Internet-based Content Delivery
Traffic Management with CDN & P2P Overlays

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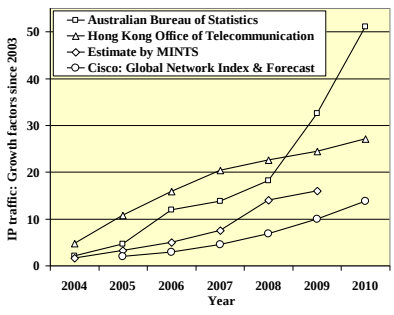
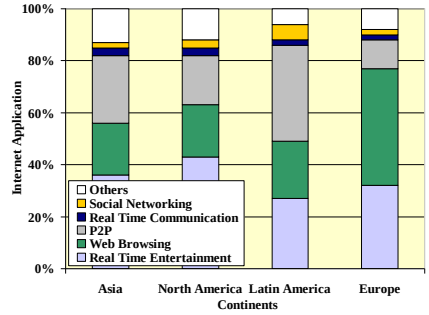
- Properties and impact of
  content delivery networks (CDN) and
  peer-to-peer networks (P2P)
  as overlays for content distribution
- Traffic management for optimized content delivery
  in the overlay and on the network layer

Trends in IP Traffic Growth & Application Mix

- Annual IP traffic growth factors 1.5-2.5 reported since 1990
- Current estimates: 1.3-1.5 for fixed and > 2 for mobile networks
- Video applications dominate IP traffic volume

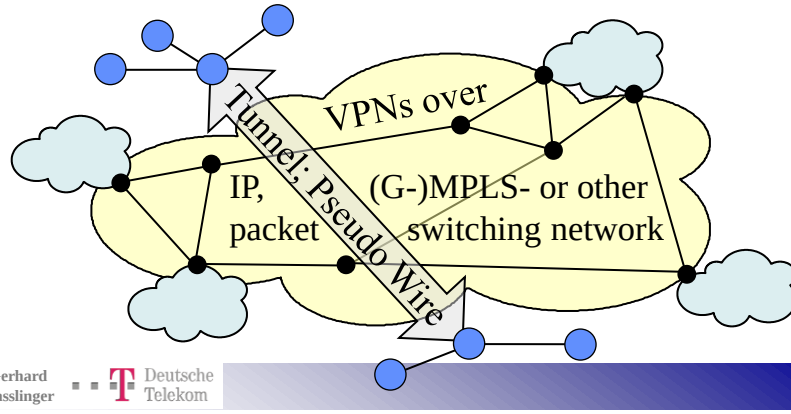




Sources, left side: <www.dtc.umn.edu/mints>, <www.cisco.com>,
<http://abs.gov.au/ausstats/abs@.nsf/mf/8153.0> ,
<www.ofta.gov.hk/en/tele-lic/operator-licensees/opr-isp/s2.html>
Right side: Fall 2010 Sandvine Internet Report <www.sandvine.com>

Overlays on Lower Layer in IETF Standardization

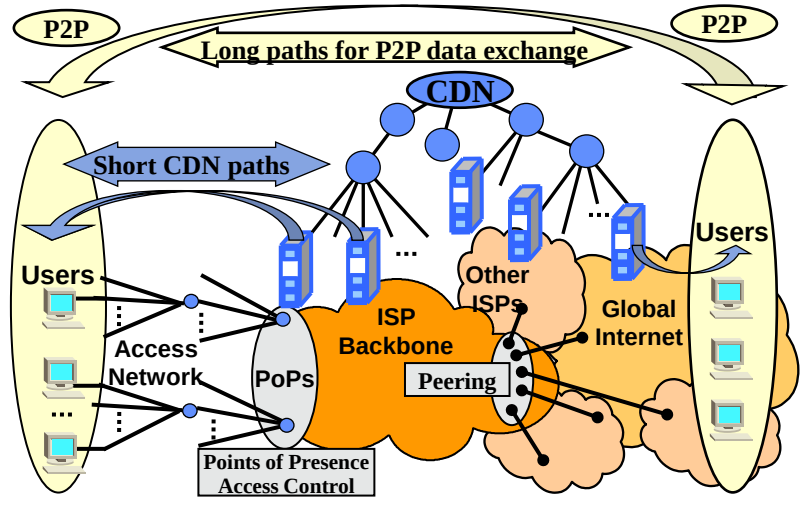
- Several IETF WGs are working on Tunnels, Pseudo Wires, VPNs, ...
- Over 200 RFCs on "Protocol X over Y", e.g.:
  RFC 895: Standard for IP datagrams over Ethernet (April 1984)
  RFC 3251: Electricity over IP (1. April 2002)
  RFC 6179: SON/SDH Circuit Emulation over Packet … (May 2011)



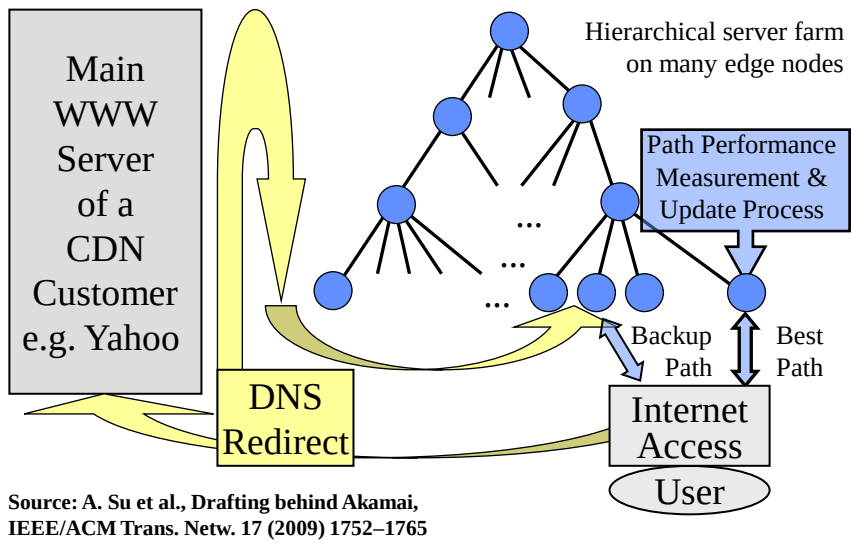
Properties of Application Layer Overlays

- Overlays can easily provide new or extend existing services/networks independent of underlying technology
- P2P networks establish overlays on user terminals to offer global services at a minimum of own network infrastructure
- Overlays introduce more overhead
  → Additional encapsulation and control data
  → Protocol functions may overlap on different layers
- Awareness of & cooperation with underlying infrastructure is essential to optimize performance & QoS regarding traffic paths & volume, delay
- P2P and CDN compete for delivery of large data volumes over IP but can also cooperate in hybrid CDN-P2P systems
  → Huang et al., Understanding hybrid P2P-CDN, NOSSDAV'08 Conf.
  → P2P streaming talk at IETF <www.ietf.org/proceedings/75/slides/P2PRG-8.pdf>

Content Distribution: CDN ↔ Peer-to-peer overlays

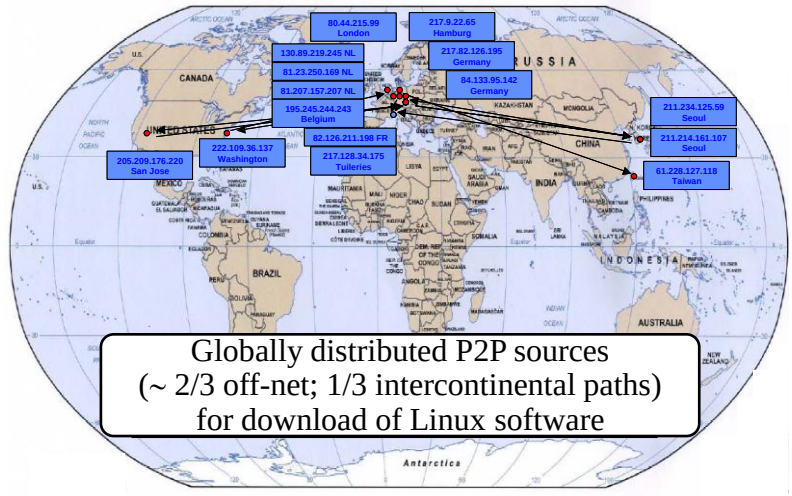


Content Delivery Overlays (CDN, Akamai, Limelight...)



Source: A. Su et al., Drafting behind Akamai, IEEE/ACM Trans. Netw. 17 (2009) 1752–1765

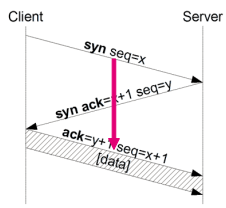
Long Transmission Paths for P2P Traffic

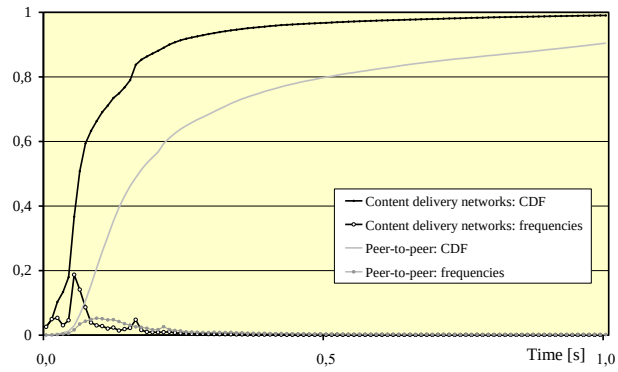


Globally distributed P2P sources
(~ 2/3 off-net; 1/3 intercontinental paths)
for download of Linux software

Delay Measurement Comparing CDN and P2P Traffic

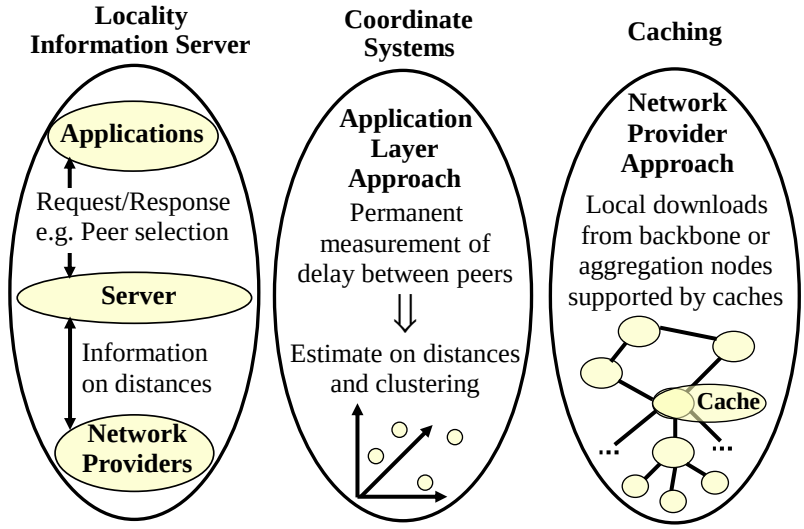
Method based on Round Trip Time (RTT) in TCP handshake, applied to link measurement





Cumulative RTT Distribution Function
Mean RTT: 0.125s for CDN; 0.33s for P2P
⇒ essentially longer RTTs for P2P traffic

Approaches for local P2P data exchange



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Server support for locality information

- IETF WG on Application Layer Traffic Optimization since 2008
  <tools.ietf.org/wg/alto/charters>
- P4P: Provider portal for applications
  <codex.cs.yale.edu/avi/home-page/p4p-dir/p4p.html>
- Main goal is to collect and provide locality information on servers useful for P2P and other application
- Who provides information and at which level of precision?
  Services for assignment IP → AS is available: <www.pwhois.org>
- Network Provider aided Distance Information System (PaDIS):
  is applicable to CDN as well via DNS redirections
  I. Poese et al.: Improving Content Delivery Using PaDIS, IMC'2010, Melbourne

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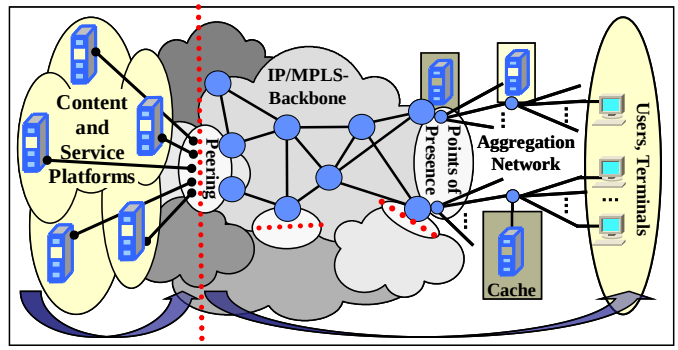
Caching & CDN in broadband access networks



Caching is applied in global content delivery networks and in large network provider platforms, but often without mutual cooperation

→ IETF is currently establishing a working group on CDN interconnection <tools.ietf.org/wg/cdni/charters>

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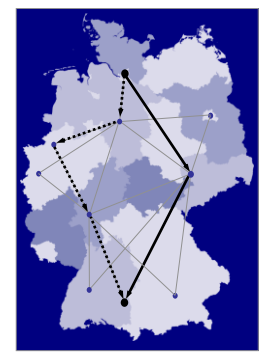
Traffic Engineering (TE) on IP/MPLS Networks

Pure IP networks don't include standard TE support as offered by Multiprotocol Label Switching (MPLS):

- explicit label switched paths instead of SPF routing
- path monitoring to obtain traffic matrices
- load balancing over network topology by optimized path design based on tools using e.g. linear programming
- failure resilience and link upgrade processes have to be integrated
- overprovisioning can be reduced by flexible and adaptive TE measures
- TE support on mobile networks studied e.g. by MEVICO (→ Euroview poster)



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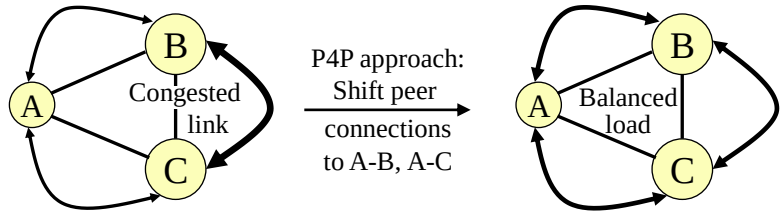
Application Layer Traffic Engineering

P4P approach studies traffic engineering and load balancing on the overlay, using linear programming for optimization

ALTO/P4P approach can integrate optimization for distributed sources, but without network layer concepts for failure resilience and link upgrades

Load balancing on the overlay may hide bottlenecks in the network infrastructure, e.g., the need to upgrade the link B-C at first



Conclusions on Traffic Management

- P2P applications need to shorten transport paths to stay competitive with CDNs
  - Application layer approach: Coordinate systems based on delay measurement are challenging and restricted to large networks
  - Pros & Cons for ALTO information server on source locations
  - Combined CDN/P2P content delivery seem most favourable

- Cross layer traffic engineering and load balancing
  - Approaches on CDN/P2P and network layer need to be aware of each other and should be coordinated
  - Distributed delivery from multiple sources opens new challenges and a higher gain for traffic engineering