The Interplay of Operations Knowledge and Policy in IPv6 Deployment

Jesse Sowell, PhD
MIT Research Affiliate

Speaker Introduction *or*
Who Let the Policy Nerd In?

- Not an operator, nor do I play one on TV
- Recovering computer scientist, thinly veiled industrial political economist

- Recent (January 2015) MIT PhD in Technology, Management, and Policy, supervised by Dr. David Clark and Dr. Ken Oye
- Multidisciplinary mix of:
  - Internet architecture
  - industrial political economy
  - operations strategy

- Slightly distilled dissertation question(s):
  - Who sustains the Internet's numbering and routing system?
  - How do these communities function as institutions?
  - Are these institutions stable?
  - How does one characterize these institutions engagement with conventional governance regimes and what are the ongoing challenges?

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- How does one characterize these institutions' engagement with conventional governance regimes and what are the ongoing challenges?

  Roadmap:
  1. Operational Adaptation in the Internet
  2. Brief Dissertation Framing
  3. Operational Epistemic Communities
  4. IPv6 Deployment Strategies
  5. Broader Implications for Infrastructure Management

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5. Broader Implications for Infrastr... Management

In this presentation the focus is on how operational knowledge can contribute to policy issues, not technical solutions

We are going to spend most of our time here, offering a "theory of cluefulness" and IPv6 deployment strategies

Adaptation in the Internet
Riding in to the Rescue…

"The Net interprets censorship as damage and routes around it."
—John Gilmore

Elmer-DeWitt, P., & Jackson, D. S. (1993, December). First Nation in Cyberspace. Time, 142(24), 62. Retrieved 2013-12-19, from http://search.ebscohost .com/login.aspx?direct=true&db=a9h&AN=9311307512&site=ehost-live.

Adaptation in the Internet
Mythological Constructs

"The Net interprets censorship as damage and routes around it."
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- "Self-healing" romanticizes an "emergent" network property
- Offers little explanatory power for understanding the underlying mechanisms
- Do those mechanisms engender and sustain stable strategies and relationships for managing endemic uncertainties?

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Operational Adaptation

- YouTube hosts video offensive to Mohammed
- Pakistan censors via route manipulation
- Route intended for Pakistan leaks
- Global negative externality: YouTube users redirected to Pakistan

- About three hours later…

- PCCW filters announcements from Pakistan Telecomm Authority (PTA)
- Kitten videos flow freely once again

External perception:
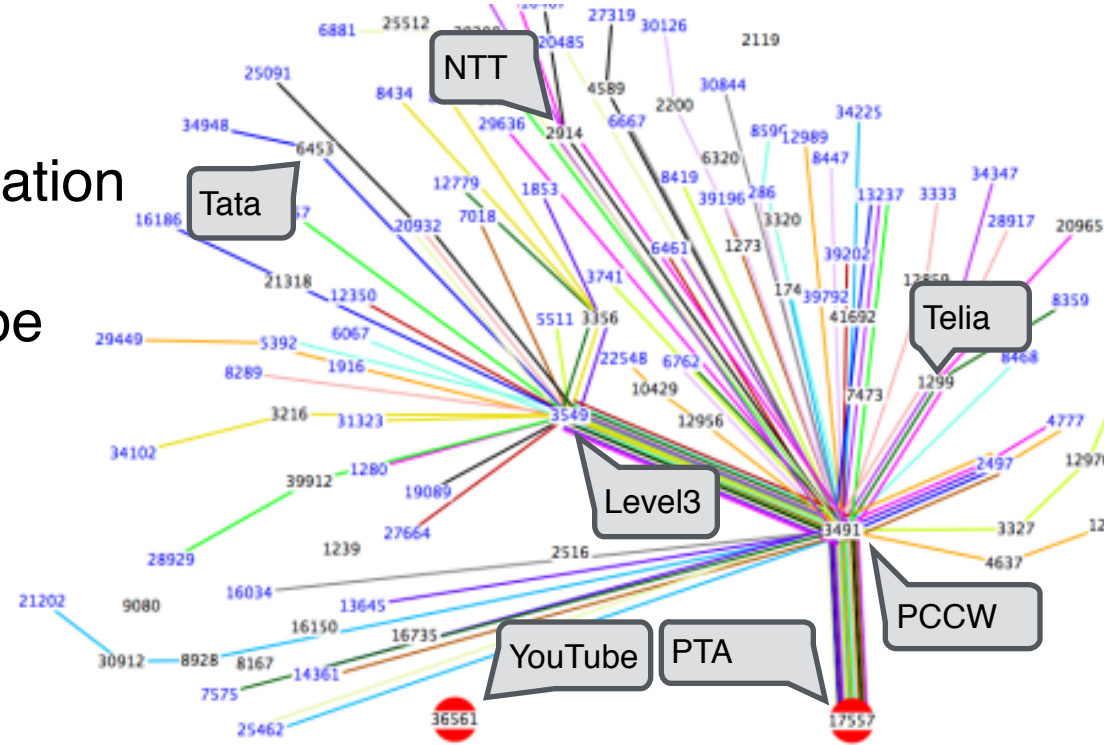It's a "self-healing" system, just as it was designed to be!
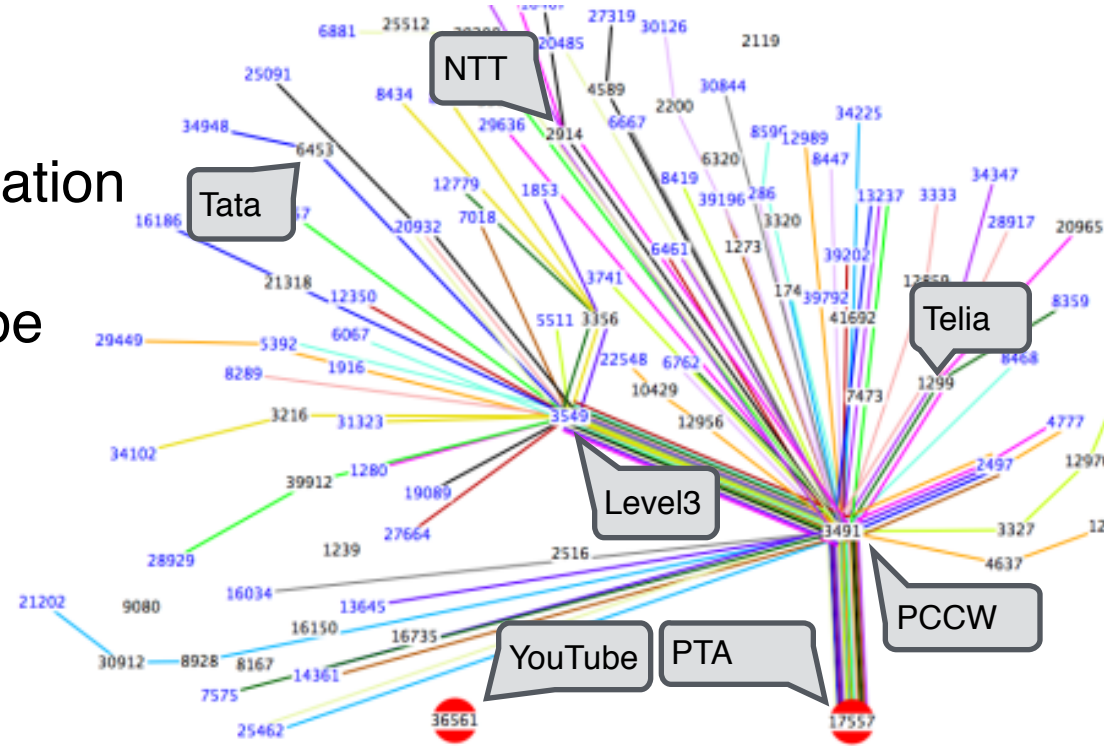
ASN	Organization	Economy
8447	Telekom Austria	Austria
1280	ISC	USA
2497	IIJ	Japan
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It wasn't quite magic though, there was some degree of concerted effort

9

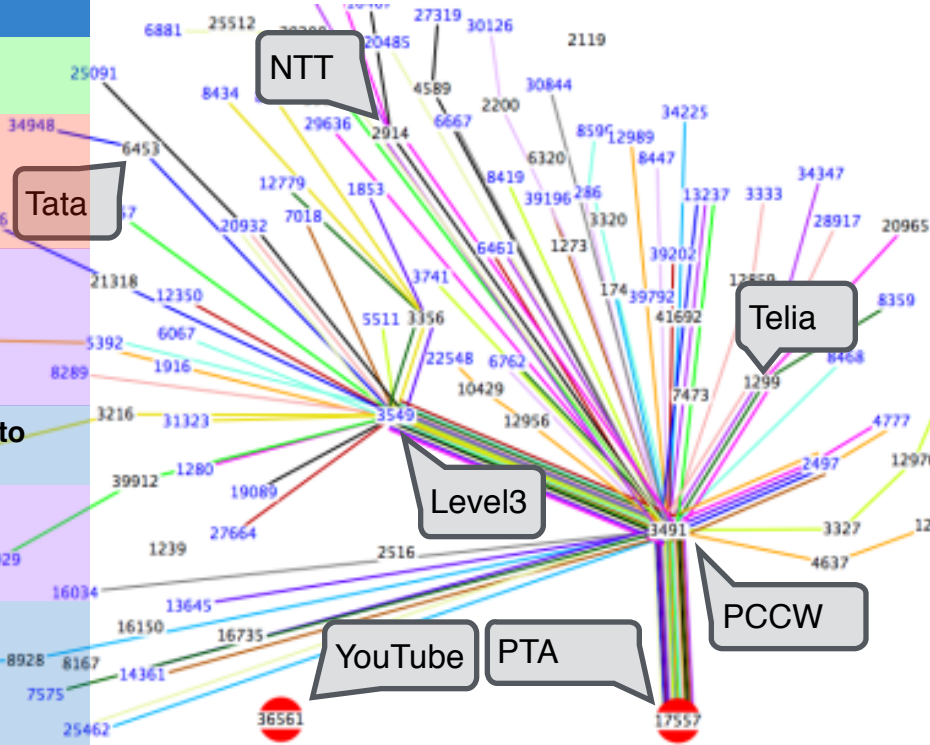| ASN	Organization	Economy
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Coordinated Remediation

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- Pakistan censors via route manipulation
- Route intended for Pakistan leaks
- Global negative externality: YouTube users redirected to Pakistan
- **YouTube and others**
  - identify the origin
  - re-announce
  - remediate complicit intermediaries
- PCCW filters announcements from Pakistan Telecomm Authority (PTA)
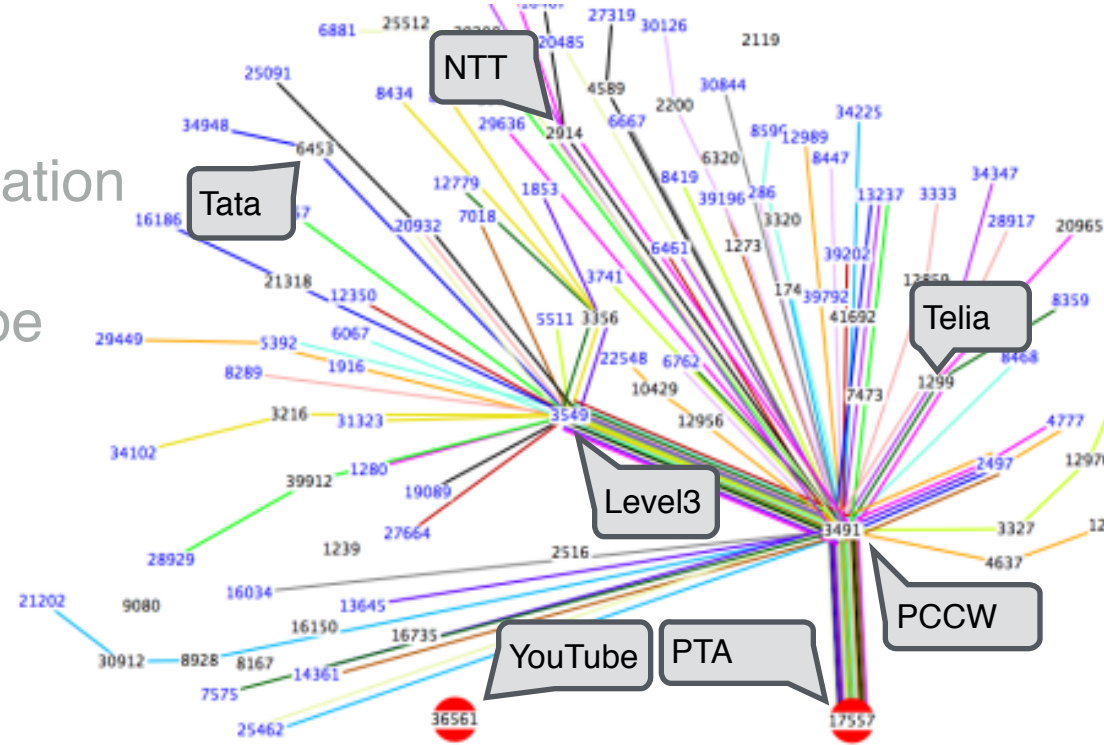
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Coordinated Remediation

Actor	Behavior	Effect
YouTube	Provision Route advertise 208.65.152.0/22	Global access to YouTube
Pakistan	Provision Route advertise 208.65.153.0/24	Hijack YouTube Deny YouTube Origination
YouTube	Provision Route advertise 208.65.152.0/24 ... advertise 208.65.155.0/24	Reassert legitimate origin Disaggregate
Community	40 networks appropriate legitimate route	Partial restoration of access to YouTube
YouTube	Provision additional /25's	Reassert legitimate origin Further disaggregate
Community	25 networks prefer /25's /24's show up in transit bundles	Further restoration
PCCW	Attempted prepending	Deprecate illegitimate route
PCCW	Rescind advertisement of 208.65.153.0/24	Global access to YouTube unfettered

This is not "organic self-healing." This is the product of well-defined norms and the application of knowledge derived from an *operational epistemic domain*

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11

Adaptive Institutions in the Internet

NOGs as a Common Su...

"The Net" comprises a *complex of function-specific institutions—-* network operator groups such as NANOG form the common substrate

In the NOGs, participants develop, manage, and enforce distinct *sets of rights and obligations* used to evaluate and maintain the *integrity* of the routing system

"The Net interprets censorship as damage and routes around it."

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- "Self-healing"

- ...ding

Do those mechanisms engender and sustain stable strategies and relationships for managing endemic uncertainties?

Where does the knowledge base necessary to diagnose system conditions and quickly remediate the root causes come from and **how can the community provider greater assurances to external authorities??**

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Well-known Problem
Distribution of Clue

How do operator communities make cluepons credible political currency?

Before jumping into a theory explaining cluefulness, you might want some idea where I observed what will be described as operational epistemic communities…

Broad Dissertation Work
Common Resource Institutions

Institutions	Common Resource	Function
Network Operator Groups	Routes	Traffic coordination
	Operational Knowledge Commons	Ops, business transactions, remediation capabilities
Regional Internet Registries	Numbers, registry	Identification, resource rights delegation and documentation
	Policy Development and Documentation	Evaluation of resource delegation practices
Internet eXchanges	Routes, jointly provisioned interconnection platform	Lower barriers to interconnection markets
	IX management knowledge commons	Value of participation, IX development knowledge
Anti-Abuse	Messaging Value Network	Manage and sustain legitimate sending space
	Knowledge Commons -> Best Common Practices	Principles for navigating and developing indicators

14

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15

Operational Epistemic Communities
Theory of Cluefulness

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An epistemic community is a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area. (Haas, 1992, p. 3)

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> Where does the knowledge base necessary to diagnose system conditions and quickly remediate root causes live?

Lists and Blogs	NOG Presentation Topics	BCPs
NANOG e-mail list and archives, other NOG archives, outages lists, community blogs	managing connectivity, deploying new technologies and services, resource utilization, operational phenomena observed, problem solving strategies, tutorials, (more recently) in-depth operations	**Maintain living repository rather than having to dig through lists, blogs, contact list, and NOG presos**

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Think about frequent presenters at NANOG and other NOGs: folks here include Bradner, RA[SIT], Ebersman, well-known actors in the community and experts in their (sub)domains

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Operational epistemic domain knowledge is derived from the feedback loop between active participation in infrastructure operations, remediation activities, and **information sharing in the NOGs**.

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The problem is, ***how do NOG community participants make that claim?*** What are the elements of first demonstrating this expertise and second offering credible assurances to regulators?

We are going to dive into this problem through the lens of IPv6 policy strategies, looking at both government efforts and how these communities leverage expertise to inform actors that can smooth the transition to IPv6.

P. M. (1992). Introduction: *Epistemic Communities and International Policy Coordination*. ational Organization, 46(1):1.

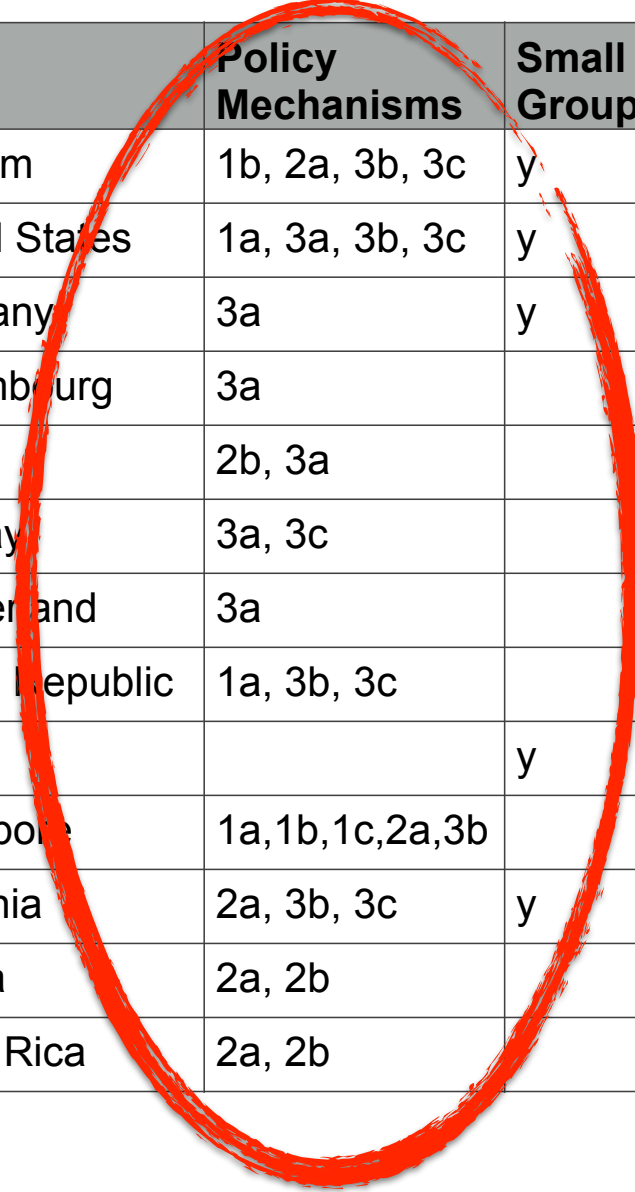# IPv6 Deployment Policy
Tactical and Strategic

Elements of Policy Configurations
1. Government public policy efforts
   a. Government services over IPv6
   b. Incent private industry support
   c. Provide funding
2. Hybrid configurations
   a. Government as legitimating convener
   b. RIR as policy entrepreneur
3. Private institutions and community
   a. Individual firms' internal incentives
   b. Operational epistemic communities
   c. Policy entrepreneurs

Notice we have jumped from **operational** to **tactical and strategic**: this requires communication between operators and C-levels and policy makers

These are not mutually exclusive—-rather, we see combinations across the cases

Howard, L. and Sowell, J. H. (2014). *A Comparison of Public Policy Approaches to the IPv4-IPv6 Transition*. In Proceedings of the 42nd Research Conference on Communication, Information and Internet Policy, Arlington, VA. Telecommunications Policy Research Consortium. Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2417079.

IPv6 Deployment Policy Mechanism Configurations

	Policy Mechanisms	Small Group	Single Company	ISP%	ISP Rank
Belgium	1b, 2a, 3b, 3c	y		30.4	1
United States	1a, 3a, 3b, 3c	y		14.5	2
Germany	3a	y		13.16	3
Luxembourg	3a		y	11.6	4
Peru	2b, 3a		y	11.1	5
Norway	3a, 3c		y	10.2	6
Switzerland	3a		y	9.7	7
Czech Republic	1a, 3b, 3c		y	7.9	8
Japan		y		6.2	12
Singapore	1a,1b,1c,2a,3b			2.6	18
Slovenia	2a, 3b, 3c	y		0.9	26
Bolivia	2a, 2b			0.84	28
Costa Rica	2a, 2b			0.02	84

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> These are your standard fare government incentive programs, kinda boring. The punchline is these incented early feature development but aside from microcosms such as Singapore, these mechanisms do not seem to have broad ***ongoing*** operational impact.

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> Hybrid configurations and community efforts are the more interesting instances: as will be developed in the following narratives, these tell the story of how combinations of policy mechanisms **drawing on both government and operator capabilities** have contributed to both IPv6 deployment and establish the potential for stronger assurances.

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Configuration:
1b: Limit number of individuals behind NAT
2a: Regulator and LEA support
3b: Prestige in communities
3c: Policy entrepreneurs in IPv6 community

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Configuration:
2a: Regulator as convening agent, get actors in the room
3b: Prestige in communities
3c: Policy entrepreneurs in IPv6 community: go6 + ISOC

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Configuration:
2a: Regulator as convening agent, get actors in the room for IX
2b: RIR takes opportunity to peddle IPv6

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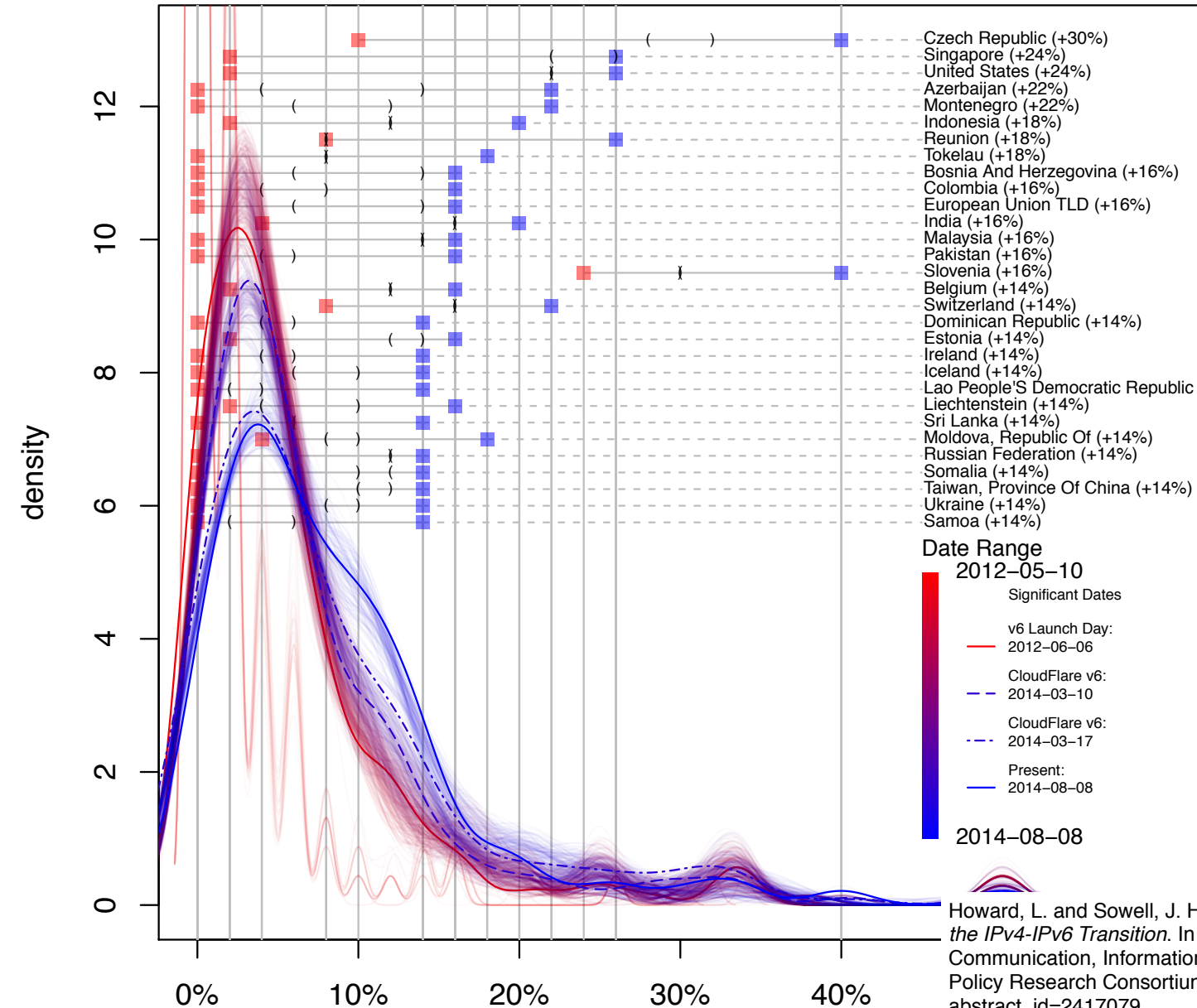
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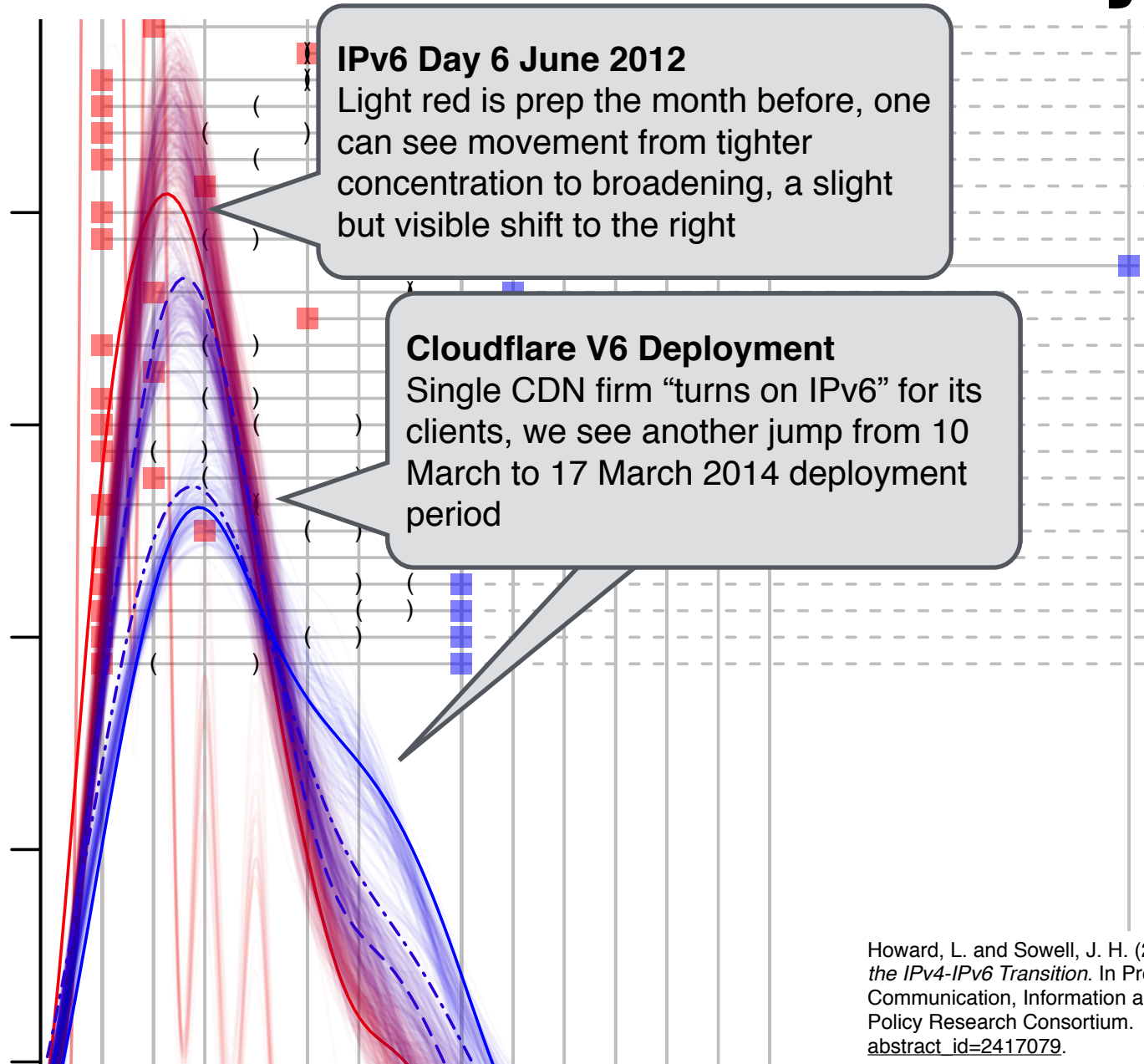# **Private and Community Efforts**

- Percentage of Alexa Top 50 on IPv6
- Area under curves represents proportion of countries in that percentage range
- Color ramp is time, so red to blue is from May 2012 to August 2014
- **Shift in the mass from left to right is progress**

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IPv6 Deployment Policy
Private and Community Efforts

IPv6 Day 6 June 2012
Light red is prep the month before, one can see movement from tighter concentration to broadening, a slight but visible shift to the right

Cloudflare V6 Deployment
Single CDN firm "turns on IPv6" for its clients, we see another jump from 10 March to 17 March 2014 deployment period

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Infrastructure Management
Reactive to Proactive

Challenge: How do operator communities make cluepons credible political currency?

Take-aways:
- **Internal Information Sharing:**
  Operational epistemic communities have quite a few mechanisms for sharing knowledge, but largely operational, what of tactical and stratetic?
- **External Information Sharing:**
  IPv6 illustrates various strategies for mixing operational capabilities and government capabilities *without becoming subordinate*

Prescriptions for community:
- Governments *will* start looking for guidance
- Developing "diplomatic capabilities" and BCPs will prepare the community to meet this demand for operational knowledge

For the managers in the audience:
- Encourage your junior engineers to supplement engineering knowledge with policy engagement