Overlays and P2P Networks

@ CRES, Monreale, Italy, 16 March-15 April 2009

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Overlays and P2P Networks: Introduction

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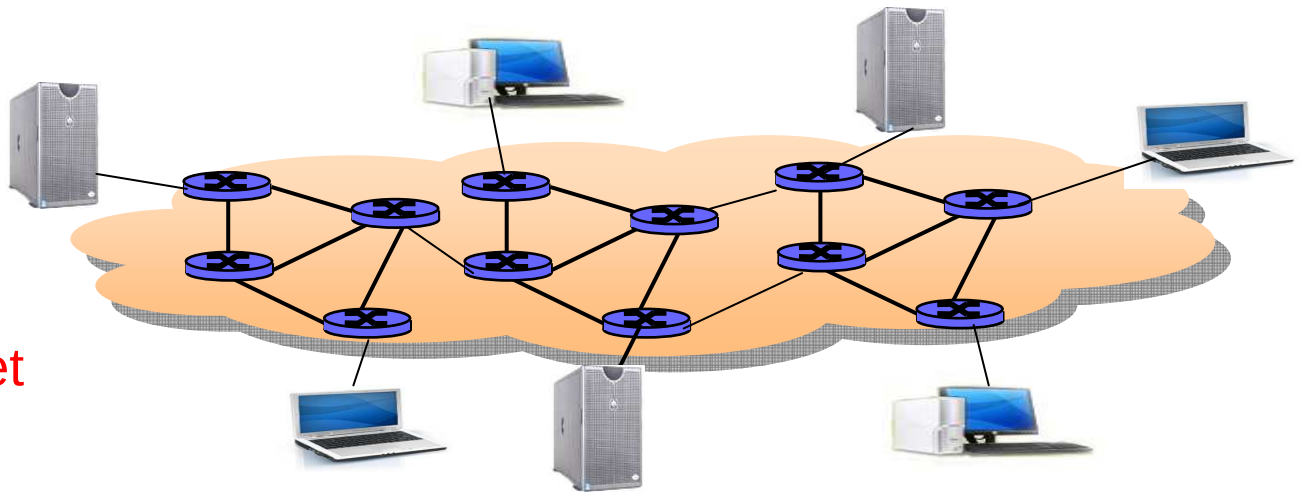
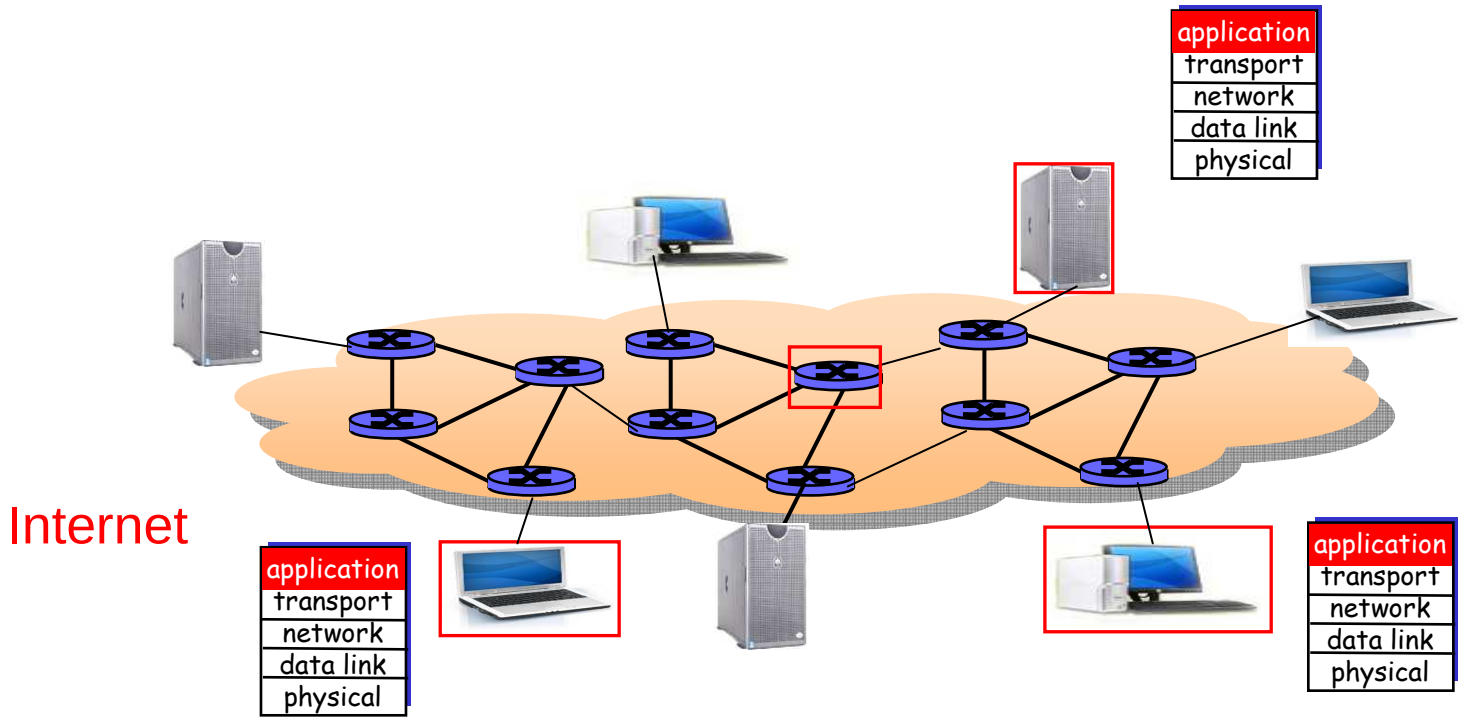
Overlay networks: what they are

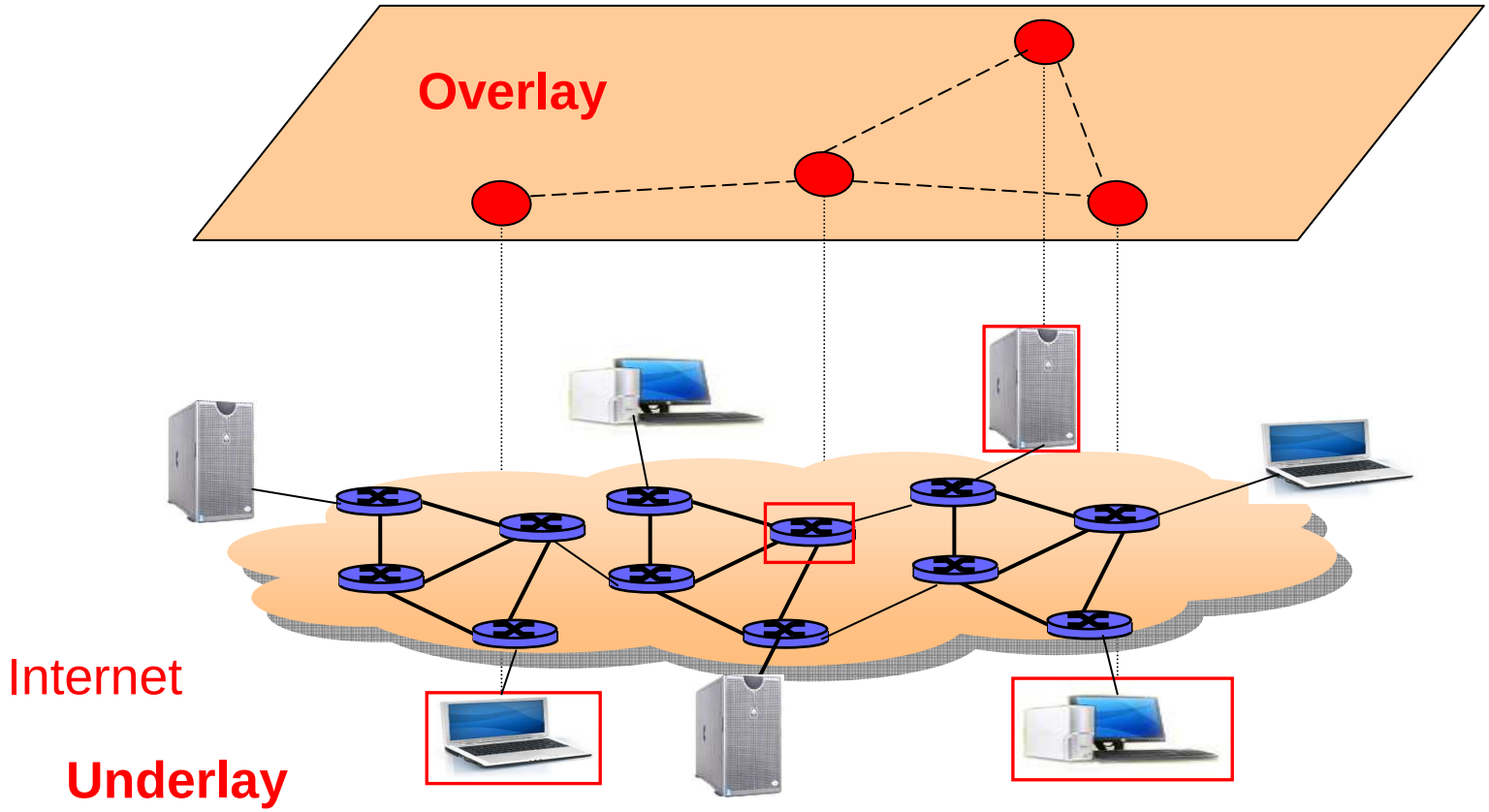


Overlay networks: what they are



Overlay networks: what they are

--- Logical connections (using TPC or UDP)



Overlay graph

Virtual edge

- TCP connection
- or simply a pointer to an IP address

Overlay maintenance

- Periodically ping to make sure neighbor is still alive
- Or verify liveness while messaging
- If neighbor goes down, may want to establish new edge
- New node needs to bootstrap

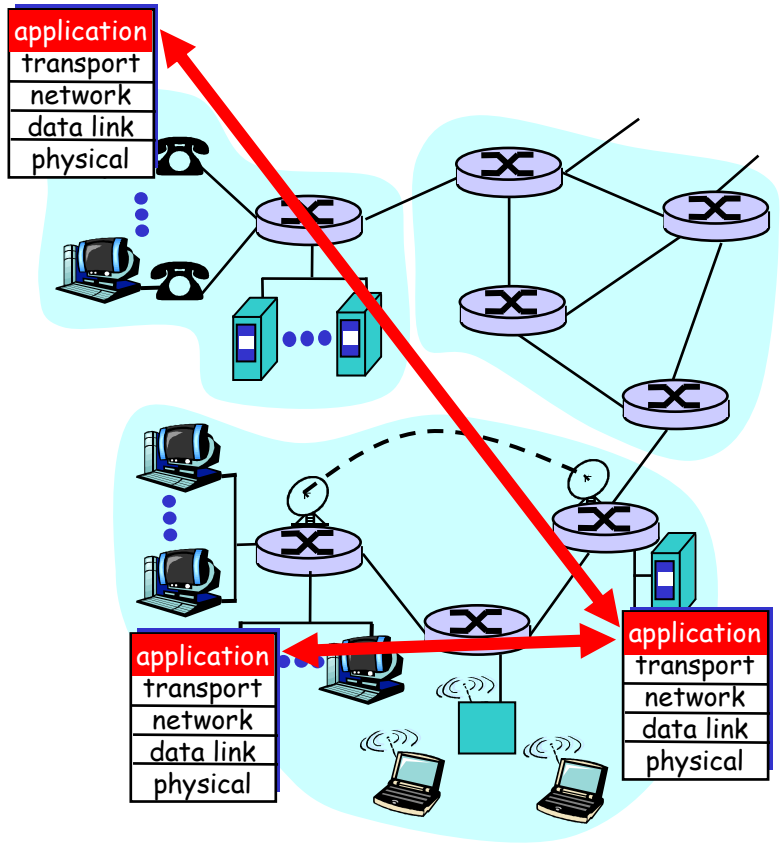
Overlays: all in the application layer

Tremendous design flexibility

- Topology, maintenance
- Message types
- Protocol
- Messaging over TCP or UDP

Underlying physical net is transparent to developer

- But some overlays exploit proximity

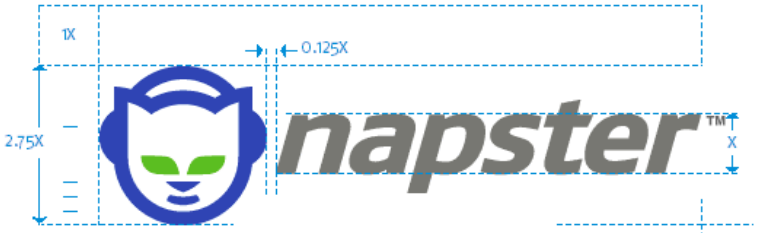


Examples of overlays

- DNS
- BGP routers and their peering relationships
- Content distribution networks (CDNs),
  - e.g. Akamai
- Application-level multicast
  - economical way around barriers to IP multicast

- And P2P apps !

What is Peer-to-Peer (P2P)?

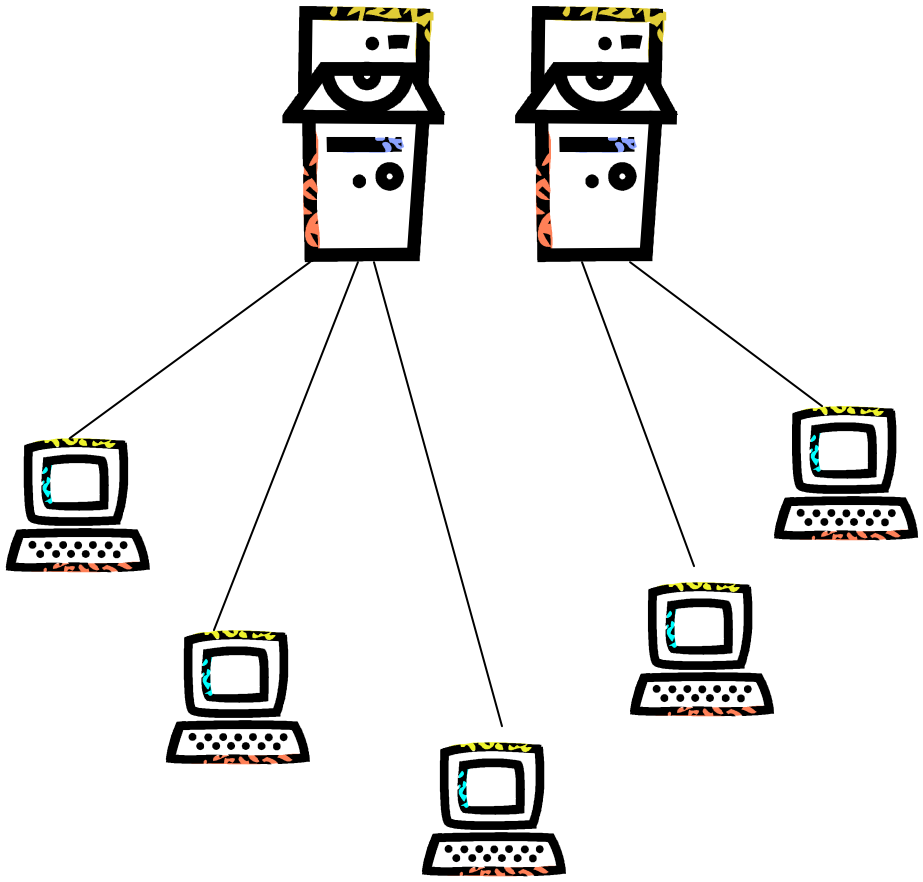


P2P Networks

1) They are overlays
   - at the application level
2) No client-server
   - interaction among *peers*
3) Application running at user side

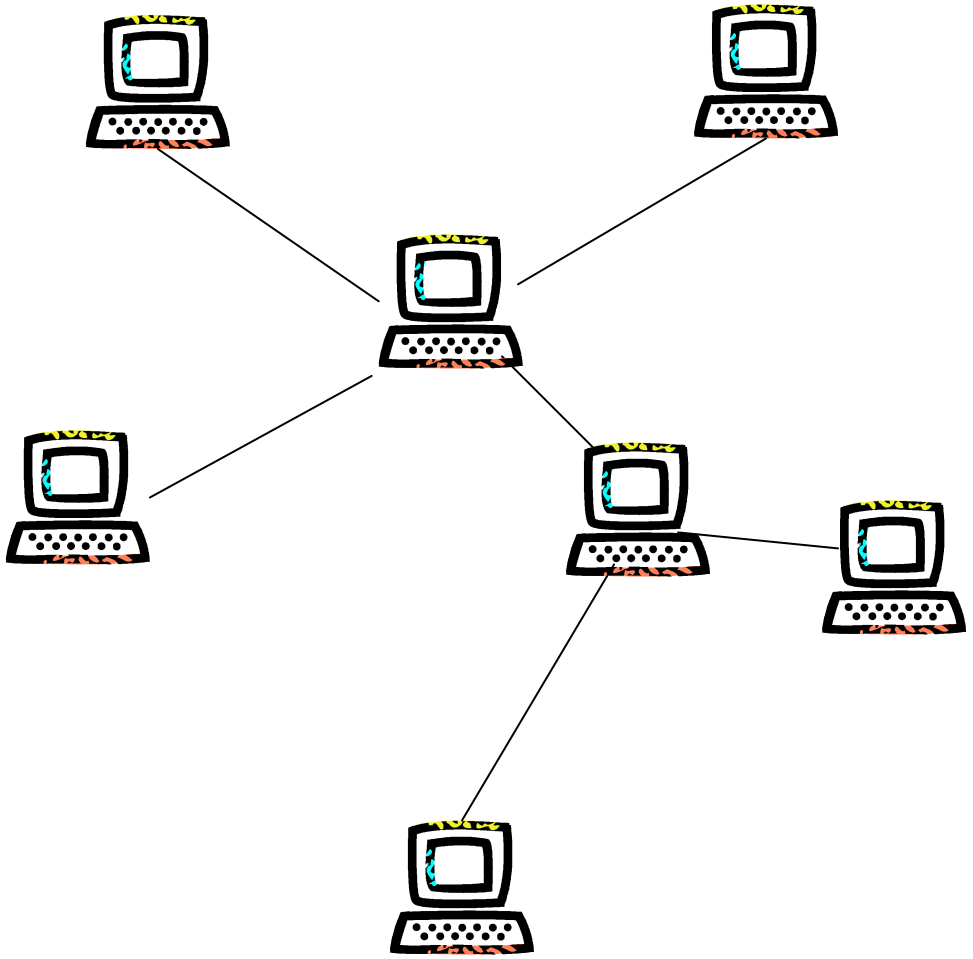
The Client-Server Model

- Contact a server and get the service.
- Server has all the resources and capabilities.
- No interaction among clients
- Common model in the Internet (e.g. www).



The P2P Model

- A peer's resources are similar to the resources of the other participants
- P2P – peers communicating directly with other peers and sharing resources
- Peer = Servent = Server+Client



Client-Server vs P2P

- RPC/RMI
- synchronous
- Asymmetric
- Emphasis on language integration and binding models (stub IDL/XDR compilers, etc.)
- Kerberos style security – access control crypto

- Messages
- Asynchronous
- Symmetric
- Emphasis on service location, content addressing, application layer routing
- Anonymity, high availability, integrity

P2P Networks

1) They are overlays
   - at the application level
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First example: Napster

- the most (in)famous
- not the first (c.f. probably Eternity, from Ross Anderson in Cambridge)
- but the first popular one
- instructive for what it gets right, and
- also wrong…
- also has a political message…and economic and legal…

P2P file sharing software

- Allows Alice to open up a directory in her file system
  - Anyone can retrieve a file from directory
  - Like a Web server
- Allows Alice to copy files from other users' open directories:
  - Like a Web client
- Allows users to search the peers for content based on keyword matches:
  - Like Google

Napster: how does it work

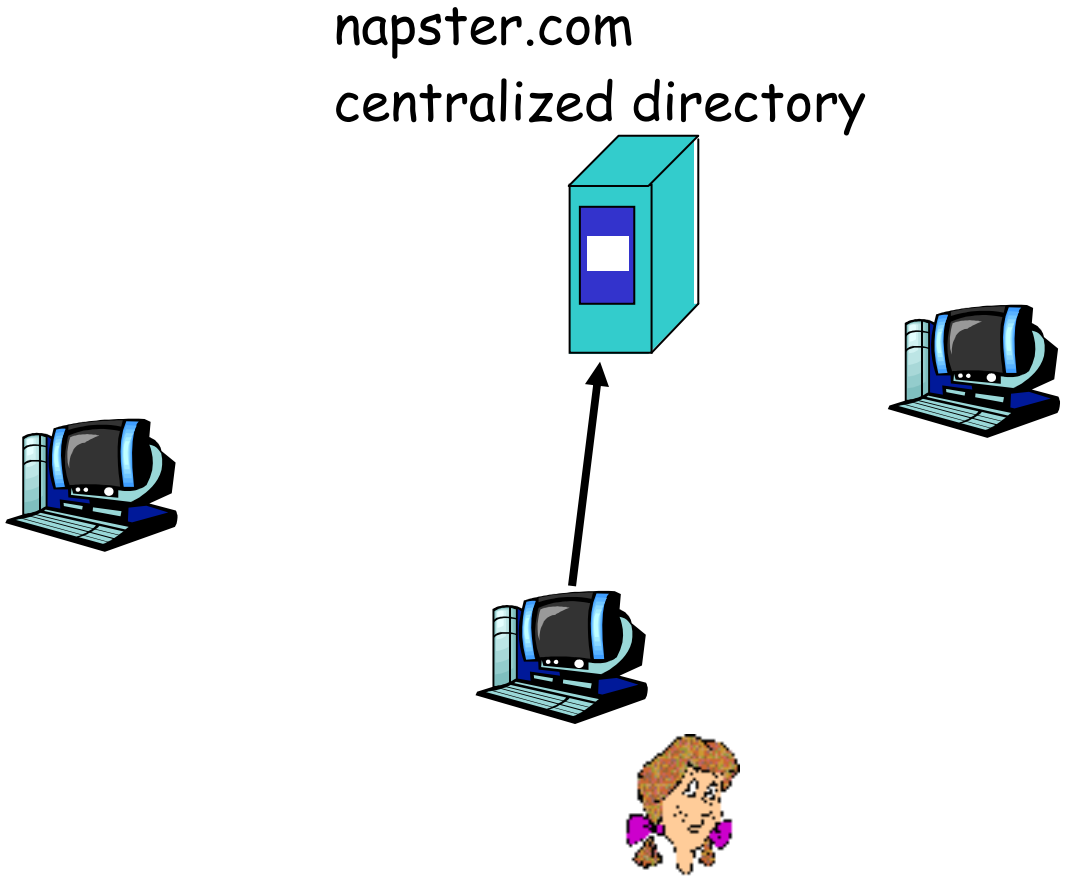
- Application-level, client-server protocol over point-to-point TCP
- Centralized directory server

Steps:

- connect to Napster server
- upload your list of files to server.
- give server keywords to search the full list with.
- select "best" of correct answers. (pings)

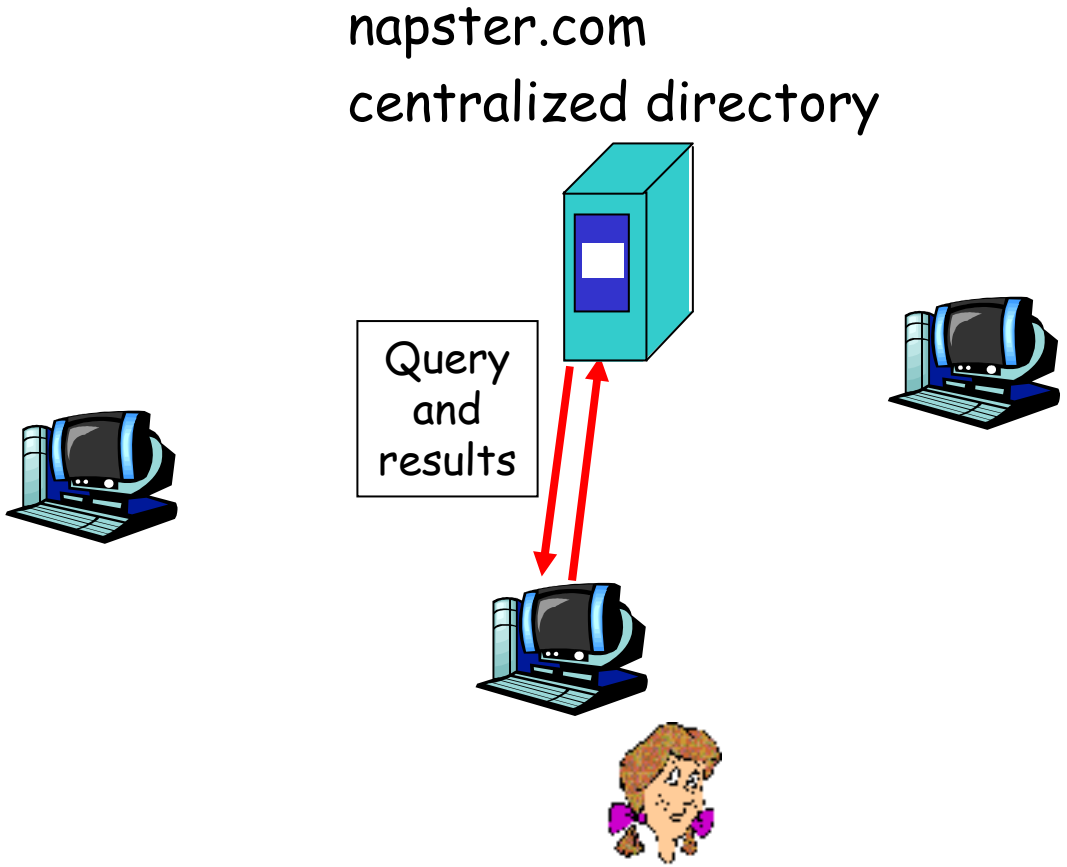
Napster

1. File list and IP address is uploaded



Napster

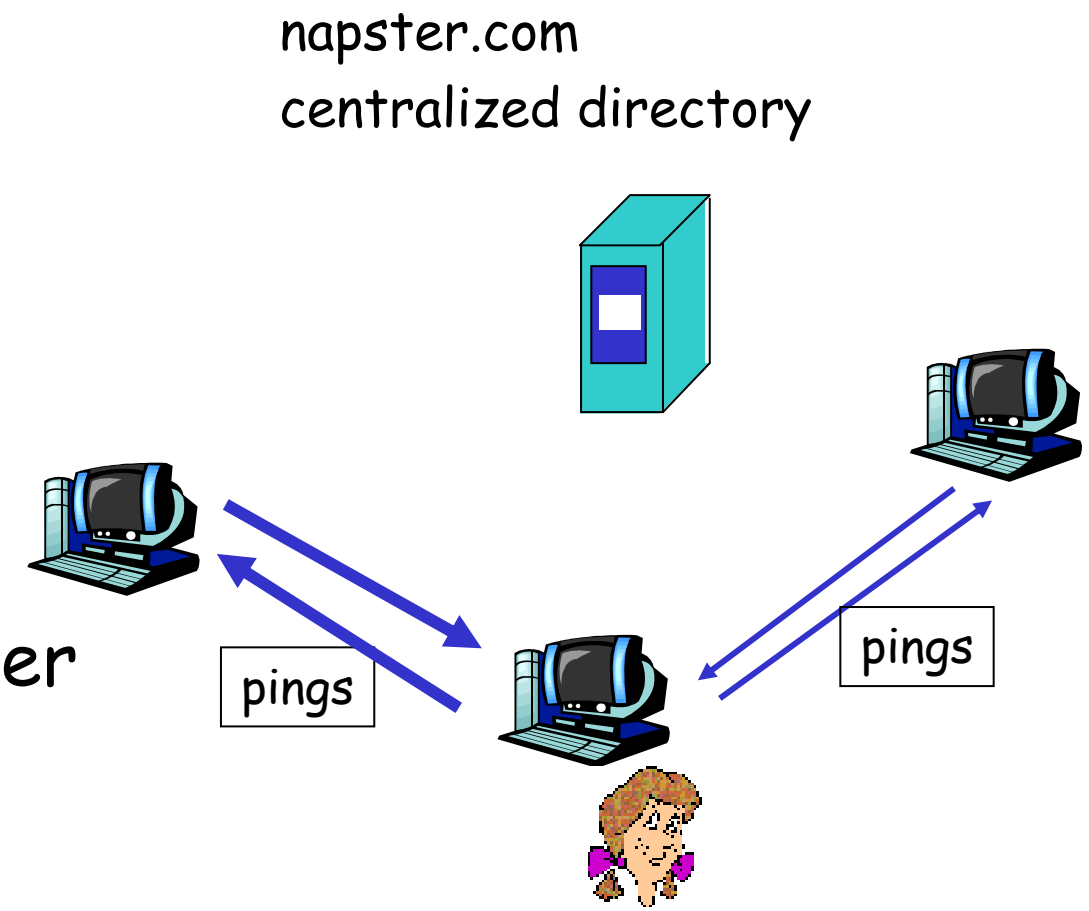
2. User requests search at server.



Napster

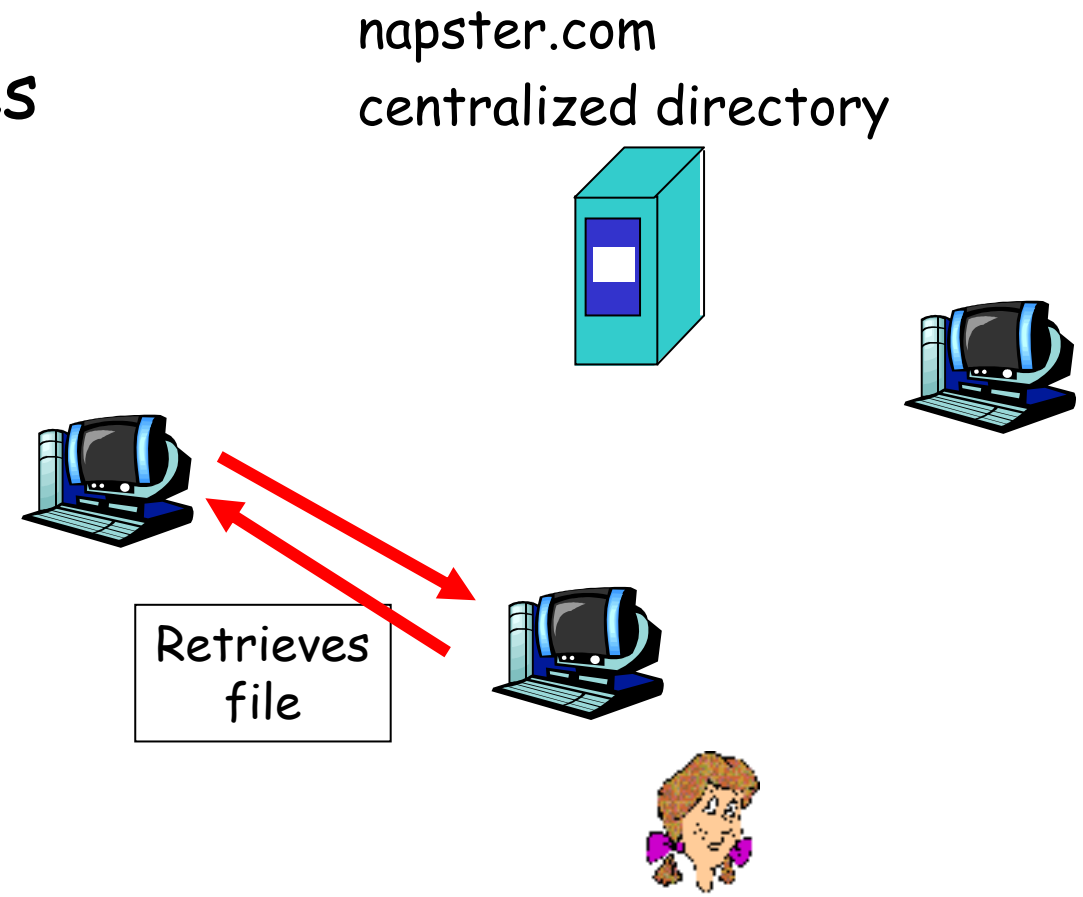
3. User pings hosts that apparently have data.

   Looks for ***best*** transfer rate.



Napster

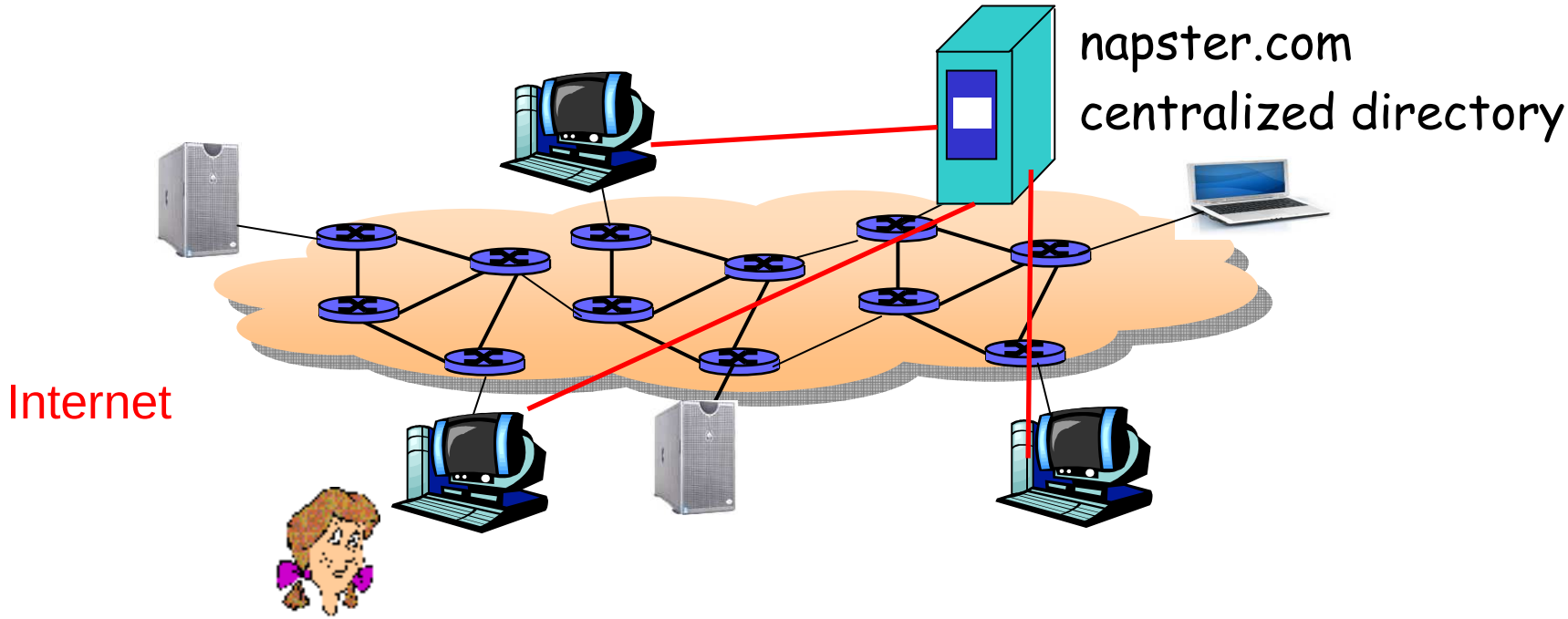
4. User chooses server



Napster's centralized server farm had difficult time keeping up with traffic

Napster as P2P

1) They are overlays YES
2) No client-server, Mostly, but one server for look-up
3) Application running at user side, Mostly



Routers as peers

- Routers in the Internet:
  - discover topology, and maintain it
  - neither client nor server
  - continually talk to each other
- Internet was born as an overlay on top of the traditional phone network

P2P & Ad-Hoc Wireless Nets

- wireless ad hoc networks have many similarities to peer to peer systems
  - no a priori knowledge
  - no given infrastructure
  - have to construct it from "thin air"!

P2P Applications

- File sharing (Napster, Gnutella, Kazaa, BitTorrent, EMule)
- Audio/video conference (Skype)
- Streaming (Sopcast, PPLive)
- Data storage
- Anonymity (Tor, I2P)
- Censorship resistance (Infranet, Tangler)
- Collaboration (Jabber, Groove)
- General Purpose platforms (JXTA)
- Distributed Computing (SETI@home)

Why P2P?

- Distributed systems pros...
  - Scalability, Reliability, Saving,...
- and cons
  - complexity, management, security
- The Internet has three valuable fundamental assets...
  - Bandwidth
  - Computing/Storage resources
  - Information
- ...all of which are vastly under utilized, partly due to the traditional client-server model

Bandwidth

- Despite miles of new fiber installed, the new bandwidth gets little use if everyone goes to Yahoo for content and to eBay
- Instead, hot spots just get hotter while cold pipes remain cold

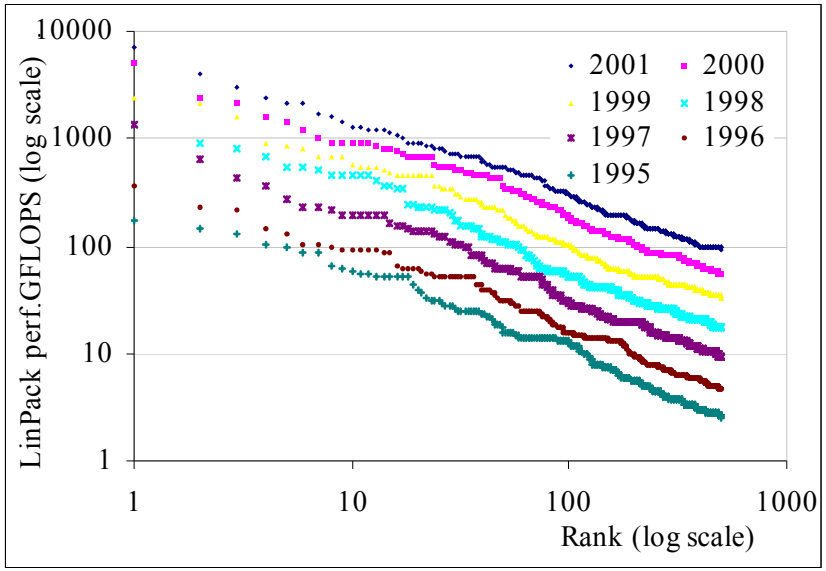
Take advantage of users bandwidth

Computing/Storage

- Super-computers (Network Attached Storage) are expensive

Take advantage of home PC CPUs

- Project like SETI@home



Top500 supercomputer list over time:

Zipf distr. Perf(rank) ≈ rank $^{-T}$

T decreases over time =>

Increasing interest to aggregate capabilities of machines in the tail

A virtual machine that aggregates the last 10 would rank 32nd in '95

but 14th in '03

Information

- Most of the information is still at users
  - No single search engine can locate and catalog it (size, accessibility, transient)

P2P impact: users#

- File sharing
  - Napster (≈2000) 1.5 million simultaneous users
  - 2003 3.8Millions [Big Champagne]
  - 2006
    - 9M (not including BitTorrent), [Big Champagne]
    - 5M in Mainline BT DHT [BitTorrent]
    - 1M in Azureus BT DHT [Azureus]
- Skype: 9 millions [skypestats.com 2008]
- PPLive 0.4M daily users [PPLive, 2006]

P2P impact: traffic (file sharing)

- 60% [Cachelogic, 2004 et 2006]
  - In 2006 50-65% download, 75/90% upload
- 2007
  - 74% of German traffic [ipoque 2007]
  - 37% North America [Ellacoya networks, 2007]
- Total cross-border Traffic [TeleGeography, 2005]
  - 2005: 1 Terabps
  - 2008: 2-3 Terabps

P2P impact: market

- P2P applications market for collaborative environment [Solomon Smith Barney,2003]
  - 5.8 Billions $ in 2003
  - 36.5B $ in 2004
- P2P traffic revenues for carriers
  - 100B $ by 2012 [Insight Research Corp., 2007]
  - Seti@Home savings: $1.5M / year
- Microsoft: user-assisted software update spreading
- Thomson: set-top box assisted movie spreading
- From 2008: P2P market conference, by Distributed Computing Industry Association

Outline (1/3)

- File Sharing: the first generation
  - Napster, Gnutella, Kazaa
- Interlude: Structured vs Unstructured and P2P topologies
- Search in Unstructured Networks
- Structured networks (DHT)
- File Sharing: state of the art
  - BitTorrent, Emule
  - Models for P2P file sharing
  - Free riders, Incentives and Strategic clients (BitThief, BitTyrant)

Outline (2/3)

- Coding for file sharing
  - Fountain codes, network coding, bloom filters
- P2P traffic
  - Tussle between ISPs and Peers (part 1)
  - P4P
- Advantage and Risks of Overlays
  - Tussle between ISPs and Peers (part 2)
  - Case study: overlays for routing (Resilient Overlay Networks)

Outline (3/3)

- Skype
- P2P for anonymity
- P2P streaming
- P2P backup
- Virtual Coordinate systems
- Distributed Virtual Environments