Internet Research Needs a Critical Perspective Towards Models

– Sally Floyd
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“Computer System Performance Modeling and Durable Nonsense”

• “A disconcertingly large portion of the literature on modeling the performance of complex systems, such as computer networks, satisfies Rosanoff's definition of durable nonsense.”
• "THE FIRST PRINCIPLE OF NONSENSE:
For every durable item of nonsense, there exists an irrelevant frame of reference in which the item is sensible.”

• "THE SECOND PRINCIPLE OF NONSENSE:
Rigorous argument from inapplicable assumptions produces the world's most durable nonsense."

• "THE THIRD PRINCIPLE OF NONSENSE:
The roots of most nonsense are found in the fact that people are more specialized than problems"
The quote is 25 years old!


The questions of this talk:

• Do we understand how our modeling assumptions affect our results?
• Do we know how our modeling assumptions affect the relevance of our results for the (current or future) Internet?
• What kind of tools do we need to help improve our understanding of models?
Assumptions:

- For each research topic, we want a model that is as simple as possible, but no simplier.
- Models underlie simulations, experiments, analysis, and pure thought experiments.
- For the fast-changing and heterogeneous Internet, determining the relevant model for a particular research question can be 95% of the work!
Topic: Active Queue Management Performance

• Research question: tradeoffs between throughput and delay.

• One model: One-way traffic, one RTT, long-lived and small flows but no medium-sized flows.
  – Result: High throughput and low delay is possible.

• Alternate model: Two-way traffic, range of RTTs, wide range of flow sizes.
  – Result: Bursty traffic, throughput/delay tradeoffs.
Topic: AQM Performance

• Question: What do we know about the actual characteristics of aggregate traffic at congested links in the Internet?
  – Distribution of flow sizes?
    • Extensively studied.
  – Distribution of round-trip times?
    • Some measurements available.
Distribution of Flow Sizes

- Distributions of packet numbers on the congested link over the second half of two simulations, with data measured on the Internet for comparison.
Distribution of RTTs:

- Distributions of packet round-trip times on the congested link of two simulations, with data measured on the Internet for comparison.
Topic: AQM Performance

• Question: What do we know about the actual characteristics of aggregate traffic at congested links in the Internet?
  – Typical levels and patterns of congestion?
    • Congestion at access links, moderate levels of congestion?
    • Tools for measuring from TCP traces.
  – Reverse-path congestion?
    • Little is known.
  – How many flows are limited by end nodes or by other access links?
    • Some measurements.
Topic: Dynamics of HighSpeed TCP

• Research topic: convergence times (for new TCP flows competing against existing flows).
• Model #1: DropTail queues, global synchronization when packets are dropped.
• Model #2: DropTail queues, some synchronization, depending on traffic mix.
• Model #3: RED queues, no synchronization.
• Which model is the best fit for the current Internet? For the future Internet?
Topic: Transport protocol performance over wireless links

• Characteristics of wireless links that affect transport protocol performance:
  – Packet loss due to corruption.
  – Delay variation due to link-layer error recovery, handovers, and scheduling.
  – Asymmetric and/or variable bandwidth (e.g., satellite).
  – Shared bandwidth (e.g., WLANs).
  – Complex link-level buffering (e.g., cellular links).
  – Mobility.
Topic: Transport protocol performance over wireless links

• Tools: The NS simulator has tools for modeling wireless links; we (Andrei Gurtoy) have added them.

• There is an interplay between wireless link mechanisms and transport protocols, with both changing.
  - E.g., corruption is often repaired at the link layer.

• It is challenging to try to characterize relevant models for the current and future Internet.
Topic: The Evolvability of the Internet Infrastructure

• Research topics:
  – How do we understand the current limits to evolvability of the Internet infrastructure?
  – What would be the impact of different architectural changes on the evolvability of the Internet infrastructure?
    • E.g., security vs. evolvability
    • Communication between layers vs. evolvability.
Topic: The Evolvability of the Internet Infrastructure

• What conceptual models do we use to help understand this?

• Standard models of complex systems have many limitations:
  – E.g., game theory;
  – Physics models;
  – Control theory and dynamical systems;
  – …
Topic: The Evolvability of the Internet Infrastructure

• Critical aspects of a conceptual model for this topic:
  – The layered IP architecture;
  – Changes over time (e.g., overprovisioning);
  – A decentralized system with many players (companies, ISPs, standards bodies, etc.);
  – Economic and political factors;
  – Chicken-and-egg deployment issues.
References:

References, cont.

• S. Floyd, “Modeling the Internet as a Complex System”, viewgraphs, End-to-End Research Group, January 2003.