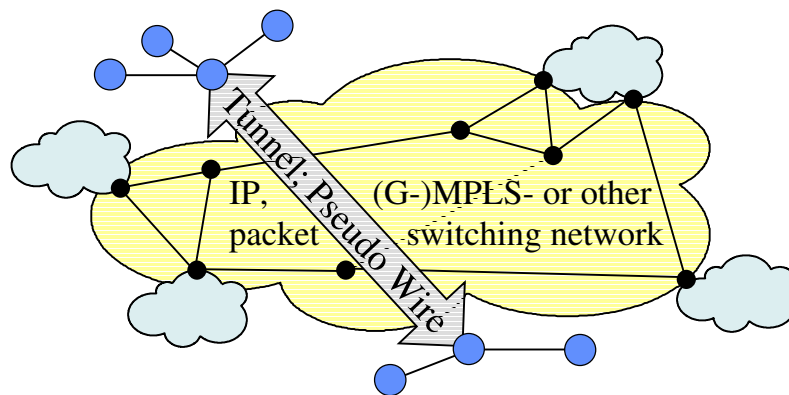


- Principles and efficiency of P2P Networking
- Internet Traffic Mix and Growth:
Measurement and Statistics on the Impact of P2P Networks
- **Cross Layer Issues:**
Broadband IP Infrastructure and Overlay Networks
- Established and Evolving Internet Services over
P2P Networks and Competition on Future Markets

Overlays standardized by the IETF on lower layers

- Pseudo wire emulation edge-to-edge (IETF: PWE3 working group)
- Working Groups on Layer-1,2,3 Virtual Private Networks
- > 250 RFCs on Protocol X over Y; Tunneling; Encapsulation; ...



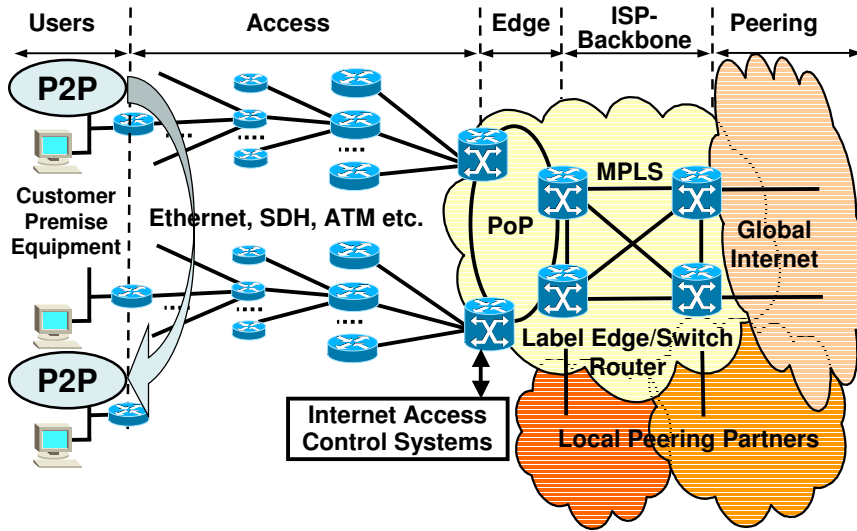
Some IETF Results on Overlays

- RFC 895/1042: Standard for **IP** datagrams **over Ethernet** (1984/88)
 - RFC 3717: **IP over Optical Networks**: A Framework
 - RFC 4717, 4619, 4618, 4448: Encapsulation for Transport of
ATM, Frame Relay, PPP, HDLC, Ethernet over MPLS
 - RFC 4798: Connecting **IPv6 Islands over IPv4 MPLS** ...
 - RFC 4817: Encapsulation of **MPLS over Layer 2** Tunneling ...
 - RFC 4906: Transport of **Layer 2** Frames **over MPLS**
 - RFC 5087: Time Division Multiplexing **TDM over IP**
 - RFC 5154: **IP over IEEE 802.16** ...
 - RFC 5270: Mobile IPv6 Fast Handovers over IEEE 802.16e Networks
 - RFC 4842: Synchronous Optical Network ... (**SONET/SDH**)
 Circuit Emulation **over Packet** ...
 - RFC 3251: **Electricity over IP**
- A statement in the abstract: *Readers of the previous work have been observed scratching their heads and muttering, "What next?"*

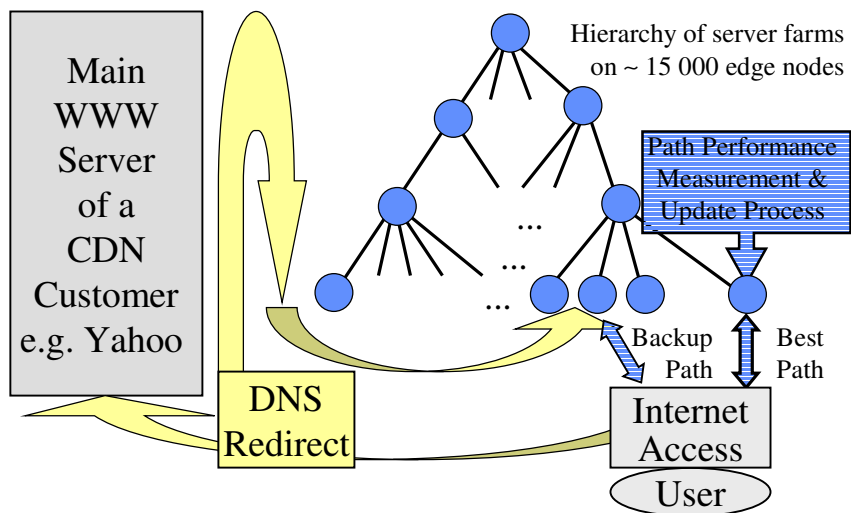
Almost no IETF Work on Peer-to-Peer Approaches

- IETF P2P research group <www.cs.umd.edu/projects/p2prg/>
 - has not been very active
 - RFC 4981 by J.Risson, T.Moors: Survey on Search Methods reprinted from Computer Networks Journal (?)
- P2P SIP working group: Peer-to-Peer Session Initiation Protocol
 - is in its early stage: → a key statement from an overview draft:
„A P2PSIP Overlay is a collection of nodes organized in a peer-to-peer fashion for the purpose of enabling real-time communication using the Session Initiation Protocol (SIP).“
- ALTO BoF: Application Layer Traffic Optimization: In July'08
 300 people met in Dublin; yet no consensus to proceed to WG status

Broadband IP Infrastructure & P2P Overlay Networks

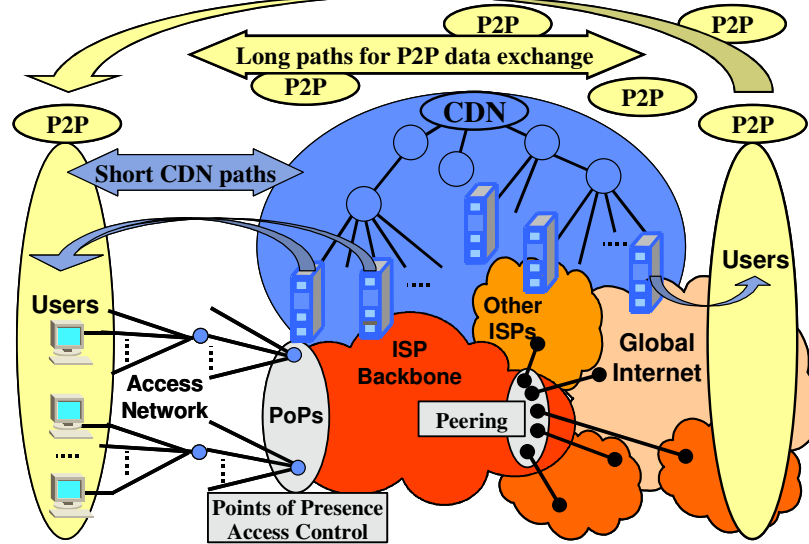


Content Distribution Overlays (CDN, Akamai, Google...)

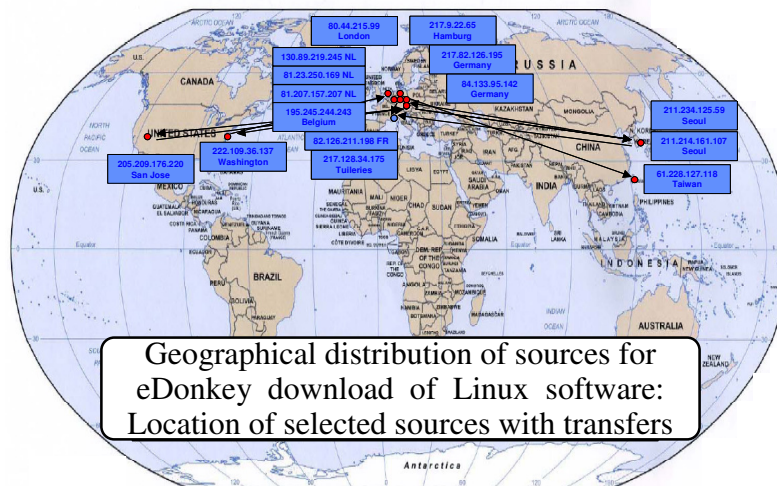


Source: A. Su et al., Drafting behind Akamai, ACM Sigcomm'06

Transmission paths in CDN and P2P networks



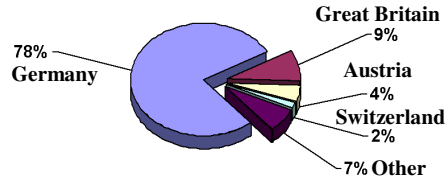
Sources & Transmission Paths for P2P Traffic



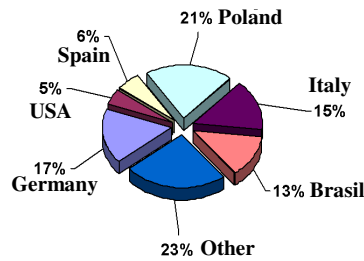
P2P Source Locations Influence of Social Communities, e.g. due to Language

Distribution of eDonkey Sources:

Downloads of German content in Germany:

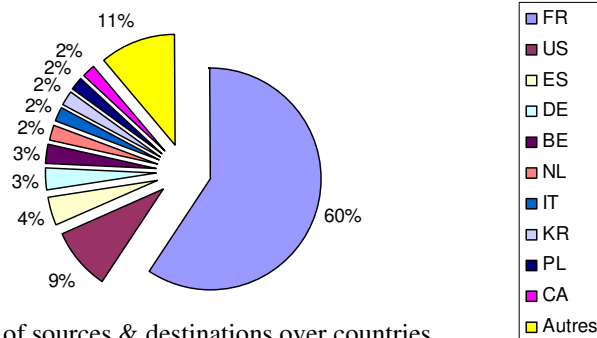


Downloads of English content in Germany: seems to depend on server locations which may change over time



P2P Source Locations: Transfers to & from France

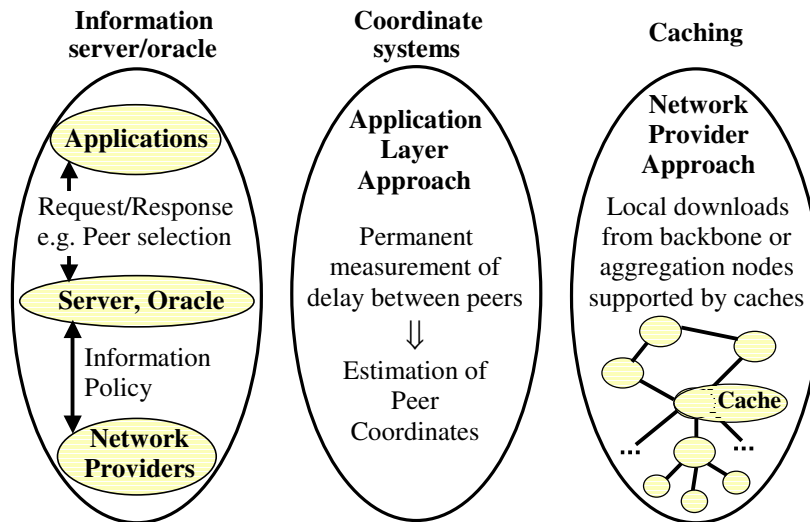
P2P Down (Volume)



Distribution of sources & destinations over countries (is similar in down- & upstream)

Source: Eurescom-P2P study

Approaches for local P2P data exchange



Server/Oracle support for locality information

- ALTO BoF at the IETF: Application layer traffic optimization
www.ietf.org/proceedings/08jul/minutes/alto.txt and alto.tilab.com
- P4P: Provider portal for applications
codex.cs.yale.edu/avi/home-page/p4p-dir/p4p.html
- Oracle approach, paper by Agrawal, Feldmann, Schneideler
 also available from paper collection at alto.tilab.com
- Problems: Standardization process at the IETF is complex
- How to build a unique interface to applications?
- Who provides information and at which level of precision?
 A service for assignment IP → AS is available: www.pwhois.org

Application layer approach for locality: Coordinate systems

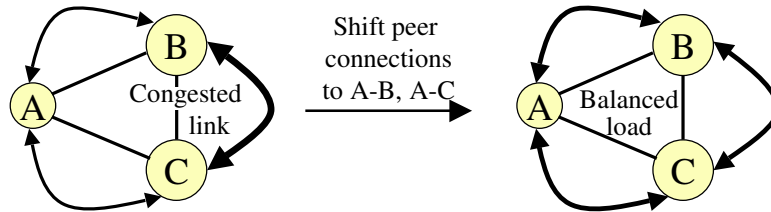
- Project of Azureus & Harvard Univ.
F. Dabek et al., Vivaldi Network Coordinate System, SIGCOMM 2004
J. Ledlie et al., Network Coordinates in the Wild, USENIX 2007
- Permanent latency measurements between nodes
piggy-backed on other P2P data exchange
- Vivaldi: 2 dimensions and a “height” for access link latency
Ledlie et al.: 4-dim. & height for more precision and stability
- Advantage: Unique application layer approach
- Problems: Variable delays, updates due to churn or route changes
detract from precision; to be implemented per application;
Seems challenging and only affordable for large P2P networks

Caches for P2P Traffic

- P2P data is suited for caching, but bypasses web caches for HTTP
High cache hit rate expected for file sharing; no out of date problems
- Transparent P2P caching offered by network analysis systems:
Online detection of P2P downloads for most popular protocols ...
- eDonkey option for transparent caching since October 2004:
In 2006, 20-25% of eDonkey peers had caching option active
7-8% of data loaded from caches in DT's IP platform at high rates
- Caches can open up the upstream bottleneck of P2P networks;
most relevant for limited bandwidth (mobile, asymmetric systems)
- Caching is ideal to improve throughput and locality of P2P transfers,
but does not necessarily decrease P2P traffic load (profit for ISPs ?)
- Problem of copyright offending data in the cache, even if not new (?)

Application Layer Traffic Engineering

P4P approach studies overlay traffic engineering, load balancing, e.g.:



Load balancing can be done on network and application layer
 P2P traffic offers more variability to optimize source locations
 But load balancing has to integrate

- the link upgrade process on an ISP platform
- failure resilience, at least for single link failures

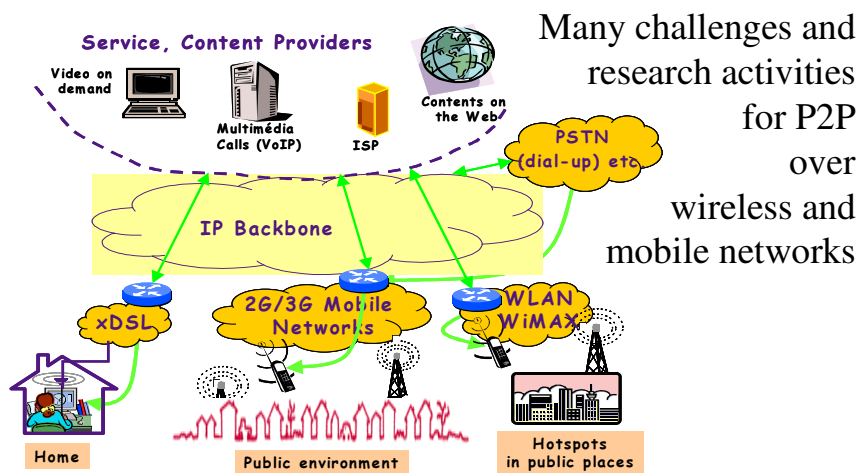
With balanced overlay load, the network provider cannot see the real bottlenecks, e.g., the need to upgrade the link B-C at first ?

Conclusions (3)

- Overlays of various type are used to bridge heterogeneous inter-connecting networks for comfortable end-to-end service delivery
- P2P networks establish overlays on user terminals offering global services without or at a minimum of own network infrastructure
- Overlays can provide new services or extend existing services or networks on top of & independent of underlying infrastructure
- Overlays introduce more overhead
 - Additional encapsulation and control data
 - Protocol functions may overlap on different layers
 - Awareness of and cooperation with lower layers required for popular P2P services to stay competitive, e.g. for shorter paths

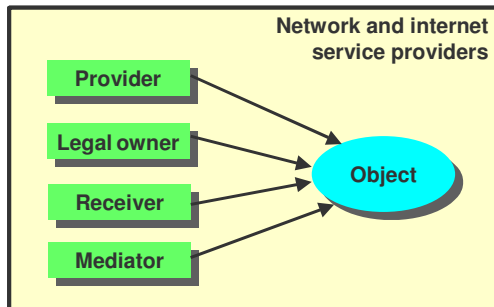
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Framework of Next Generation Networks



P2P for Business Applications

Players



Charging principles in telecommunication

- Monthly fee per subscription
- Charge per time
- Charge per transferred data volume
- Charge per received service or content
- Charge based on flat-rates depending on access speed
- Charge based on auction for limited resources ...

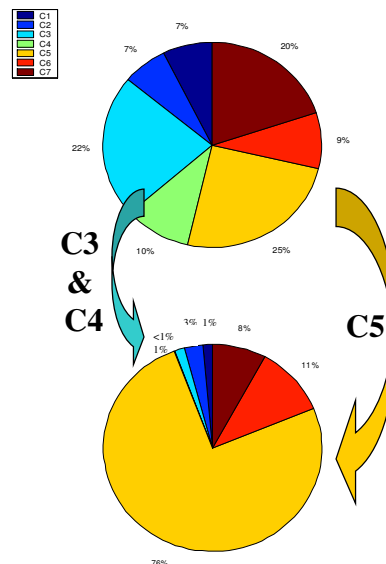
Broadband Internet Access: Classes of ADSL users observed in France

Class C5: Heavy users
25% of the population generate
76% of traffic (File sharing)

Class C3, C4: Inactive users
32% of the population
generates < 2% of traffic

Business users
are usually neither heavy
nor inactive users

Source: Eurescom P2P study



Skype P2P solution for VoIP

- Simple P2P overlay network for free VoIP globally on the Internet
- Proprietary solution bypassing standardization (SIP ...)
- Sound quality as compared to competitors (→ Bazet & Schulzrinne)
- Indirect business model (SkypeIn, SkypeOut, + VoIP equipment)
- Huge impact on voice services (Evalueserve Market Analysis Rep.: estimated Skype user population 2005-2008: 40 → 140-280 Mio.)

Estimated impact of Skype on ISP revenues (M. Vollenweider www.evalueserve.com)	in the USA (Verizon)	in Europe (Swisscom)
Decline in long distance call revenues		
due to decline in customer base	- 9 %	- 24 %
due to reduced prices	- 20 %	- 18 %
Decline in local call revenues		- 17 %
Decline in total revenues for ISPs without regarding the mobile sector incl. the mobile sector and roaming	- 2.6 % - 3.4 %	- 4.8 % - 7.9 %

P2P applications: Radio & TV over P2P

BBC iPlayer

BBC offers content over P2P network incl. DRM enforcement for program of last 7 days; Field trial Sep.05-Feb.06 Online in GB

- www.bbc.co.uk/iplayer
- www.onlinetvrecorder.com

iMP in 3 easy steps

- 1 go to guide, download.
- 2 Download done. Play it.
- 3 enjoy :-)

Program	Start	End	Channel	Size
EastEnders	7:30pm	00:30	BBC ONE	225MB
Holby City	8:00pm	01:00	BBC ONE	225MB
Cutting It	9:00pm	01:00	BBC ONE	225MB
ONE Life	10:35pm	00:45	BBC ONE	168MB
The Weakest Link	5:10pm	00:50	BBC TWO	187MB
Time Flare	7:30pm	00:30	BBC TWO	112MB

Cutting It
 9:00pm
 Last seen setting fire to both the Henshall and Ferraday hair salons, Mia (Amanda Holden) returns to Manchester an apparently reformed character. But how long can this new incarnation last? [AD]
 File size: 225MB

SERIES DOWNLOAD
 DOWNLOAD NOW

EU-Project P2P-Next: Evolutionary Extension of Media and Entertainment Distribution Systems

<www.p2p-next.org>

“ Broadcasters and content providers consider P2P as a future-proof, universal, and ubiquitous two-way distribution mechanism. Initially, P2P will complement the existing distribution mechanisms such as satellite, cable and terrestrial networks, but ultimately it may supersede them.

The P2P-Next Project extends the notion of a conventional media distribution network. It introduces a concept of on-demand, personalised and social network. “



Gerhard Haflinger, P2P-Next Systems

Emerging P2P services and prerequisites

- Online Gaming and e-Learning Applications
 - Software downloads via modified BitTorrent P2P clients
 - P2P support of online activity (VoIP, video channel, real time data)
- Content distribution: More frequent and larger software updates
- Streaming services: Video on demand, IP-TV
- P2P solutions can adapt to the demands of small communities
- Extension to wireless and mobile environment
- Prerequisites:
 - Many security aspects are still unsolved in popular P2P networks
 - Enforcement of complex business models & payment flows in converging Telecom & Broadcast & IP-TV market

Gerhard Haflinger, P2P-Next Systems

Conclusions (4)

- Peer-to-peer services compete with alternative overlays
 - by CDNs: Content Delivery Networks
 - by Network Providers, ISPs, e.g., on local multicast platforms
- P2P is easy to install on users equipment
 - no network resources required beyond Internet connectivity
 - powerful global scale solutions for cooperative communities
- CDNs require server infrastructure as overlays within IP platforms
 - Efficient control of security, reliability and quality of service (QoS)
 - Large CDNs can deliver many services at good quality and low cost
- Future role of P2P and CDN overlays depends on efficiency and on the incentives for content/network/service providers and users