Defense at Hyperscale: Technologies and Policies for a Defensible Cyberspace

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@Jason_Healey

Outline

1. De-buzzwording This Talk
2. Bad Guys Finish First
3. A More Defensible Cyberspace
4. Payout for Getting it Right (or Wrong)

Not Trying to Make This an RSA Talk…

- Forget “Hyperscale” and “Defensible”
- Substitute “Internet and connected devices” instead of “cyberspace” if that helps

Core Ideas

Beyond Buzzwords

- No central strategy behind infosec today
  - To drive our actions
  - To judge between competing public goods
  - To measure our overall strategic progress against

Core Ideas

- "Making _____ more defensible" is the strategy
  - My Organization
  - My Sector
  - Cyberspace as a whole

- Being defensible means solutions with *advantage* and *scale*
- To find future advantage and scale, we must know what has so succeeded in the past

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$$O > D$$

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Lt Col Roger Schell (USAF) *in 1979*

Why is O>D?

A dollar (or hour) spent on attack buys far more than a dollar spent on defense

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   "We need more secure products, not more security products.” (Phil Venables, 2004)

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   Resulting complex systems: “processes that can be described, but not really understood ... often discovered through trial and error” (Charles Perrow)

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6. **Troublesome humans:**

   Even the best and most secure technological systems can be bypassed when human users are lazy, confused or downright tricked.

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If the problem is O>D

the solution must be D>O (or even D>>O)

Is this even possible?

Key Questions to Tackle D>O

Results from NY Cyber Task Force

1. What is a defensible cyberspace and why hasn't it been defensible to date?
2. What past interventions have made the biggest difference at the largest scale and least cost?
3. What interventions should we make today for the biggest differences at the largest scale and least cost?

Membership of the NY Cyber Task Force			
Dmitri Alperovitch	Crowdstrike	**Jeff Moss**	DEF CON and Black Hat
Ed Amoroso		**Angela McKay**	Microsoft
Steve Bellovin	Columbia University	**Derek O'Halloran**	World Economic Forum
John Carlson	FS-ISAC	**Gary Owen**	Time-Warner
Gordon Goldstein	Silverlake	**Neal Pollard**	PriceWaterhouseCoopers
Royal Hanson	American Express	**Greg Rattray**	JP Morgan Chase
Jason Healey	Columbia University	**Katheryn Rosen**	Blackrock
Melody Hildebrandt	Palantir	**Marc Sachs**	NERC
Yurie Ito	Japan CERT	**Karl Schimmick**	Morgan Stanley
Merit Janow	Columbia University	**Adam Segal**	CFR
James Kaplan	McKinsey	**Timothy Strabbing**	Viola Foundation
Elena Kvochko	Barclays	**Christine Taylor**	SIPA Student
Art Langer	Columbia University	**Phil Venables**	Goldman Sachs
David Lashway	Baker McKenzie	**Matt Waxman**	Columbia University
Herb Lin	Stanford CISAC	**John Yetter**	NASDAQ
Aaron Martin	JP Morgan Chase	**Larry Zelvin**	Citi

What Would a Defensible Cyberspace Look Like?

Results from NY Cyber Task Force

Defensible = "Defense Advantage"

1. Agile response and decision-making
2. Instrumented and measurable
3. Multi-stakeholder and collaborative
4. Well-governed and policed
5. Few externalities
6. Resilient: Recovers readily

A dollar (or hour) spent on ***defense*** buys far more than a dollar spent on ***attack***!

What past interventions have made the biggest difference at the largest scale and least cost?

To slash or to trim

Emission reductions by policies/actions, bn tonnes CO_2 equivalent

Policy/Action	Cumulative emissions	Period	Annual emissions*
Montreal protocol[1]	135.0bn	1989-2013	5.6bn
Hydropower worldwide[2]	2.8bn	2010	2.8bn
Nuclear power worldwide[2]	2.2bn	2010	2.2bn
China one-child policy[3]	1.3bn	2005	1.3bn
Other renewables worldwide[2]	600m	2010	600m
US vehicle emissions & fuel economy standards†[4]	6.0bn	2012-25	460m
Brazil forest preservation[5]	3.2bn	2005-13	400m
India land-use change[6]	177m	2007	177m
Clean Development Mechanism[7]	1.5bn	2004-14	150m
US building & appliances codes[4]	3.0bn	2008-30	136m
China SOE efficiency targets[8]	1.9bn	2005-20	126m
Collapse of USSR[9]	709m	1992-98	118m
Global Environment Facility[10]	2.3bn	1991-2014	100m
EU energy efficiency[11]	230m	2008-12	58m
US vehicle emissions & fuel economy standards‡[4]	270m	2014-18	54m
EU renewables[11]	117m	2008-12	29m
US building codes (2013)[12]	230m	2014-30	10m
US appliances (2013)[12]	158m	2014-30	10m
Clean technology fund[13]	1.7bn	*project lifetime*	*na*
EU vehicle emission standards[14]	140m	2020	*na*

CATEGORIES:
Energy production
Transport
Other regulations
Global treaties
Land & forests
Other

See following panel for sources and explanations

*Annual emissions are cumulative emissions divided by the relevant period. The estimate for the current emissions avoided under the Montreal protocol is eight billion tonnes of CO_2e. The annual figure for the collapse of the USSR refers to the years 1992-98. †Cars and light trucks ‡Heavy trucks

http://www.economist.com/news/briefing/21618680-our-guide-actions-have-done-most-slow-global-warming-deepest-cuts

Game-Changing Solutions

Results of NY Cyber Task Force

Requires two components:

- **Advantage**: Dollar of defense must buy more than a dollar of attack
- **Scale**: Dollar of defense should give 10x, 100x, or even 1,000,000x the benefits – hyperscale

Least Game-Changing Solutions

- Generally impose far higher costs to the defender than the attacker
  - **Technology**: Compliance and other solutions featuring checking-the-box
  - **Policy**: Wassenaar Agreement to limit “cyber weapons”

Game-Changing Technologies

With Scale and Advantage

1. Automated Updates
2. Cloud-Based architecture
3. Encryption
4. Secure default configurations
5. Authentication beyond passwords
6. Mass vulnerability scanning
7. Kerberos
8. Built-in NAT for home router
9. Address space layout randomization (ASLR) and kernel memory protection
10. DDoS protection

Game-Changing Technologies
With Scale and Advantage

Automated updates:

Including, but not limited to Microsoft Update. “Once Microsoft got vested in security they were in the best position to do something about it”

(Jeff Moss, Jeff Schmidt)

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Game-Changing Technologies
With Scale and Advantage

Cloud-Based architecture:

Including related technologies like virtualization and containterization.

"When deployed properly, the cloud provides several critical security advantages over perimeter-based models including greater automation, self-tailoring, and self-healing characteristics of virtualized security."

(Ed Amoroso, Phil Venables)

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Game-Changing Technologies
With Scale and Advantage

Encryption:

One of the few places in all computer science where, if properly implemented, the defense has all the advantages against the attacker
(Steve Bellovin)

"Effective enough that it dissuades most from breaking it; there are usually other, less costly means available to the attacker."
(Wade Baker)

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Game-Changing Technologies
With Scale and Advantage

Secure default configurations:

"Some vendors have made some progress here (particularly Microsoft), and it makes a huge difference. The most impactful parts of the USG Configuration Baseline are when vendors just incorporate it into their standard configuration."

(Senior Government Official)

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Game-Changing Technologies
With Scale and Advantage

Kerberos: “Changed the way the entire world did authentication” (Phil Venables)

Authentication beyond passwords: Not just authentication, but a slew of multi-factor solutions such as algorithmic and the like (Bruce Schneier)

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Mass vulnerability scanning:

"Solutions like nmap gave an easy and fast enterprise-wide view making fixing them far easier"

(Mike Aiello)

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Game-Changing Technologies
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Built-in NAT for home router:

"Built-in NAT (simple firewall) has been extremely effective in stopping direct front door assaults against systems with open ports and unknown running services."

(Marc Sachs)

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Game-Changing Technologies
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Address space layout randomization (ASLR) and **kernel memory protection**:

"Measures like stackguard and ASLR moving from research (ca 2000) to mainstream (ca 2008) defeated slew of common attacks … prioritizing security over compatibility."

(Jose Nazario, Dan Geer)

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DDoS protection:

"If an org can afford Cloudfare, etc., they can withstand hundreds of Gbps and stay online … not 'solved,' but defenses can substantially mitigate impact, unlike so many other issues."

(Richard Bejtlich)

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Additional Possibilities: Beau Woods

I Am the Cavalry and Atlantic Council

- Language choice
  - With C it's really hard to prevent errors and the failure modes are catastrophic to the software stack. By contrast something like Ruby on Rails has the penalty for failure of a nerf football
- Controls Retirement
  - We keep adding one control after another in pursuit of better defense in depth. Most organizations are up to their neck in DiD and it's suffocating them without benefit. Old controls like AV aren't really helping but they're costing 8-10B per year.
  - Radically different IT thinking obviates some of these old expensive things by fixing root causes not apparent ones
  - Related: Retire legacy infrastructure (Phil Venables)
- MAC not DAC
  - Mandatory Access Control is like whitelisting on steroids. The entire OS is hostile to untrusted code. Especially effective in Mobile, IoT, and other places
- Software Supply Chain
  - Modern software platforms are 80-90 percent assembled rather than written
  - DevOps is an application of supply chain theory to agile development allowing us to run faster and stay safer
- Software Bill of Materials
  - Even the best vulnerability scanners have high degree of false positives and negatives. SBOMs are precise and accurate

Possible Next-Gen Game-Changers

Ongoing Work of the NY Cyber Task Force

- **Return of Formal Methods**, like DARPA's High-Assurance Cyber Military Systems

  "Not unhackable completely. There are certain obvious pathways for attackers that have all been shut down in a way that's mathematically proven to be unhackable for those pathways." (Arati Prabhakar)

- **Compiler-Generated Software Diversity**:

  "After every 100th download of a given app … re-compiles that app with a strong diversity compiler making the next 100 downloads different from the previous 100. This prevents mass exploitation, though at a cost: it is no longer possible to confirm whether a given binary corresponds to a given source blob." (Dan Geer)

- **Security solutions for IoT**

  If you think cyberspace is insecure today, just wait for the coming Internet of Things. "The first 5 billion devices won't be like the next 50 billion. Modern cars are computers on wheels, and cutting edge patient care is delivered over the Internet. If we get this right, the promise will transform society; if we get this wrong we eliminate the resilience we seek." (Beau Woods)

- **Security score cards** like BitSight to drive insurance, behavior (Phil Venables)
- **Data-level protection** (Greg Touhill)

Hyperscale: Critical mass of cloud deployment

How Do Techs Become Real Game-Changers

Ongoing Work of the NY Cyber Task Force

1. Take Away Entire Classes of Attacks (Arati Prabhakar)
2. Take User out of the Solution (Bruce Schneier)
3. "Those responsible make a change that helps all their users" (Jeff Moss)
4. "Improve security by decreasing cost of control" (Phil Venables)
5. Minimize Consequence - agility, detection, and resilience (Art Coviello)

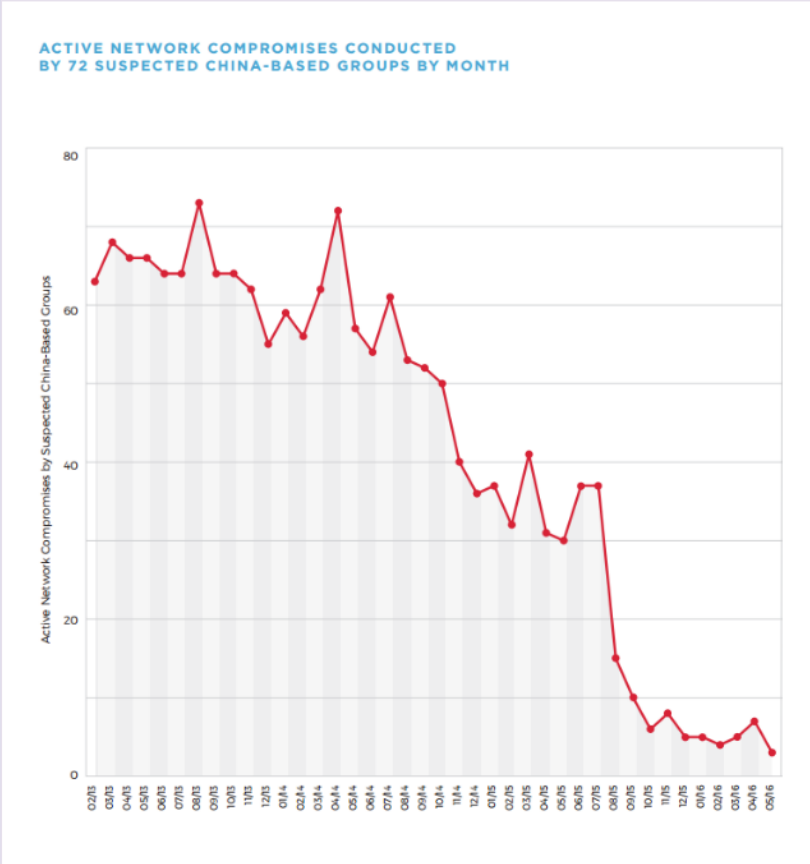
Operational and Policy Game-Changers

Harder to Measure

- Creation of the first CERTs in late 1980s
- Operational innovations: kill chain
- Automated threat sharing – STIX, TAXII, CyBox
- Institutionalized bug bounty programs
- Volunteer groups: Conficker, NSP-SEC, I am the Cavalry
- Industry Alliances: ICASI, Cyber Threat Alliance
- Budapest Convention on cyber crime

Operational and Policy Game-Changers

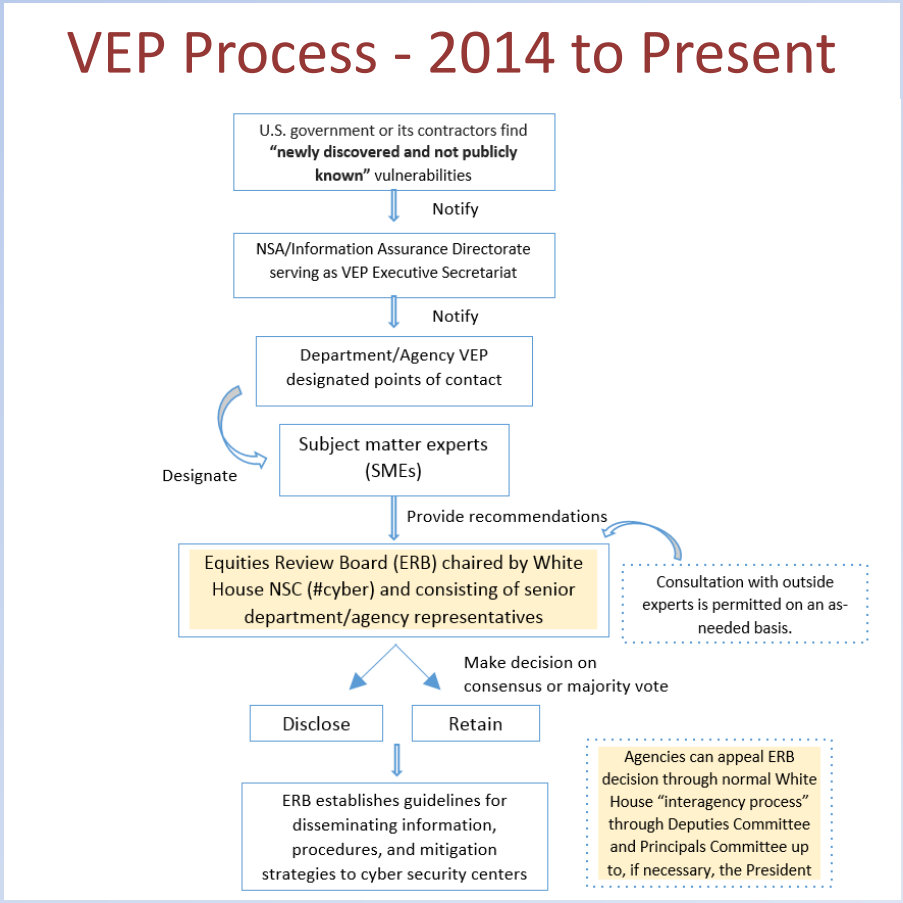
- **International norms along with indictments and threat of sanctions**
- FireEye: massive reduction of detected Chinese intrusions from ~70/month to less than 5/month
- What other solution have we *ever* implemented for such success at so little cost?



https://www.fireeye.com/content/dam/fireeye-www/current-threats/pdfs/rpt-china-espionage.pdf

Operational and Policy Game-Changers

- **USG policy of "bias" to not retain vulnerabilities, but disclose to vendors**
- USG "discloses far more vulnerabilities than it decides to keep secret, in one year keeping only about two for offensive purposes out of about 100 the White House reviewed"



Operational and Policy Game-Changers

- **USG policy bias to disclose to US companies when they've been pwned**
- Result: Law Enforcement now #1 source for breach notification (esp for botnet takedown), per Verizon

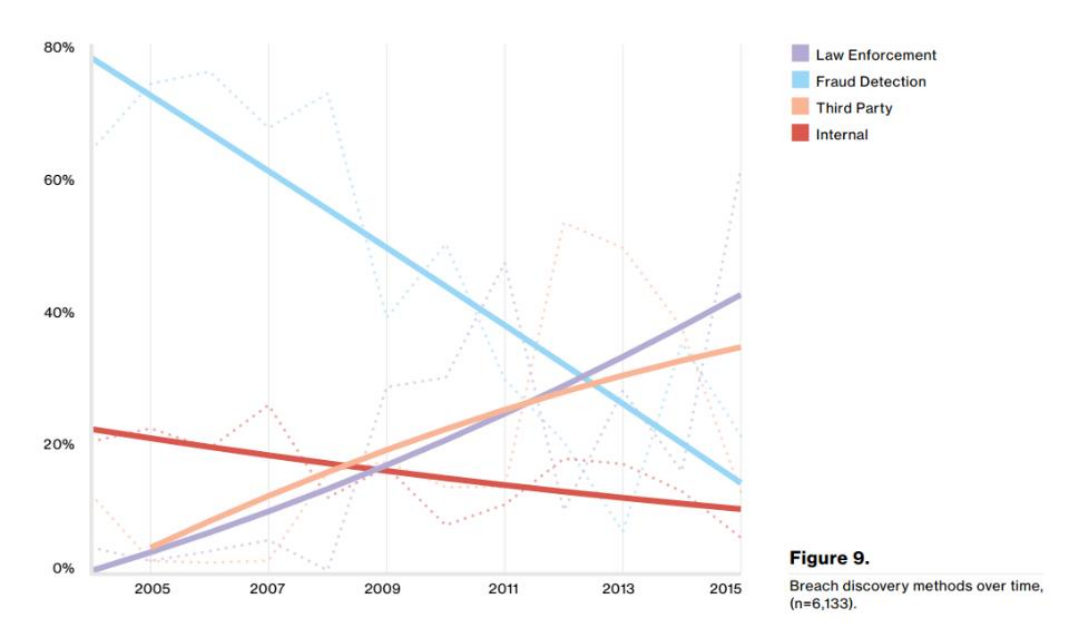


Figure 9.
Breach discovery methods over time, (n=6,133).

http://www.verizonenterprise.com/verizon-insights-lab/dbir/2016/

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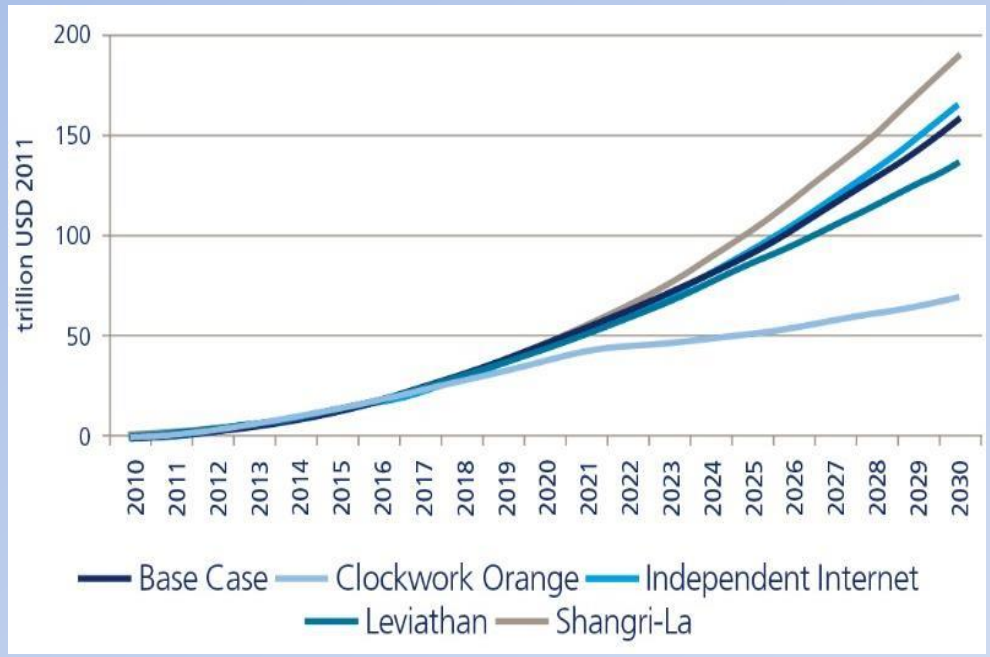
Implications

- Only potential futures aren't just
  - O>D (continued status quo)
  - D>O (defense advantage)
- Could be far worse, O>>D
  - or far better, D>>O
- Atlantic Council and Zurich Insurance Group modeled the economic impact of getting it right (or horribly wrong)

Possible Futures…

Best case is "**Cyber Shangri-La**" where D>O
Worst case is "**Clockwork Orange Internet**" where O>>D



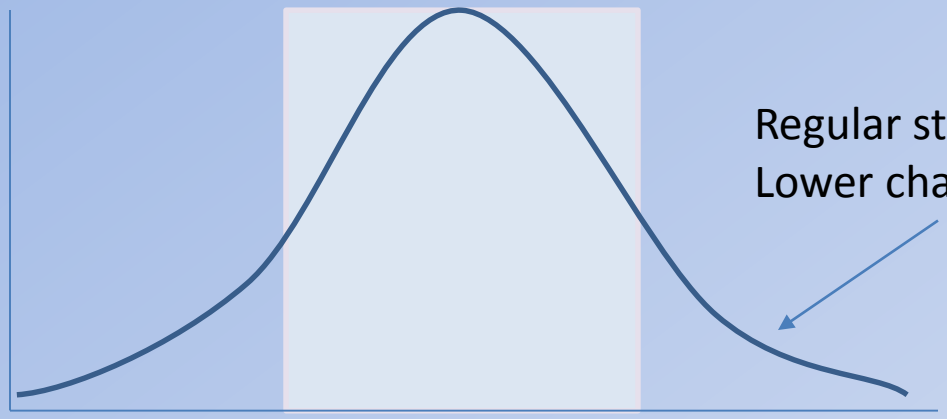
Cumulative Annual Benefits and Costs

Economic Impact Through 2030

Best case: ~$30 trillion
Worst case: ~$90 trillion

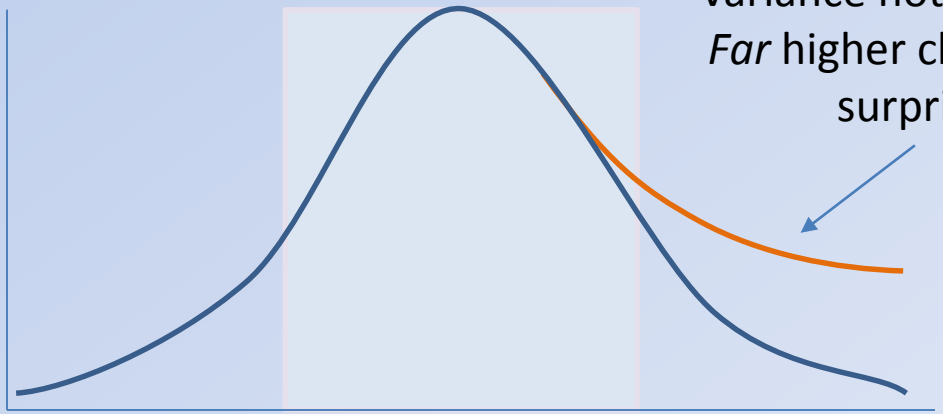
Difference in government control less impactful, still meaningful: $30 trillion

If Future Possibilities are "Fat Tail Distribution" Then Far More Potential Variability



Regular standard deviation
Lower chance of massive, unexpected events

Expected Future

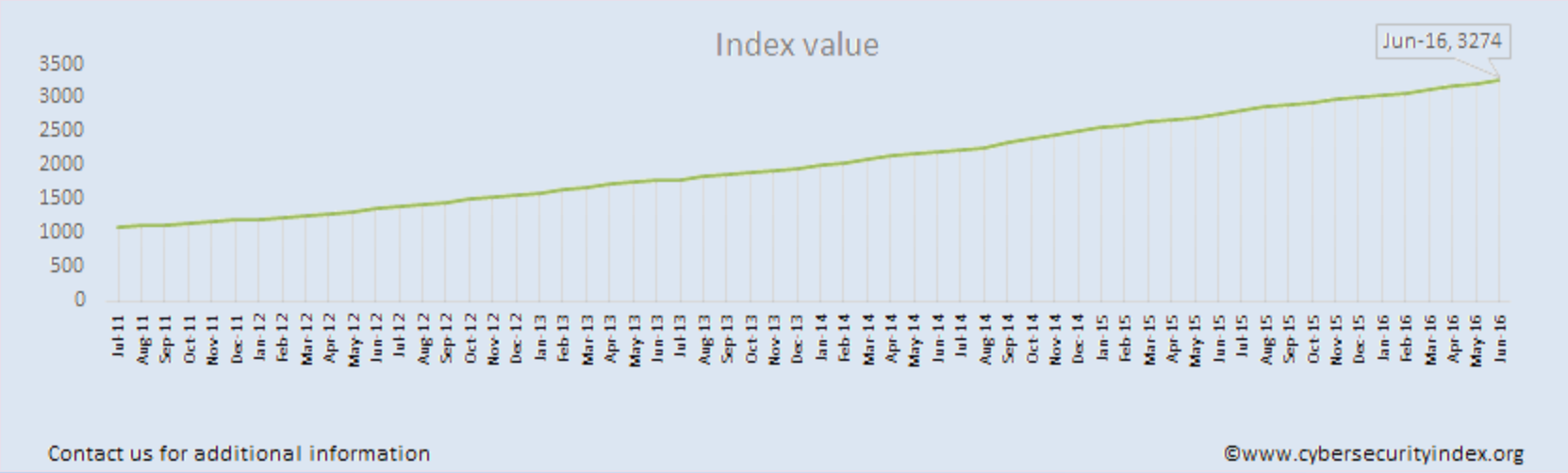


Variance not bounded
Far higher chance for surprise

Expected Future

Measuring Defensibility

- Verizon Data Breach Investigations Report
  - "Detection deficit … is getting worse"
  - "Attackers are getting even quicker at compromising their victims"
  - Slight improvements in how quickly defenders detect compromises
- Commerce: 45 percent of US online households have stopped some sensitive online transactions
- Index of Cyber Security



For a More Defensible Cyberspace

And a $120 Trillion Payoff

- **Advantage**: Dollar of defense must buy more than a dollar of attack
- **Scale**: Dollar of defense should give 10x, 100x, or even 1,000,000x the benefits – hyperscale

THANK YOU

@Jason_Healey