CSF641 – P2P Computing

點對點計算

Introduction to Peer-to-Peer Systems

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Outline

- Introduction
  - Why P2P
- Basic P2P Technologies – Search/Lookup
  - Centralized
  - Unstructured
  - Structured
- Comments on P2P

Peer-to-peer Model

"Peer-to-Peer (P2P) is a way of structuring distributed applications such that the individual nodes have symmetric roles. Rather than being divided into clients and servers each with quite distinct roles, in P2P applications a node may act as both a client and a server."

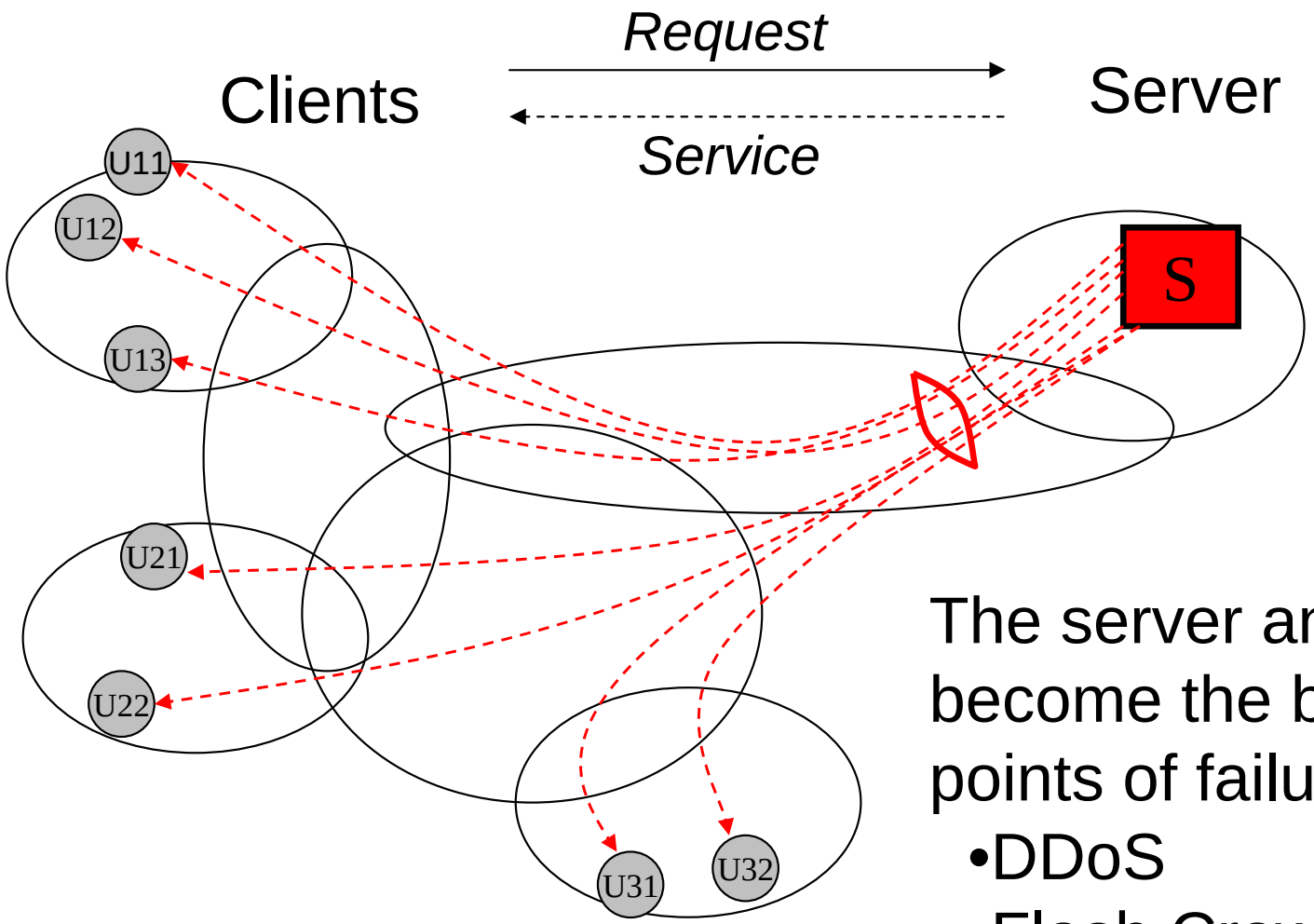
Excerpt from the Charter of Peer-to-Peer Research Group, IETF/IRTF, June 24, 2003

http://www.irtf.org/charters/p2prg.html

Peers play similar roles
No distinction of responsibilities

Client-server Model

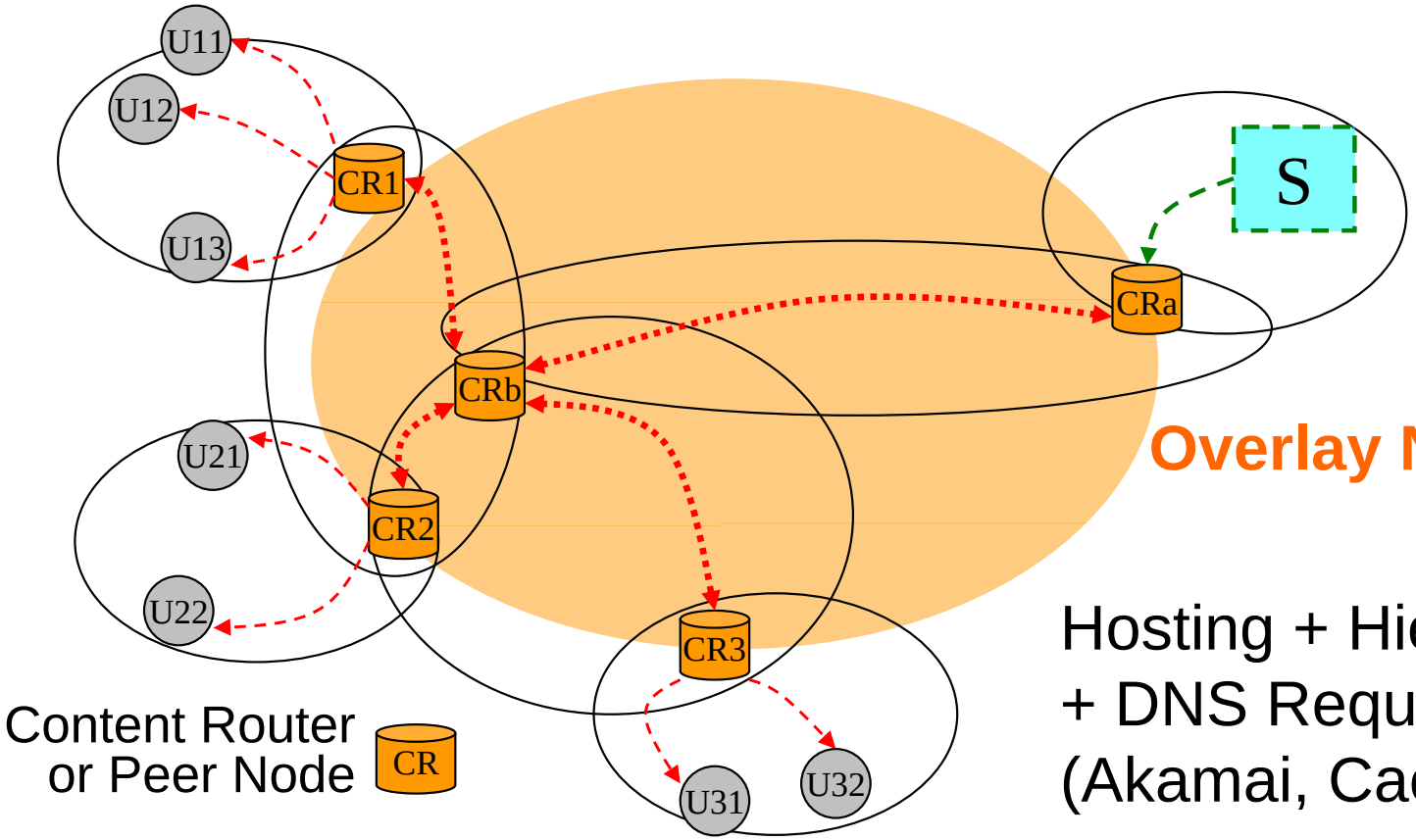
Clients and servers each with distinct roles



The server and the network become the bottlenecks and points of failure

- DDoS
- Flash Crowd

Content Distribution Networks



Hosting + Hierarchical Proxies
+ DNS Request Routing
(Akamai, CacheFlow, etc.)

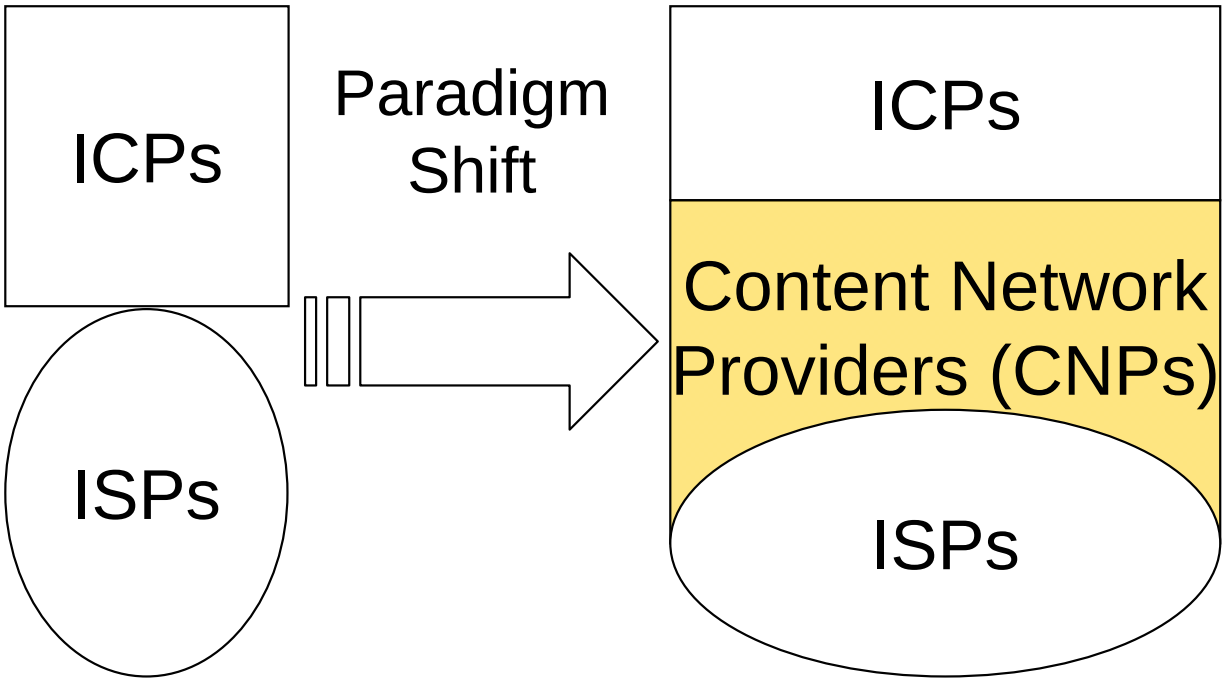
Name: lb1.www.ms.akadns.net
Addresses: 207.46.20.60, 207.46.18.30, 207.46.19.30, 207.46.19.60, 207.46.20.30
Aliases: **www.microsoft.com**, toggle.www.ms.akadns.net, g.www.ms.akadns.net

Name: www.yahoo.akadns.net
Addresses: 66.94.230.33, 66.94.230.34, 66.94.230.35, 66.94.230.39, 66.94.230.40, …
Aliases: **www.yahoo.com**

Name: e96.g.akamaiedge.net
Address: 202.177.217.122
Aliases: **www.gio.gov.tw**, www.gio.gov.tw.edgekey.net

Name: a1289.g.akamai.net
Addresses: 203.133.9.9, 203.133.9.11
Aliases: **www.whitehouse.gov**, www.whitehouse.gov.edgesuite.net

Content Distribution Networks *(Cont.)*



"Serverless ICP"
(Fabless IC Design House)

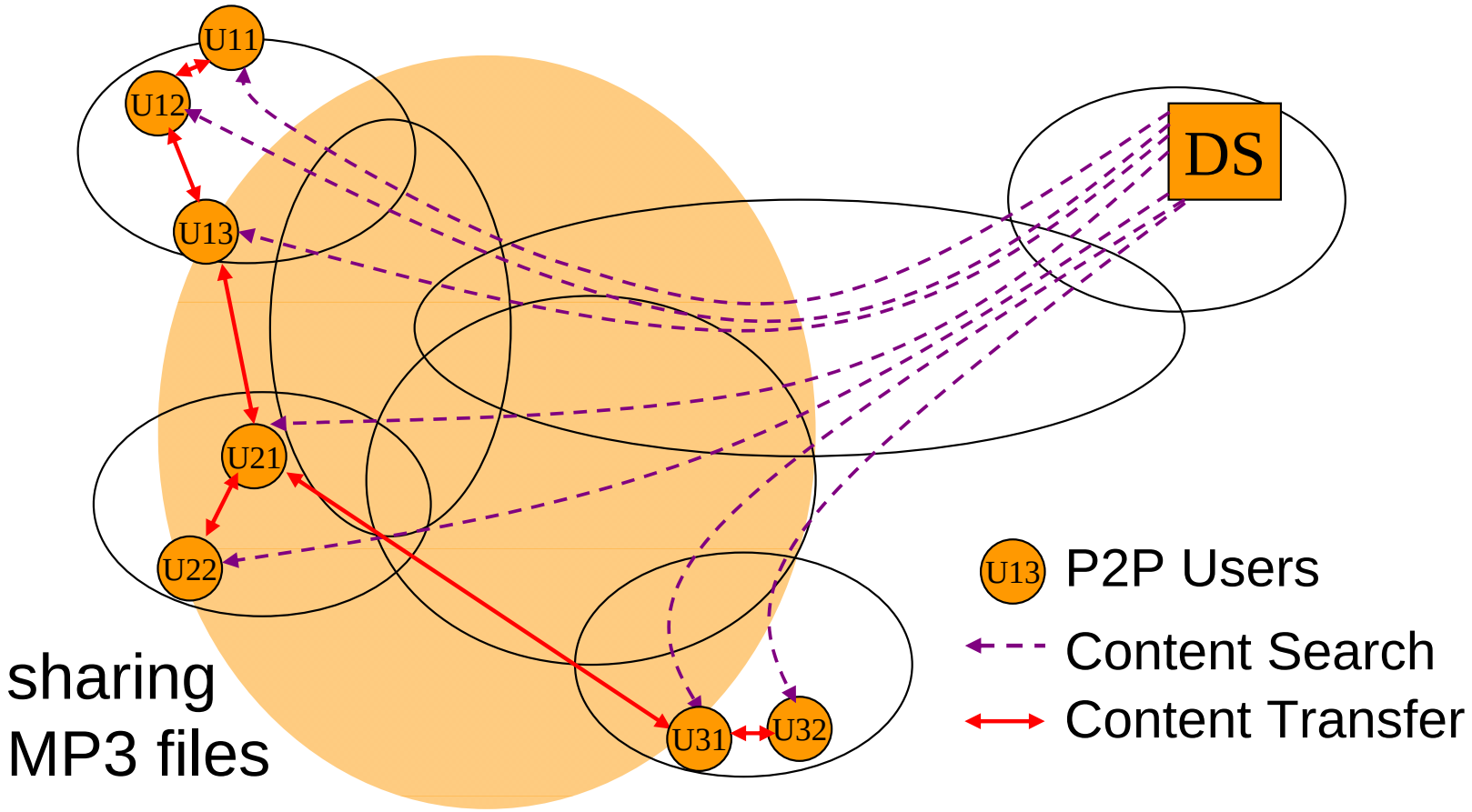
"Content Foundry"
(Semiconductor Foundry)

ICPs need contents, servers, equipments, IT experts, etc.

Now, ICPs need only contents and trusted CNPs.

I.C. = Internet Contents

P2P Example - Napster

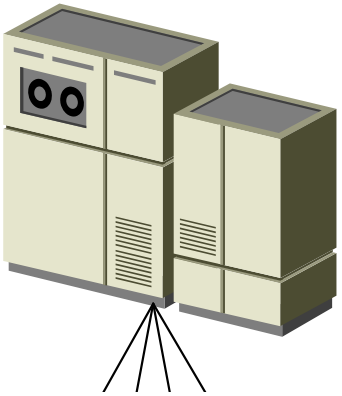


Any two P2P nodes can exchange contents directly

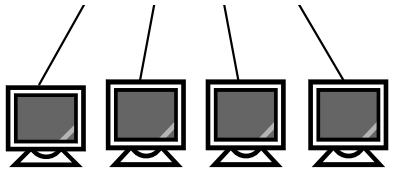
+ Running P2P software is much easier than maintaining servers
+ Reduce the load of server, even without servers

Paradigm Shift of Computing System Models

1980~
Terminal-Mainframe
(Super-computing)

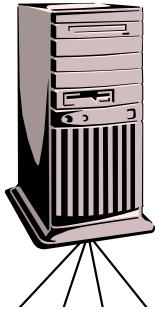


RS-232

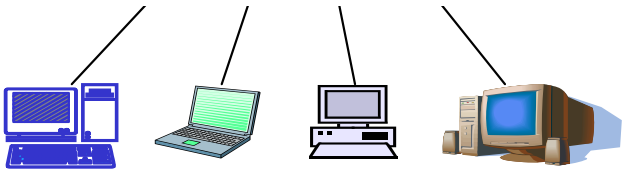


VT100/DOS

1990~
Client-Server
(Micro-computing
/Personal Computer)

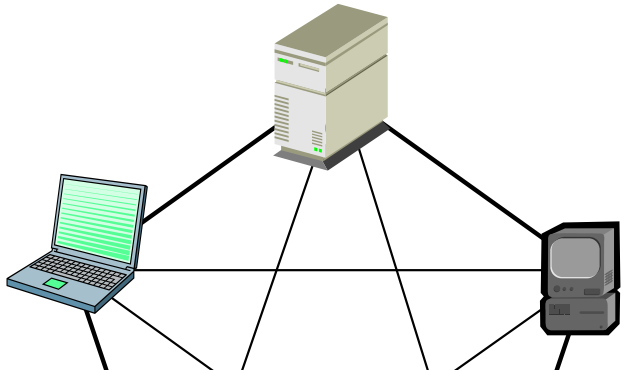


Dialup/10M Ethernet

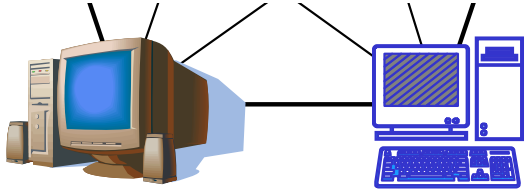


Windows 31/95

2000~
Peer-to-Peer
(Macro-computing)



ADSL/100M+ Ethernet



Linux/Windows XP

Generations

- Early services
  - DNS, Netnews/Usenet
  - Xerox Grapevine name/mail service
  - Lamport's part-time parliament algorithm
  - Bayou replicated storage system
  - classless inter-domain IP routing algorithm
- 1st generation
  - Napster
- 2nd generation
  - Freenet, Gnutella, Kazaa, BitTorrent
- 3rd generation – P2P middleware
  - Pastry, Tapestry, CAN, Chord, Kademlia

Example of P2P File Swapping: KaZaA

As of July 2003

Users Online	3,824,411
Total Number of MP3 Files	294,468,383
Total Size of Movies Files	894,435
Total Number of Files Shared	2,936,033,461
Total Size of Shared Files	8,283,375GB

- 77% of surveyed companies had at least one installation of file-swapping software (AssetMetrix, July 16, 2003)
- Today more KaZaA traffic than Web traffic!

Skype – P2P VoIP

Background

- Created by Niklas Zennstrom and Janus Friis, founders of KaZaA
- Beta launched August 29, 2003
- As of 16 Nov 2004: 34,642,017 downloads and
  2,551,163,700 Minutes served (1,771,641 days; 4853 years)
- Uses 3-16 KB/s while calling and 0-0.5 KB/s while idle

Features

- High-quality Internet conference calls
- Firewall and NAT traversal
- Global decentralized user directory
- Intelligent routing for encrypted calls through effective path
- Encrypting all calls and instant messages end-to-end

P2P Applications

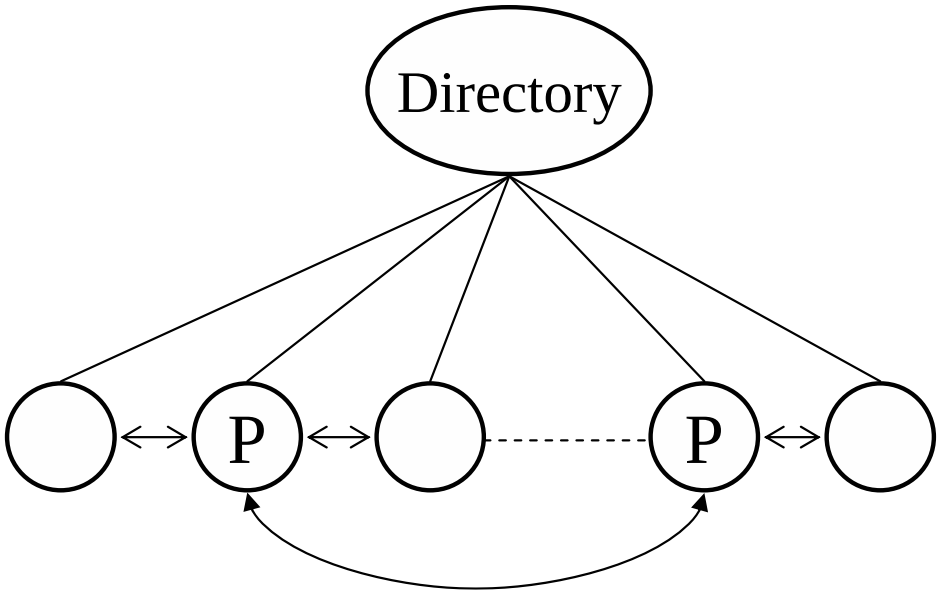
- P2P File Swapping (Sharing)
  - Napster, FreeNet, Gnutella, KaZaA, eDonkey/eMule, EZPeer, Kuro, BT
- P2P Communication
  - NetNews (NNTP), Instant Messaging (IM), Skype (VoIP)
- P2P Lookup Services and Their Applications
  (Distributed Hash Tables and Global Repositories)
  - IRIS, Chord/CFS, Tapestry/OceanStore, Pastry/PAST, CAN
- P2P Overlay Networking
  - (Inter-domain Routing – BGP), RON, PDF, Detour
- P2P Multimedia Streaming (Application-layer Multicast)
  - CoopNet, Zigzag, Narada, P2Cast, Joost, PPStream
- Proxies and Content Distribution Networks
  - Squid, Akamai, DigitIsland
- Overlay Testbed
  - PlanetLab, NetBed/EmuLab
- Other Areas
  - P2P Gaming, Grid Computing

Basic P2P Issues

- How to connect each other?
  - Topology
- How to find out resources?
  - Search / Lookup

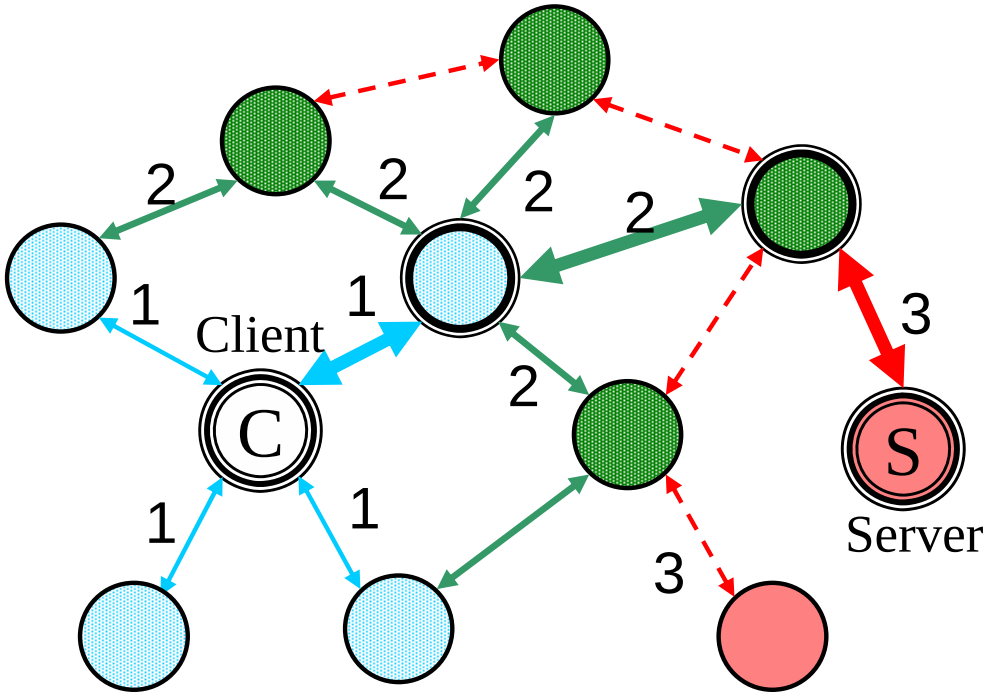
- P2P Classification
  - Centralized
  - Unstructured: flooding (DFS, BFS)
  - Structured: tree, hypercube

Example of Centralized P2P Systems: Napster



- Announced in January 1999 by Shawn Fanning for sharing MP3 files and pulled plug in July 2001
- Centralized server for search, direct file transfer among peer nodes
- Proproprietary client-server protocol and client-client protocol
- Relying on the user to choose a ‘best’ source
- Disruptive, proof of concepts
- IPR and firewall issues

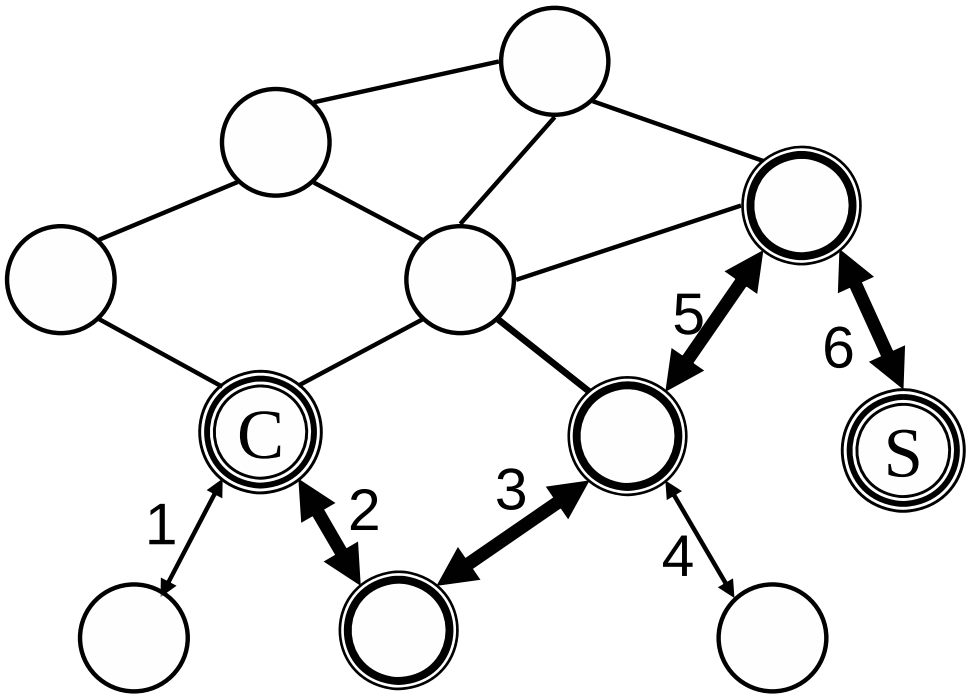
Example of Decentralized P2P Systems: Gnutella



Servent (=***Serv*** er + Cli ***ent***)

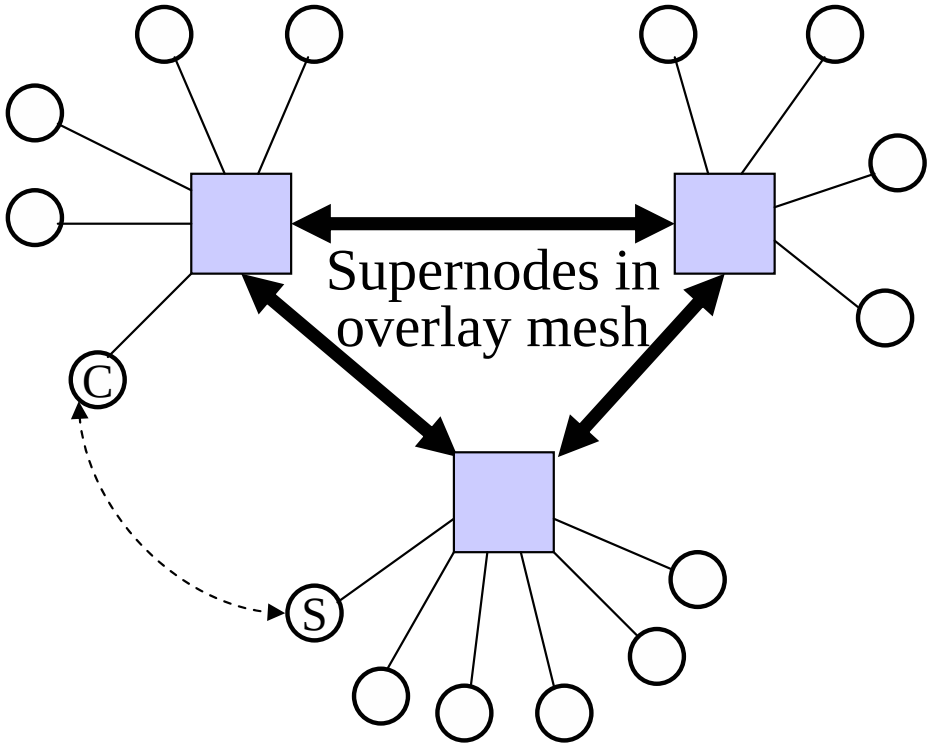
- Open source
- 3/14/2000: Released by NullSoft/AOL, almost immediately withdrawn, and became open source
- Message flooding: *serverless, decentralized* search by message broadcast, direct file transfer using HTTP
- Limited-scope query

Example of Unstructured P2P Systems: Freenet



- Ian Clarke, Scotland, 2000
- Distributed depth-first search, Exhaustive search
- File hash key, lexicographically closest match
- *Store-and-forward* file transfer
- Anonymity
- Open source

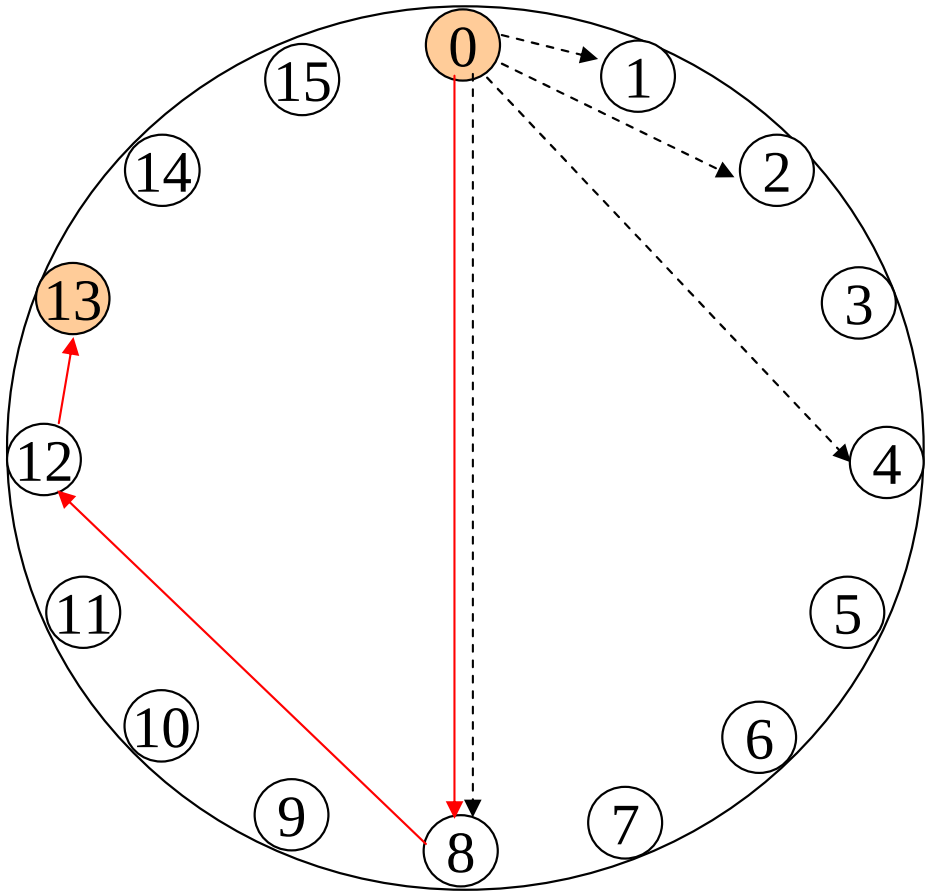
Example of Hybrid P2P Systems: FastTrack / KaZaA



- Proprietary software developed by FastTrack in Amsterdam and licensed to many companies
- Summer 2001, Sharman networks, founded in Vanuatu, acquires FastTrack

- Hierarchical supernodes (Ultra-peers)
- Dedicated authentication server and supernode list server
- From user's perspective, it's like Google
- Encrypted files and control data transported using HTTP
- Parallel download
- Automatically switch to new server

Example of Structured P2P Systems: Chord



- Frans Kaashoek, et. al., MIT, 2001
- IRIS: Infrastructure for Resilient Internet Systems, 2003

- Distributed Hashing Table
- Scalable lookup service
- Hyper-cubic structure

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BitTorrent: Swarming and Tit-for-Tat

- Swarming: splitting and pipelining
  - **Search**: Out-of-band. E.g., use Google to find the .torrent metafile for the file you want
    - file information: length, name, hashing information
    - URL of tracker
  - **Join**: contact centralized “tracker” server, get a random list of peers
  - **Publish**: Run a tracker server
  - **Fetch**: Download chunks of the file from your peers. Upload chunks you have to them.
- Tit-for-tat: “I’ll share with you if you share with me”
  - Be optimistic: occasionally let freeloaders download

Outline

- Road to P2P Systems
  - Why P2P
  - Definition of P2P
- Basic P2P Technologies – Search/Lookup
  - Centralized
  - Unstructured
  - Structured
- Comments on P2P

Characteristics of P2P Systems

- Heterogeneous
  - Ubiquitous devices: PDAs, laptops, desktops, servers, etc
  - Multi-roles: clients, servers, and relays
- Autonomous
  - Join or leave at any time: network churn
  - Share or not share: incentive
  - Select or be selected: peer selection
- Self-organizing
  - Centralized or ultra-peer infrastructure
  - Decentralized: structured or non-structured

Strengths of P2P Systems

- Solve distributed denial-of-service (DDoS) problems
- Support serverless content providers
- Achieve high-performance systems through cooperation among participants
  - content distribution and file swapping
  - application-layer multicasting
  - overlay networking
  - VOIP communication
- Resilient - ease management overheads of large-scale distributed systems

Challenges to P2P Systems

In an ideal P2P system

- Each node will contribute as he can and consume as he need
- It will cooperate to perform much more stably, securely and efficiently than any single one computer

In a real open P2P system

- There are many nodes that consume much more resources than they contribute $\Rightarrow$ ***Fairness***
- Some nodes or groups of nodes who may attack or cheat the other normal nodes of the system $\Rightarrow$ ***Trustworthy***

These may probably make the system malfunctioned, unfair or inefficient

Attacks on P2P Systems

- Sybil attacks – any node could manufacture any number of identities
- Malicious peers or frauds
  - Announce false capacities or query results
  - Accept payments or obtain contents but fail to complete the transaction
- Spurious files or messages
  - Malicious members could put up dummy/polluted files giving them popular names
- Collusion
  - Collect credits from colluded dummy peers

Summary

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  - P2P definition: client + server / relay
  - Why P2P
- Basic P2P Technologies – Search/Lookup
  - Centralized
  - Unstructured: flooding
  - Structured
- Comments on P2P
  - Characteristics
  - Strengths
  - Challenges
  - Attacks