



Managing Network Traffic on Broadband Access Networks

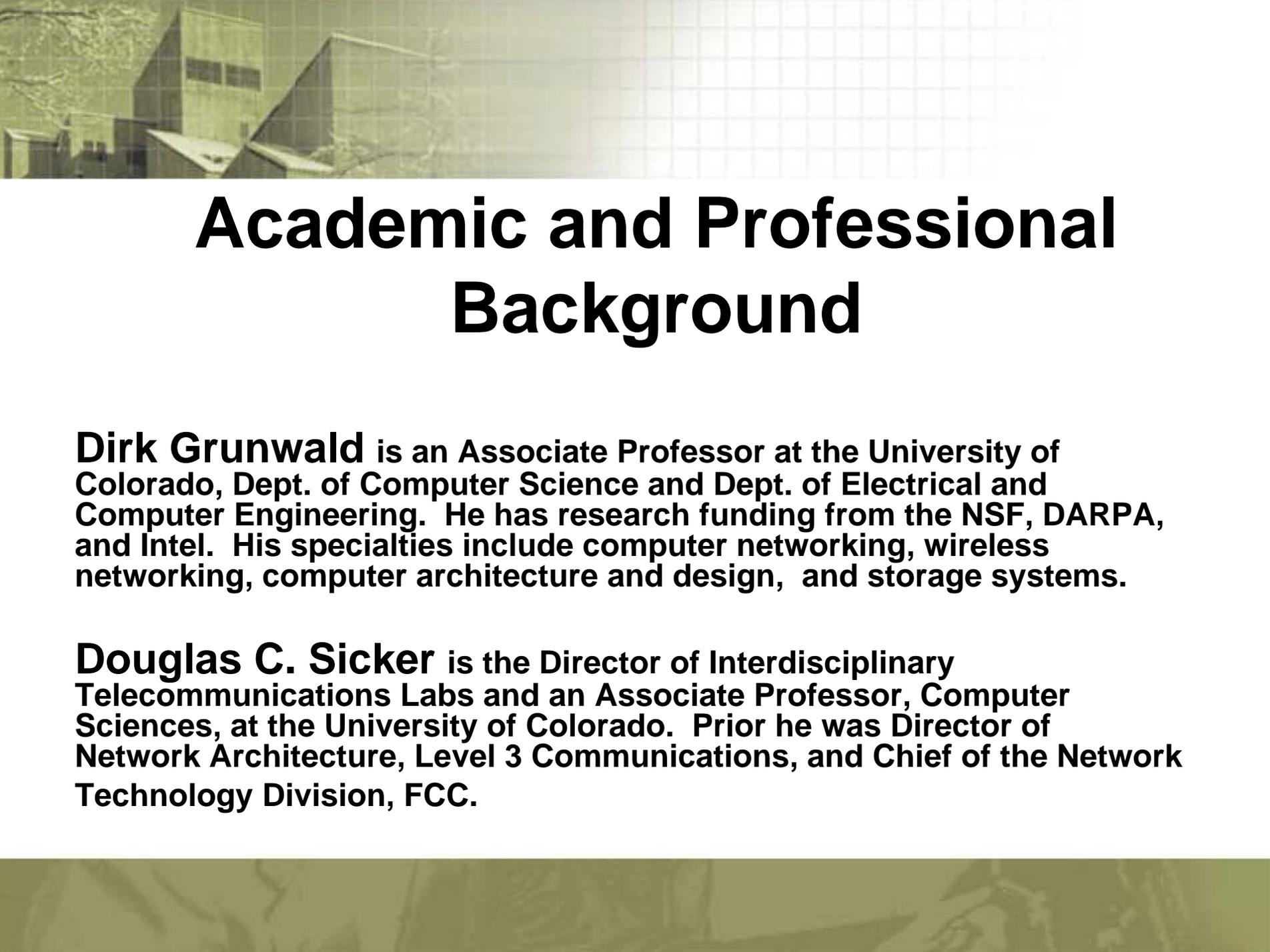
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While the Telecommunications Industry Association (TIA) provided financial assistance in connection with this paper, the views expressed herein are solely those of the authors, and do not necessarily reflect or correspond with the views of TIA or its member companies.





Academic and Professional Background

Dirk Grunwald is an Associate Professor at the University of Colorado, Dept. of Computer Science and Dept. of Electrical and Computer Engineering. He has research funding from the NSF, DARPA, and Intel. His specialties include computer networking, wireless networking, computer architecture and design, and storage systems.

Douglas C. Sicker is the Director of Interdisciplinary Telecommunications Labs and an Associate Professor, Computer Sciences, at the University of Colorado. Prior he was Director of Network Architecture, Level 3 Communications, and Chief of the Network Technology Division, FCC.



Overview of Broadband Infrastructure





Broadband Infrastructure

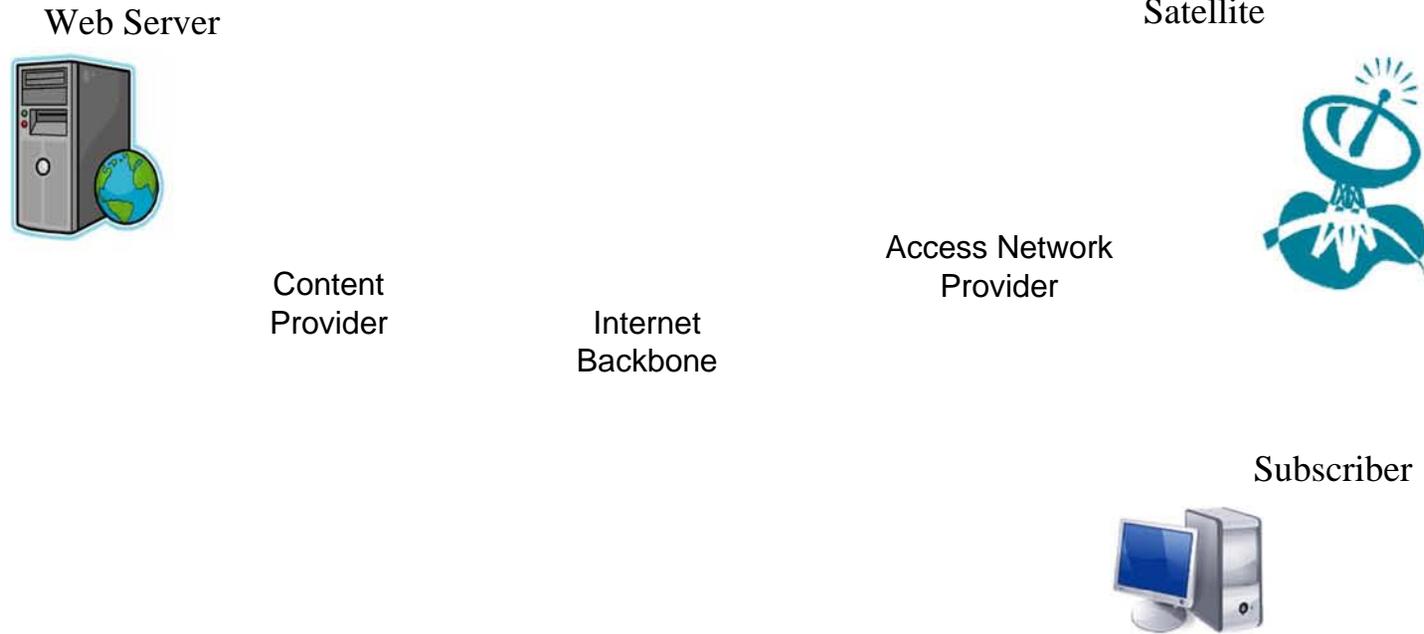
- **Backbone:** The collection of large “trunk” connections that carry communications between networks.
- Largest Backbone Networks:
 - AT&T
 - Global Crossing
 - Level 3 Communications
 - NTT Communications
 - Qwest Communications International
 - Sprint
 - Verizon Business (formerly MCI/UUNET)



Broadband Infrastructure

- **Access Networks:** “Last mile” technologies that rely on the backbone to provide aggregated bandwidth to subscribers.
 - Ethernet
 - Digital Subscriber Line
 - Cable Broadband
 - Wireless Broadband – fixed
 - Wireless Broadband – cellular
 - Fiber to the Home
- Each of these platforms is undergoing an evolution to provide additional capacity and this growth will be part of managing the demands of existing and new applications

Broadband Infrastructure



- Broadband service is only as strong as the network's weakest link.



Current Application and Bandwidth Demands





Common Applications and Bandwidth Demands

- Common Applications:
 - Voice – less than 100 kbps
 - Data – generally, 20-30 mbps
 - Non real time multi-media traffic – requires a high average rate, but more tolerance for errors.
 - Real time multi-media traffic – video data requires most bandwidth; compression technology lessens demand.
 - Peer-to-Peer (P2P) – less about an application (e.g., distribution of video) and more about a network design choice.
 - Management Traffic Overhead – small amount of the total traffic on the link but crucial to proper operation of the network.

Focus: Peer to Peer Traffic

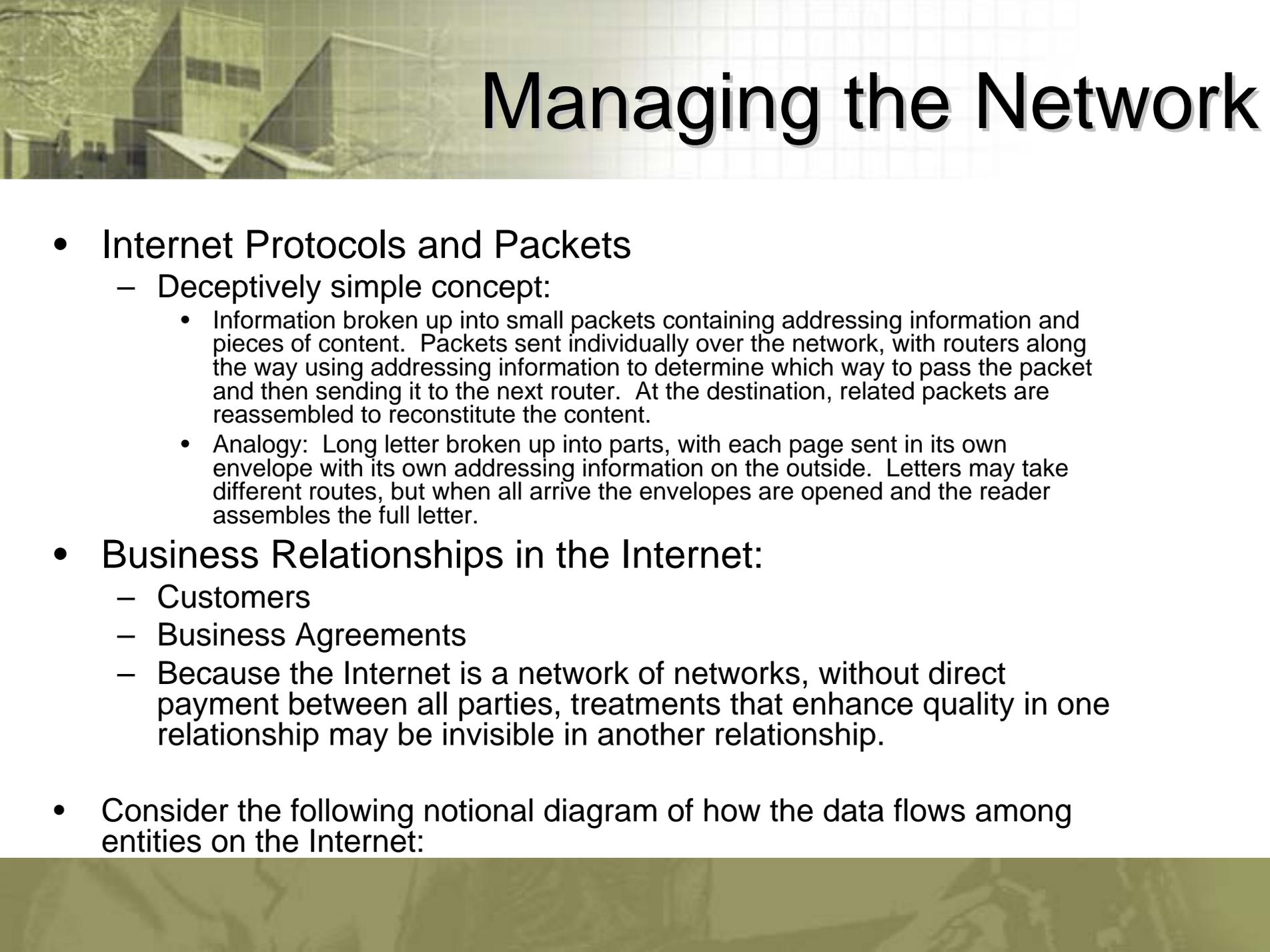
Most access networks use *asymmetric* links, meaning that the uplink speed is significantly slower than the downlink speed.

- Most communication needs to operate in *both* directions, but historically users have downloaded far more information than they have uploaded.
- In response, providers have configured networks for asymmetric traffic.
- The rise of P2P traffic has increased upload needs and has thus caused problems for asymmetric access networks.



Managing the Network

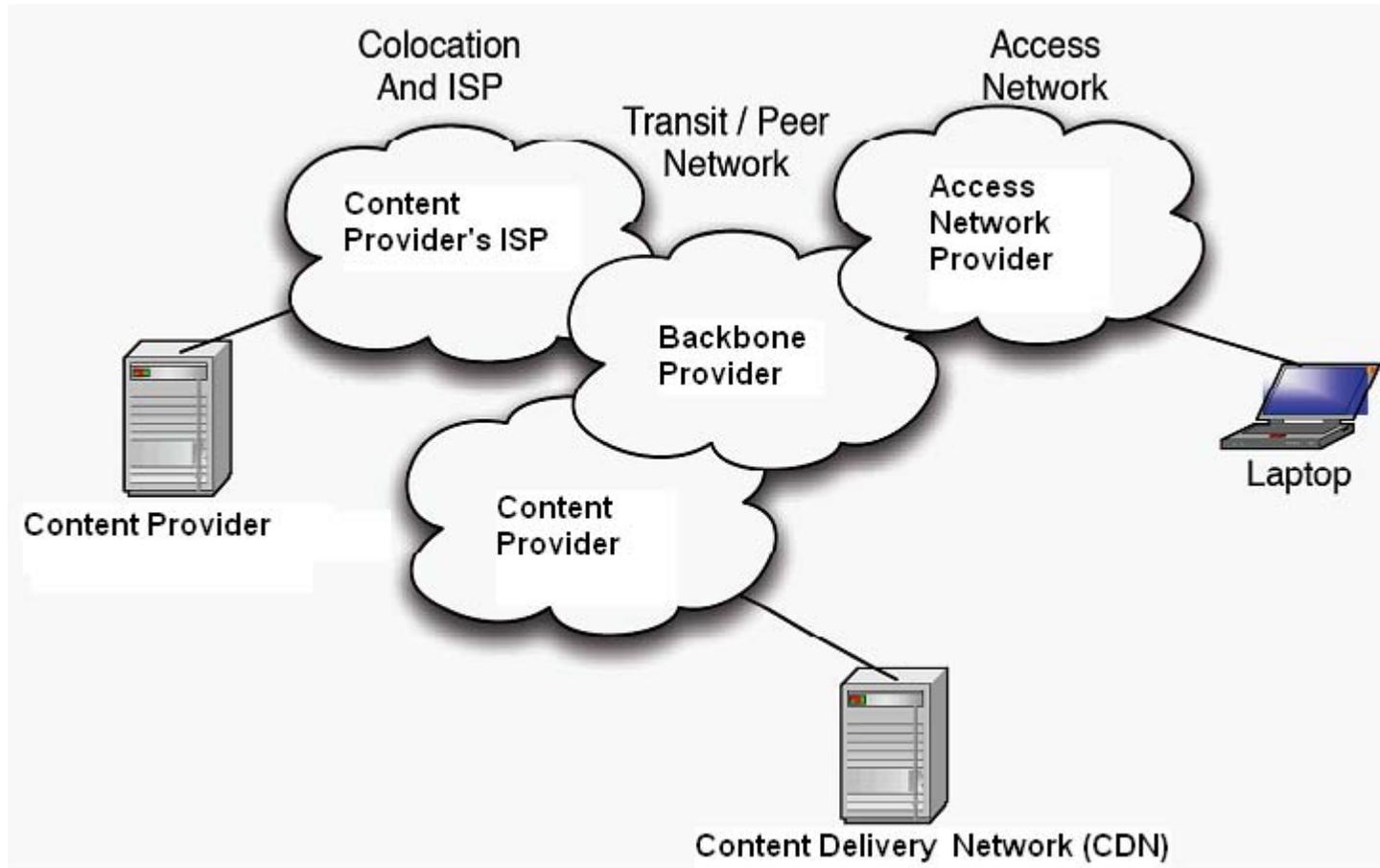


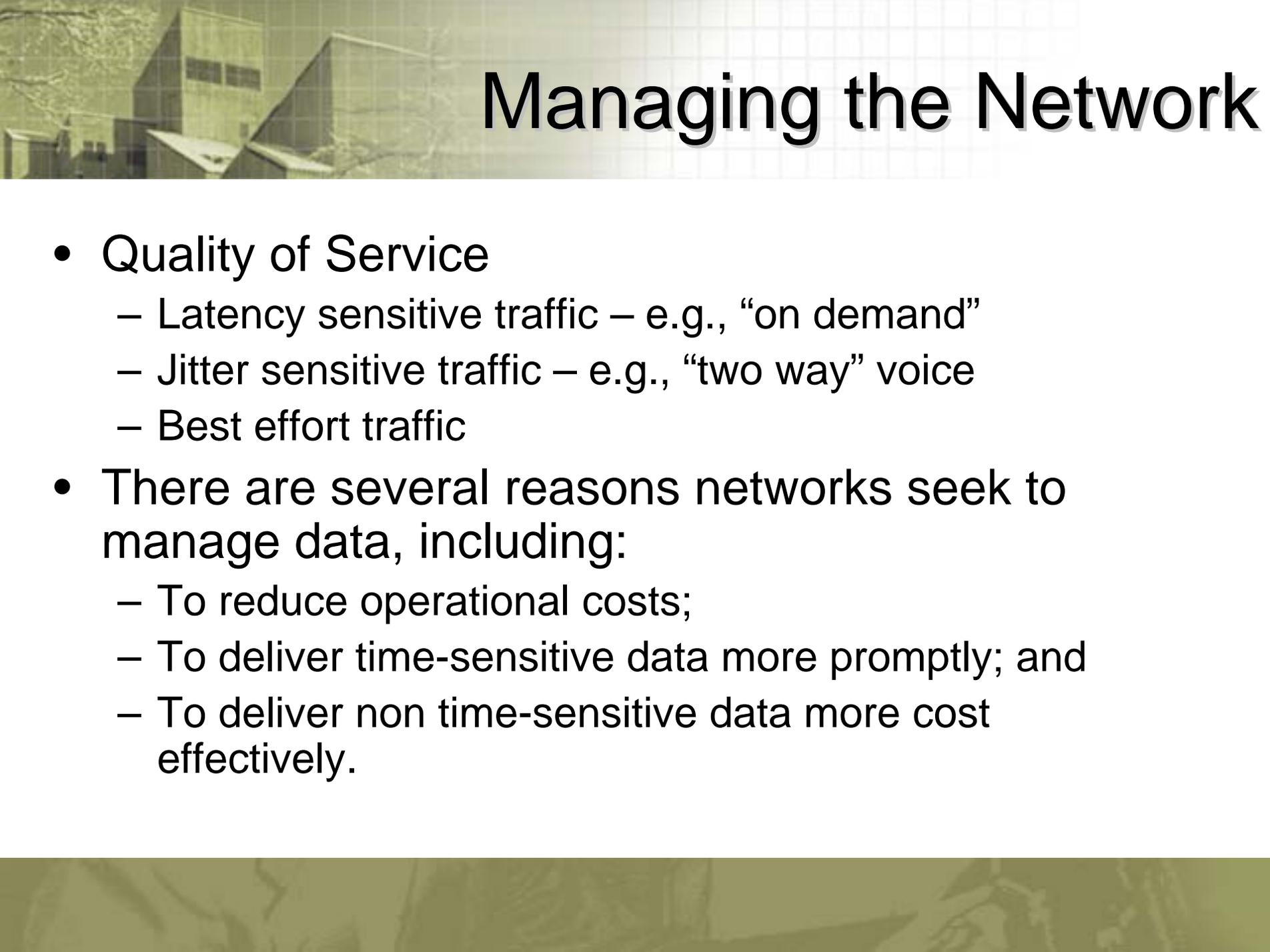


Managing the Network

- **Internet Protocols and Packets**
 - Deceptively simple concept:
 - Information broken up into small packets containing addressing information and pieces of content. Packets sent individually over the network, with routers along the way using addressing information to determine which way to pass the packet and then sending it to the next router. At the destination, related packets are reassembled to reconstitute the content.
 - Analogy: Long letter broken up into parts, with each page sent in its own envelope with its own addressing information on the outside. Letters may take different routes, but when all arrive the envelopes are opened and the reader assembles the full letter.
- **Business Relationships in the Internet:**
 - Customers
 - Business Agreements
 - Because the Internet is a network of networks, without direct payment between all parties, treatments that enhance quality in one relationship may be invisible in another relationship.
- Consider the following notional diagram of how the data flows among entities on the Internet:

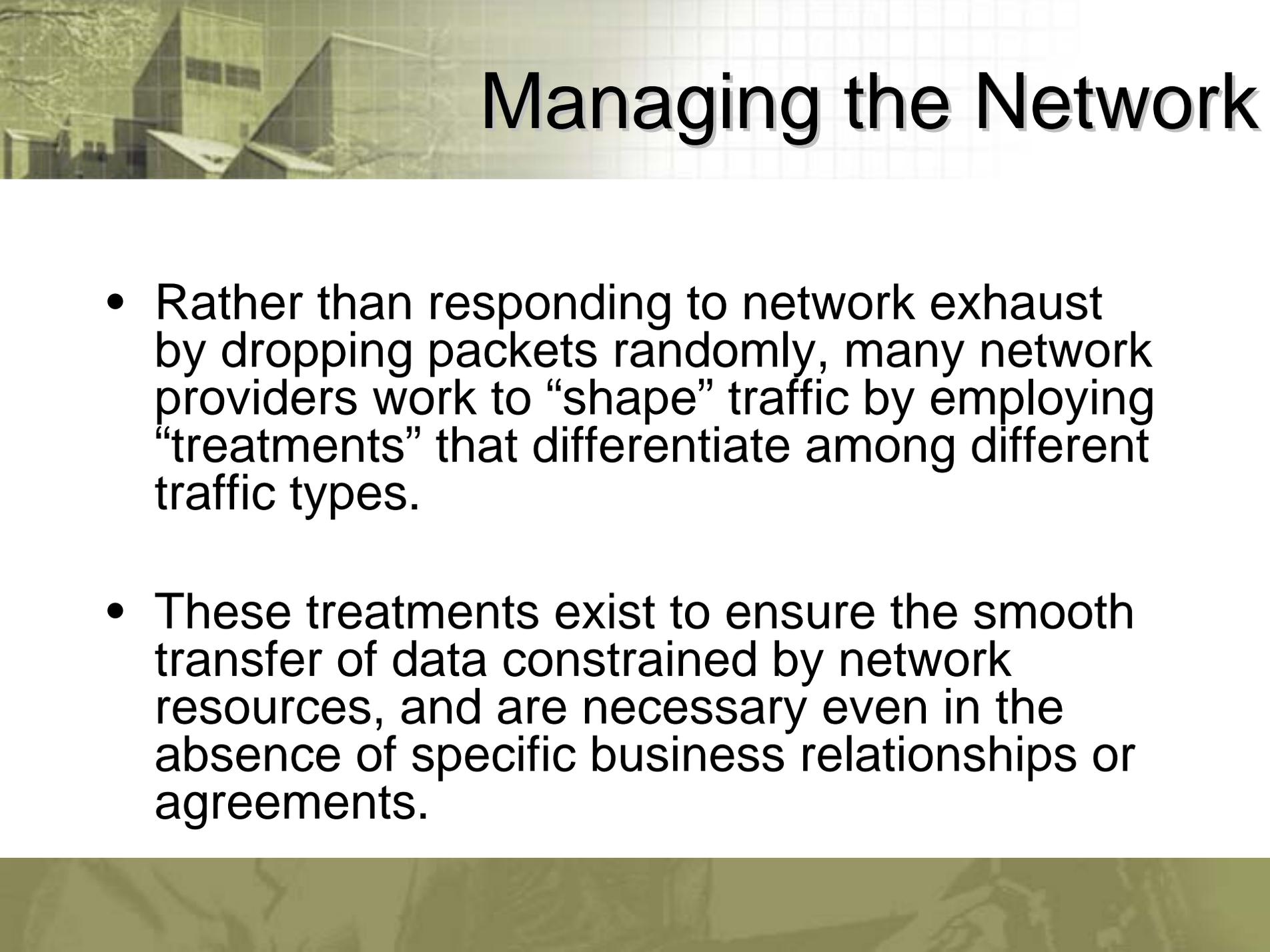
Managing the Network





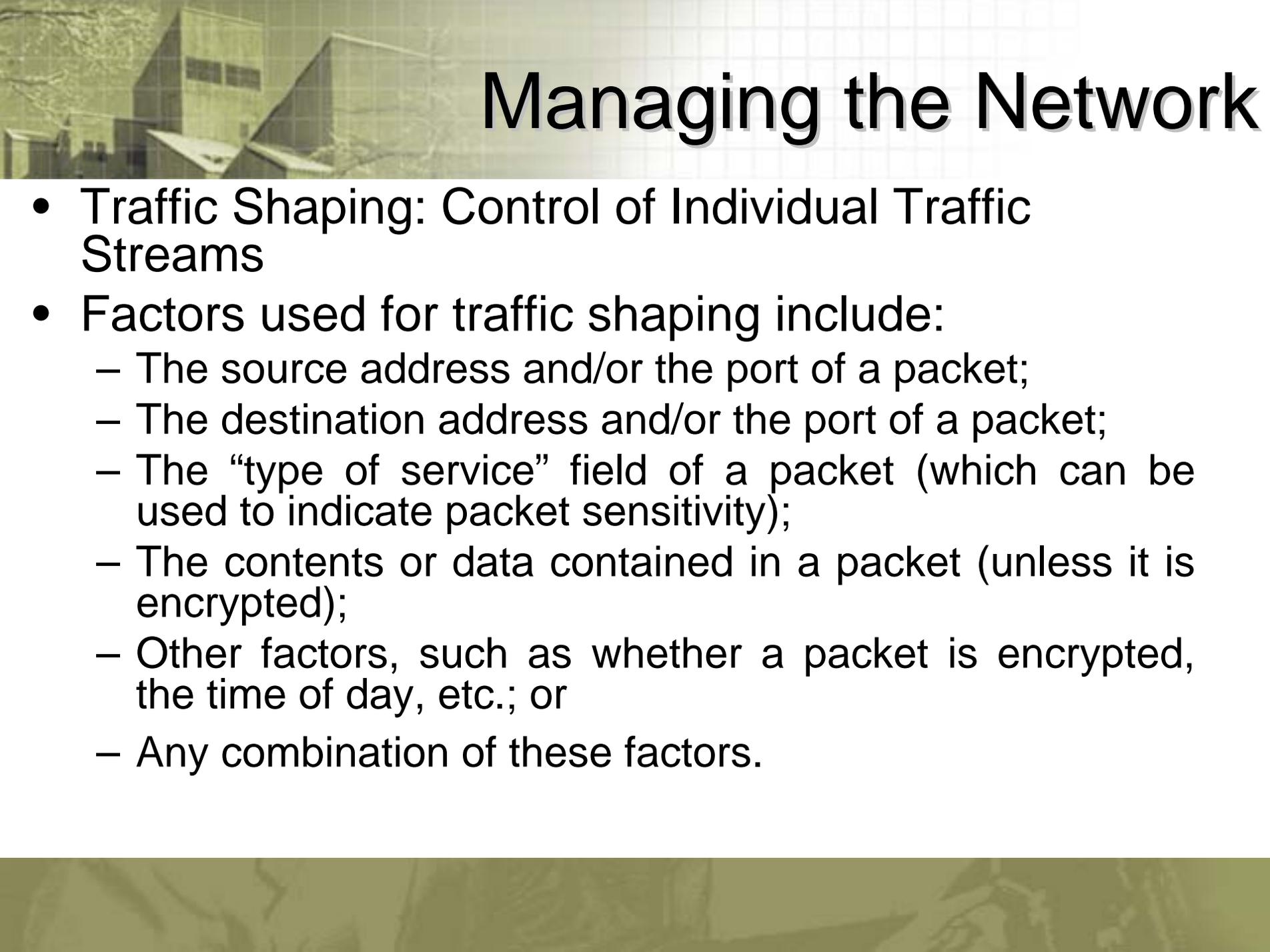
Managing the Network

- Quality of Service
 - Latency sensitive traffic – e.g., “on demand”
 - Jitter sensitive traffic – e.g., “two way” voice
 - Best effort traffic
- There are several reasons networks seek to manage data, including:
 - To reduce operational costs;
 - To deliver time-sensitive data more promptly; and
 - To deliver non time-sensitive data more cost effectively.



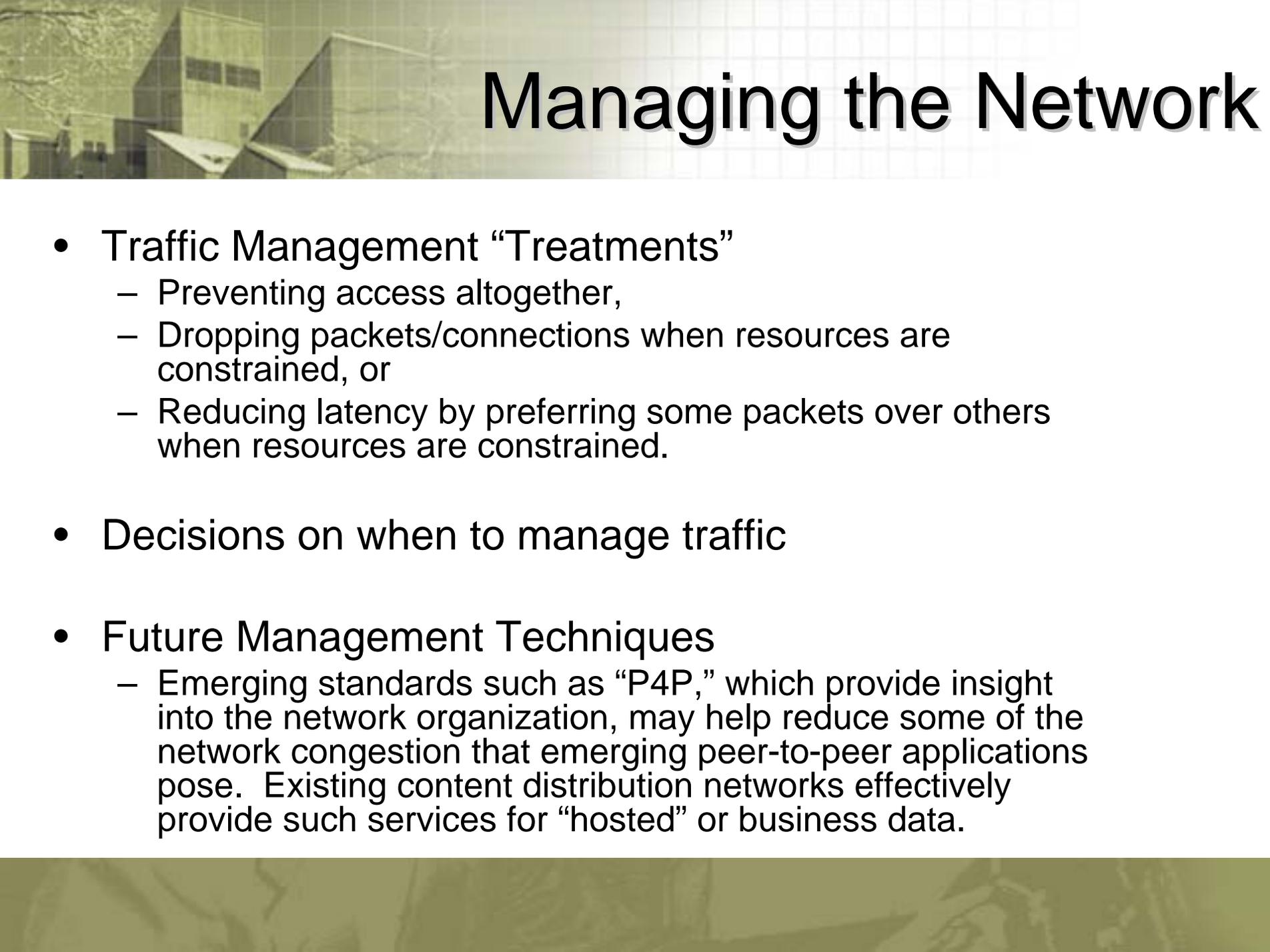
Managing the Network

- Rather than responding to network exhaust by dropping packets randomly, many network providers work to “shape” traffic by employing “treatments” that differentiate among different traffic types.
- These treatments exist to ensure the smooth transfer of data constrained by network resources, and are necessary even in the absence of specific business relationships or agreements.



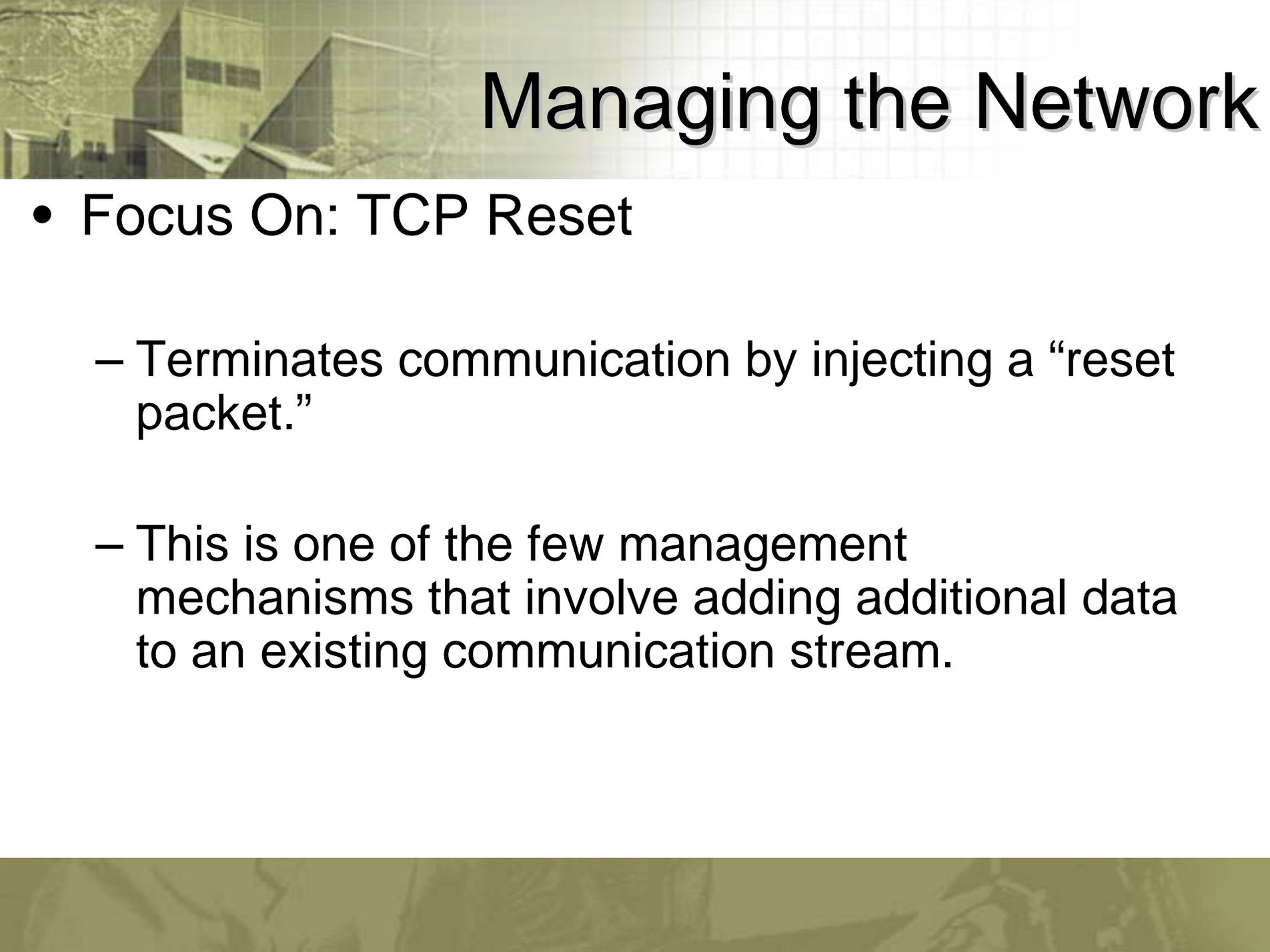
Managing the Network

- Traffic Shaping: Control of Individual Traffic Streams
- Factors used for traffic shaping include:
 - The source address and/or the port of a packet;
 - The destination address and/or the port of a packet;
 - The “type of service” field of a packet (which can be used to indicate packet sensitivity);
 - The contents or data contained in a packet (unless it is encrypted);
 - Other factors, such as whether a packet is encrypted, the time of day, etc.; or
 - Any combination of these factors.



Managing the Network

- Traffic Management “Treatments”
 - Preventing access altogether,
 - Dropping packets/connections when resources are constrained, or
 - Reducing latency by preferring some packets over others when resources are constrained.
- Decisions on when to manage traffic
- Future Management Techniques
 - Emerging standards such as “P4P,” which provide insight into the network organization, may help reduce some of the network congestion that emerging peer-to-peer applications pose. Existing content distribution networks effectively provide such services for “hosted” or business data.

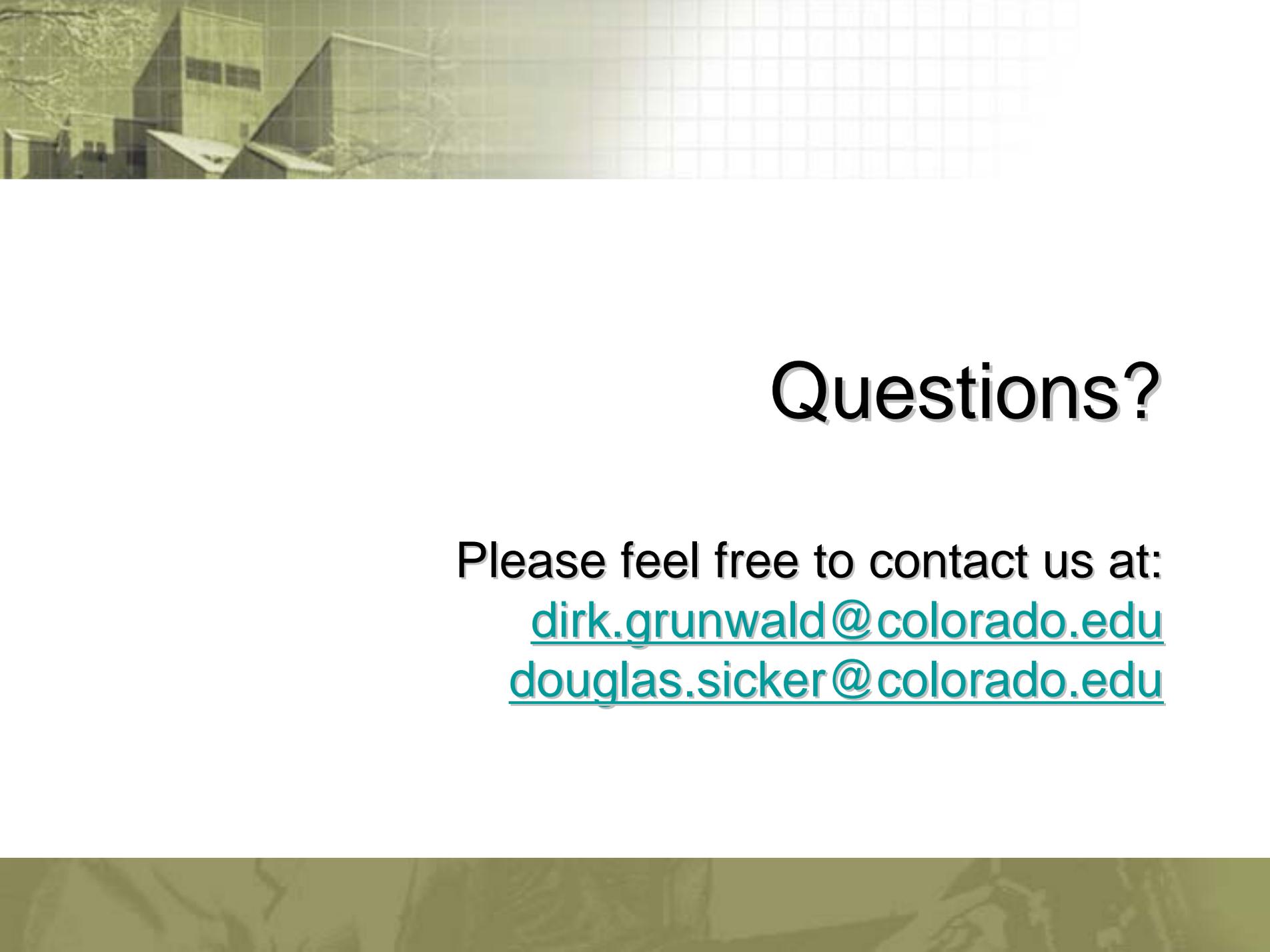


Managing the Network

- Focus On: TCP Reset
 - Terminates communication by injecting a “reset packet.”
 - This is one of the few management mechanisms that involve adding additional data to an existing communication stream.

Conclusions

- Key Conclusions:
 - Internet is a complex ecosystem of interconnected networks and infrastructures.
 - These interconnected networks are governed by a complex web of commercial relationships.
 - The online consumer's experience is a function of all of those networks and business relationships.
 - As network usage grows (and as jitter- and latency-sensitive applications become more prominent), network management is increasingly important.
 - There is a wide variety of tools available to manage traffic. Different tools may be more or less suitable in different situations.

The background of the slide features a photograph of a multi-story building with a grid pattern overlaid on it. The grid is composed of thin, light-colored lines. The building is on the left side of the image, and the grid extends across the entire width of the slide. The overall color scheme is muted, with shades of green and brown.

Questions?

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