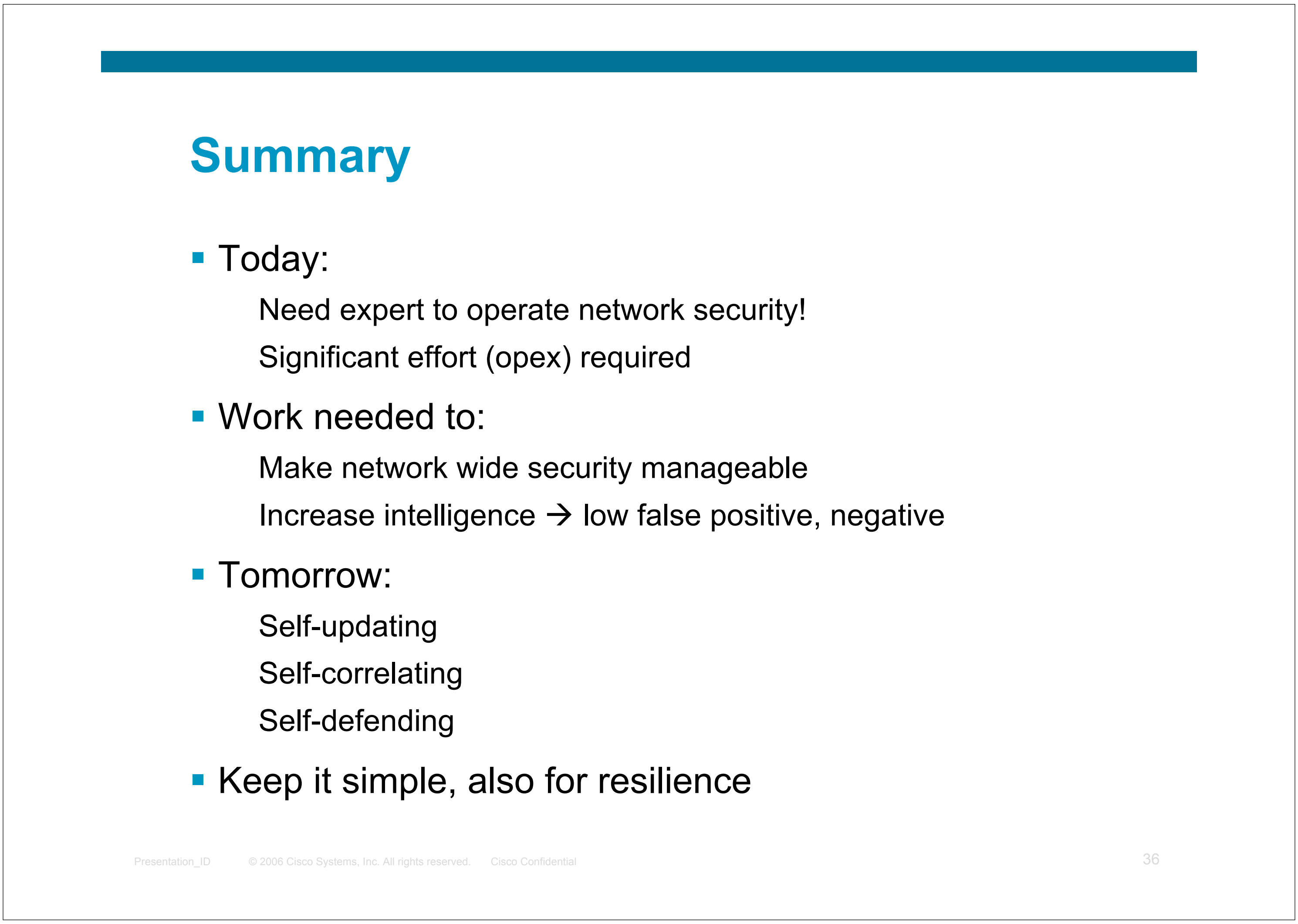
  Signature based, flow based, behaviour based, …

… more research needed!



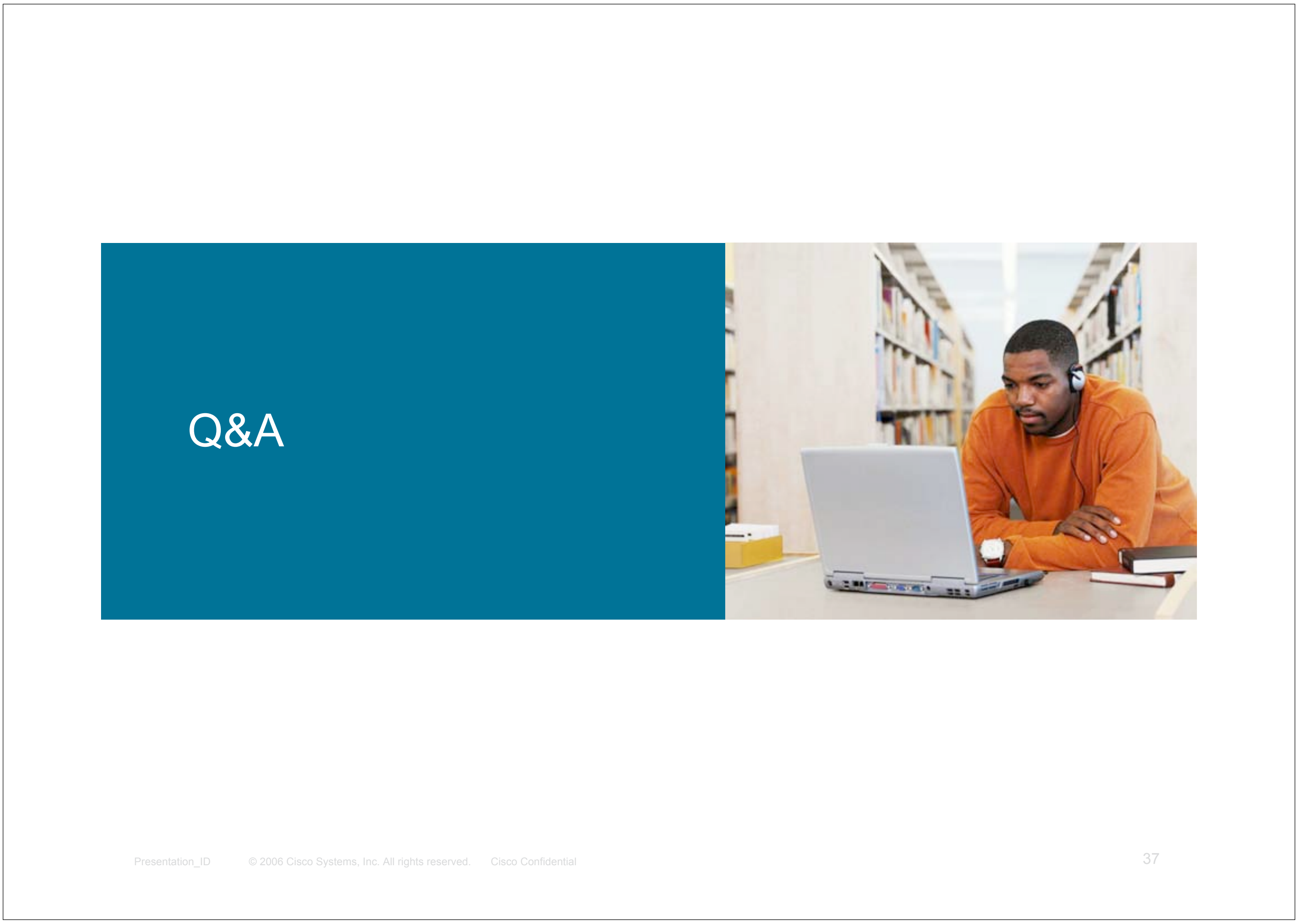
Resilience and Security

- Too much resilience is counter productive
  - Increased complexity actually lowers effective resilience
- Lesson learned: Focus on a single method
  - Do that one well
- Do not forget operations
  - operators must understand their network
  - → Keep it simple



Summary

- Today:
  - Need expert to operate network security!
  - Significant effort (opex) required
- Work needed to:
  - Make network wide security manageable
  - Increase intelligence → low false positive, negative
- Tomorrow:
  - Self-updating
  - Self-correlating
  - Self-defending
- Keep it simple, also for resilience



Q&A