Network Topologies of the Physical Internet and Tech Standards Governance

Maggie Oates



Early keepers of the Internet



Joyce Reynolds



Jon Postel

Maintinaed the "address books" for many years. It was 'a side task.' In early times, if you wanted to join, you had to get someone to agree to bring you a cable & then ask Postel to register you in. Postel, in the late 90s, decided one day to test a feature & re-indexed all the pentagon's machines. The feds decided to step in.



Dr. Nicki Washington @dr_nickiw

Here's the thing that everyone in **#computing** should be completely upset by wrt **@timnitGebru**'s story right now. **NON-BLACK FOLKS: PAY SPECIAL ATTENTION**

NO BLACK WOMAN WOULD DARE SAY ALL THIS ON VINT CERF'S INTERNET IF IT WEREN'T 100% TRUE!

11:05 PM · Dec 2, 2020 · Twitter Web App

50 Retweets 2 Quote Tweets 339 Likes



At this time, ARPANET infrastructure *was* nearly synonymous with a social network. Crocker, Cerf, & Postel all went to the same *high school*.

Cerf worked with the feds & helped ensure a hands-off libertarian-y approach. Gave governance & standards to a series of nonprofit bodies that were the contracted by US government.

Link to Dr Washington's tweet <u>https://twitter.com/dr_nickiw/status/1334348067055800323</u>

Standards Collaboration over time

Node = person

Edge = collaboration

Size = # of standards

Color = I just like pink

Is this just a general discussion on collaboration?

What makes <u>Internet</u> governance special?



The Internet Engineering Task Force

- Official start 1986
- "rough consensus and running code"
- only individuals participate, not corporations or governments
- "We reject kings, presidents and voting. We believe in rough consensus and running code" -David Clark
- a precursor of the open source movement

This was a big shift in industry governance

Compare to Unicode Consortium (1991)



FULL \$21,000 Full Membership in the Consortium gives your company or organization the most direct access to information on the Unicode Standard, the Unicode Locales Project (CLDR), and the Unicode Localization Interoperability Project. Decisions affecting implementation and news about Unicode-related products are at your disposal. You are an active participant in shaping future enhancements to these Unicode standards, data, and initiatives, and you financially support the existence and maintenance of the Unicode Web and FTP sites, where upd Member, your organization has full acce Full Members (Voting) meetings and receives one vote in all te for the board and the right to vote at Ful

INSTITUTIONAL \$14,000 / \$10 Institutions)

Institutional membership is open to qual





The Internet Engineering Task Force

"The IETF mission further states that the Internet isn't value-neutral, and neither is the IETF. The IETF wants the Internet to be useful for communities that share our commitment to openness and fairness. The IETF embraces technical concepts such as decentralized control, edge-user empowerment and sharing of resources, because those concepts resonate with the core values of the IETF community. These concepts have little to do with the technology that's possible, and much to do with the technology that we choose to create."

-The Tao of the IETF

This was a big shift in industry governance

https://www.ietf.org/about/participate/tao/#what

IETF - Two famous founding beliefs

David Clark: "We reject kings, presidents and voting. We believe in rough consensus and running code."

Jon Postel: "Be conservative in what you send and liberal in what you accept".

https://www.ietf.org/about/participate/tao/#what

1. To IETF, open governance = open Internet

One of the reasons the IETF has maintained a lot of governance power is *how technical it keeps itself.*



from https://www.submarinecablemap.com/

Google build it's own subsea cable (Curie). "le. There are currently more than 400 undersea cables in service around the world, constituting 1.1 million kilometers (700,000 miles). Google is now directly invested in around 100,000 kilometers of these cables (62,000 miles), which equates to nearly 10% of all subsea cables globally."

https://venturebeat.com/2019/04/24/how-google-is-building-its-huge-subsea-cable-infr astructure/

Internet topology & standards are connected

The standards will change based on the topology. For example, congestion. This is not wild, for example, the content of the internet has changed its topology! Streaming video has asked for

Co-evolutionary networks (topology)





Question: Is there a relationship between governance & infrastructure topologies?

Obvi yes, at some level! For example, raw scale! Or geography. But intuitively, those factors should be less salient over time.

Question: Does IETF successfully embed its values at a *topological* level?

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This also might make you think of convos we had about the DAO & Etherium! People who are really trying to tie structures.

"...Denis Hayes concludes, 'The increased deployment of nuclear power facilities must lead society toward authoritarianism. Indeed, safe reliance upon nuclear power as the principal source of energy may be possible only in a totalitarian state.' ...dispersed solar sources are more compatible than centralized technologies with social equity, freedom and cultural pluralism.'"



Aside, this is one of my favorite articles ever.

Question: Does IETF successfully embed its values at a *topological* level?

Goal: Can I predict an edge in the Internet infrastructure based on info from the IETF network ? Too hard!

Edge data on Internet is often guarded. Lots of covariables to control for (e.g., company affiliations, geography).

First step: How much does the IETF topology correlate with Internet topology?

This is a dissatisfying approximation of my question, but it will have to do for now.

So I can't get Internet data. That *is* quite guarded. I could pay thousands to TeleGeopgraphy to get some. But...



definition.			
nd definition. Power-Law 1 (rank exponent) The outdegree, d_{v_1} of a node v_1 is proportional to the rank of the node r_1		Power-Law 2 (outdegree exponent) The frequency, f_d , of an outdegree, d , is	s proportional
		to the outdegree to the power of a constant, O :	
to the power of a constant, \mathcal{R} :		$f_d \propto d^{\mathcal{O}}$	
$d_v \propto r_v^{\mathcal{R}}$		Definition 2 We define the outdegree expe the slope of the plot of the frequency of the out the outdegrees in log-log scale.	onent, O, to be utdegrees versus
	Power-Law 3 (eigen exponent) The eigenvalu λ_i , of a graph are proportional to the order, i, to a power of a constant, \mathcal{E} :		
	Denne Lenn 9 (simer and	ponent) The eigenvalues.	

"These power-laws hold for three snapshots of the Internet, between November 1997 and December 1998, despite a 45% growth of its size during that period."

The "Hierarchical" and "Flat" Internet

The Hierarchical Internet (late 90s - 2007)

- . Top content providers generated small fraction of total traffic
- Content providers were typically served from origin Peering was restrictive .

The Flat Internet (2007 onwards)

- . Top content providers generate large fraction of total traffic
- Content providers have expanded geographically
- Dearing is more open

The Internet is Flat: Modeling the Transition from a Transit Hierarchy to a Peering Mesh

Amogh Dhamdhere *, Constantine Dovrolis † * CAIDA † Georgia Tech

(mid 2000s)

ABSTRACT

ABSTRACT Recent measurements and anecdotal evidence indicate that the Internet ecosystem is rapidly evolving from a multi-tier hierarchy built mostly with transit (eastome-provider) links, to the internet ecosystem is rapidly evolving from a multi-tier hierarchy built mostly with transit (eastome-provider) links, to the another traffic flow and topological structure of the therent. In this paper, we study this evolutionary transition with an agent-based network formation model that captures gives appexts of the interdomain corrostem, viz., interdomain traffic flow and routing, provider and peer selection strate-sitic appearing interconnections. The model predicts sev-rel a substantial differences between the Herenricical Inter-net and the Flut Internet in terms of topological structure, nul hengths, interdomain traffic flow, and the profitability of transit newiders. We also quantify the effect of the three fac-

These interconnections are dynamic, as ASes attempt to min-imize their operational expenses, maximize their transit rev-eme and/or improve performance and reliability. The result-ing dynamics create a complex feedback loop between: i) interdomain topology (the AS graph anotated with the type of each link), 2) interdomain routing and traffic flow, and 3) per-AS economic variables such as revenues and costs. The resulting interretwork is co-evolutionary in the sense that its polyogy affects the state of each AS (e.g., its maxim traffic) but at the same time the state of each AS affects the interret-main links. Sinch co-evolutionary dynamic networks exhibit unexpected behaviors and self-organization, but at the same time it is noteriously hard to analyze them mathematically and to make predictions about the if long-term evolution [21]. The conventional widdom about the literent ecosystem, as reflected in networking textbooks, can be summarized as



"Internet Interdomain Traffic", Labovitz et al., Sigcomm 2010

IETF origins vs today





Analysis Plan

		Justification
Time	1970 (first standards publications)1998 (gov intervention, commercialization)2007 (consolidation of content)2017 (IPv6 ratified, ICANN leaves US control)	Key events in infrastructure/gove rnance. Also there is data.
Metrics	Degree distributions Path length	Relatively stable metrics over time in simulation (Dhamdhere & Dovrolis 2010)
Comparisons	scale, KS test, Pearson's correlation	Will depend also what specific data is available for comparison

(Dhamdhere & Dovrolis)

Unconvinced:

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-Advocate that your metrics successfully capture topology

(or I'll just do a collaboration question)

Plot pagerank vs degree vs external citation counts

• Identify social butterflies vs impact