Exploring differing definitions of congestions and analytic techniques for evaluating and identifying congestion

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Defining Congestion

The Evolution of Internet Congestion

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Abstract

This paper discusses the evolution of the congestion controls that govern all Internet traffic. In particular we chronicle and discuss the implications of the fact that the most significant "congestion signals" are increasingly coming from network operators, not the TCP stack. Providers now nudge users into different traffic patterns using a variety of new technical and non-technical means. These 'network-based congestion management' techniques include volume-based limits and active traffic management of best effort traffic. The goal and effect of these techniques differs from the historically coveted flow-rate fairness of TCP, provoking some in the technical and policy community to question the appropriateness of such deviations, and feeding
Queuing theory definition of congestion

• **Formula 1:** arrival rate > service rate
  \[ \lambda > \mu \]

• **Formula 2:** congestion = arrival rate / service rate
  \[ \rho = \frac{\lambda}{\mu} \]
Networking text book definitions

- **Congestion**: router runs out of buffer space and must start dropping packets if more arrive.
- **Contention**: the buildup of packets in a queue

Diagram:

- Drop if buffer full
Network provider definitions of congestion

- Average link/network utilization of some period of time
One economic definition of congestion

• MIT Dictionary of Modern Economics:

"When an increase in the use of a facility or service which is used by a number of people would impose a cost (not necessarily a monetary cost) on the existing users, that facility is said to be ‘congested’.\"
Application centric definitions of congestion
User centric definitions of congestion
Uncongested Networks
Congested Internet

Congested link
Congested Networks
Congested Internet

Congested link
Analyzing congestion data with wavelets
Short-time Fourier transform
Wavelet analysis

Wavelet-analysis
Far
Wavelet coefficients for daily signal
Far link power spectrum