Three case studies

- **peer to peer networking**
- **wireless systems**
- **search engines**
- **each includes issues of**
  - hardware
    processors, storage, peripherals, networks, ...
    representation of information, analog vs. digital, bits & bytes
  - software
    applications, operating system, client-server and peer to peer
    organization of information, file systems, ...
    algorithms: searching, sorting, compression
  - communications,
    Internet, Web, TCP/IP, protocols
    bandwidth, speed, caching
    compression, error detection and correction
  - security and privacy; cryptography
  - intellectual property and ownership
  - social & legal & policy concerns

Peer to peer networking

- **direct connections between peers**
  - distributed instead of clients talking to single server
  - all clients provide bandwidth, storage, processing

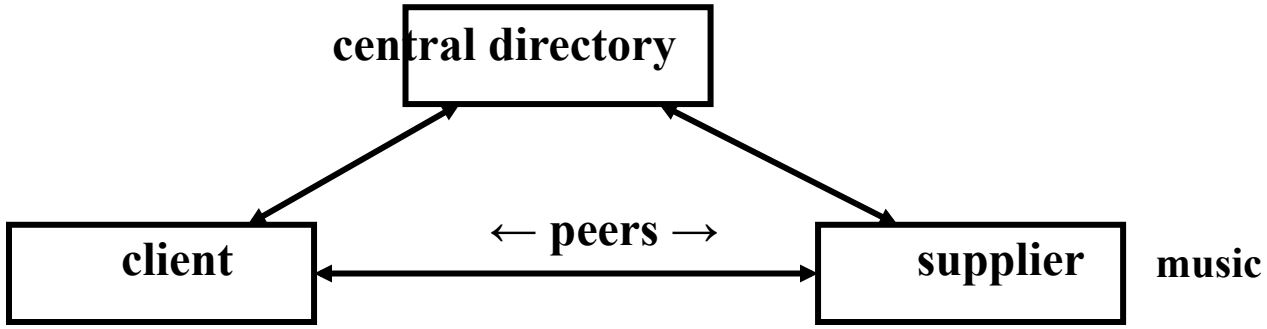
- **"peer-to-peer" file-sharing**
  - centralized directories (original Napster in 1999)
  - decentralized directories (Gnutella, Kazaa, Limewire, Morpheus, etc.)
- **once a file is found somewhere**
  - set up direct connection between supplier and consumer ("peers")
  - applications use TCP/IP (analogous to HTTP, SSH, SMTP, etc.)

- **other examples**
  - BitTorrent file distribution system
  - Skype Internet telephony

Peer to peer history

- **Napster (1999-2001) [Shawn Fanning]**
  - centralized real-time directory, distributed files
  - mostly MP3 music; ideal for Ethernet bandwidths
  - based in USA; lawsuits put it out of business
- **Gnutella and friends (Grokster, Kazaa, ...)**
  - decentralized directories: not as fast or reliable but less vulnerable to legal processes since no way to turn it off
- **BitTorrent (2001)**
  - distributed directories, distributed files
  - distributed peer servers for load-sharing: good for movies
- **Digital Rights Management (DRM) systems**
  - largely unsuccessful (awkward, inconvenient, don't really work anyway)
  - pay services like iTunes with reasonable DRM do better
- **legal action**
  - RIAA/MPAA lawsuit put Grokster out of business (2005)
  - numerous lawsuit threats against students and other individuals
  - Viacom sues Google over YouTube postings of movies & TV programs (2007)
- **lobbying**
  - numerous attempts to create more laws against file-sharing

Napster vs distributed directory systems



- **distributed directory**
  - finds neighbors; each neighbor passes search to other neighbors
  - if a node has result, connects directly to original system
  - program has initial list of supernodes, client connects to one
    supernodes act as directory servers, use other supernodes for searches
- **legal issues**
  - less vulnerable to legal process, since no centralized target
    (and main sites are outside USA)
  - not restricted to MP3 files (therefore "substantial non-infringing uses")
    Grokster sued by RIAA; RIAA lost appeal in Aug 2004 but won in Jun 2005;
    Grokster now out of business, along with several others
  - may deposit adware and spyware
    (therefore there is a commercial purpose)

BitTorrent

- **file-sharing for big files in high demand**
- **original file exists on at least one "seed" site**
- **"tracker" server knows who has what pieces**
  - coordinates all transfers but does not have any of the file contents
- **clients download blocks of file from multiple sources in parallel**
  - blocks have cryptographic checksum to verify correct content
- **downloaded blocks also then uploaded to others**
  - download rate limited by upload rate: have to contribute
  - tracker knows download and upload statuses
    - balances traffic, favors sites that are cooperating
- **blocks reassembled by client**
  - when client has the whole file, it can be a seed for further transfers

- **much faster than single server for right kind of use**
  - less vulnerable to flash crowds
  - but takes time to get started, can't do streaming, etc.

Internet telephony

- **Voice over IP**
  - package speech in IP packets
  - may connect to public telephone network on each end
  - strict requirements on delay (latency), jitter (variable delay), error handling, etc.
- **lots of commercial providers (AT&T, Comcast, Verizon, Vonage,...)**
  - alternative to conventional telephone service
  - somewhat cheaper, probably less reliable, maybe fewer services
- **Skype: peer to peer VoIP**
  - comes from creators of Kazaa, claims no spyware or adware
  - free within Internet, ~2 cents/min to connect to regular phone system
  - 256-bit AES to encrypt each call, RSA to establish AES session key
  - proprietary protocol, uses both TCP and UDP
  - it can use your computer as a supernode (like Kazaa)
  - Skype bought by eBay 10/05 for $2.5B, sold again 11/09 for $2B
  - bought by Microsoft 10/11 for $8.5B

Technology meets law/policy/economics/politics

- **should there be laws controlling peer to peer technology?**
- **should content providers like RIAA be permitted to install search (& destroy) software on home computers?**
- **should universities be required to enforce file-sharing laws?**
- **should VoIP be regulated by the FCC?**
  - should VoIP suppliers have to provide services like 911?
  - should VoIP suppliers pay taxes and fees, and for connectivity to public telephone network?
  - should VoIP calls be subject to wire-tapping laws like regular phones?
- **should common carriers like Verizon be permitted to discriminate against traffic from competitors like other VoIP suppliers?**
  - should there be different prices and policies for different kinds of traffic?

Net neutrality examples

- **Comcast interferes with some BitTorrent traffic (2007)**
  - claimed to be legitimate network management action to prevent a service from hogging bandwidth
  - when does a common carrier have the right to discriminate against some kinds of traffic to provide service to other kinds?
  - FCC told Comcast to stop; Comcast appealed;
  - 2010: court decided for Comcast because FCC lacks authority

- **Verizon redirects failed DNS queries to its own search page instead of returning the failure status (2007)**
  - example of DNS hijacking (for commercial purposes)
  - violates a standard protocol
  - breaks unrelated services (e.g., non-browser traffic)
  - overrides consumer choice of services

- **what regulations, if any, should there be?**
  - see http://citp.princeton.edu/pub/neutrality.pdf

Copyright issues

- **digital media are intrinsically easy to copy**
  - and hard to protect by technical means
- **peer to peer enables copyright violation on a grand scale**
- **Digital Millennium Copyright Act (DMCA)**
- **test cases**
- **disclaimer**
  - an enormous topic
  - IANAL

Copyright

- **protects expression, not idea**
- **duration used to be 17 years + one renewal**
- **now life + 70 years, or 95 years for commercial works**
  - (the "Mickey Mouse Protection Act", 1998)
- **"fair use" permits limited copying under some circumstances**
  - criticism, comment, scholarship, research, news reporting, teaching
- **uncertain what fair use really is -- case by case decisions**
- **considerations:**
  - purpose and character of the use
  - nature of the copyrighted work
  - amount and substantiality of the portion used
  - effect of the use on potential market or value of copyrighted work
- **recent copyright laws may prevent some fair uses**
  - can't decrypt to make excerpt for teaching or criticism
  - can't reverse engineer to make copies in different media

DMCA: Digital Millennium Copyright Act (1998)

- **US copyright law: www.copyright.gov/title17, Chapter 12**

- **anticircumvention: illegal to circumvent a technological measure protecting access to or copying of a copyrighted work**
  - limited exceptions for reverse engineering for interoperability, encryption research, security testing

- **illegal to remove or alter copyright notices and management information**

- **"safe harbor": protects ISPs from copyright infringement claims if they follow notice and takedown procedures**

No circumvention

- **Chapter 12 - Copyright Protection and Management Systems**
- **§ 1201. Circumvention of copyright protection systems**
- **(a) Violations Regarding Circumvention of Technological Measures.**

- **— (1)(A) No person shall circumvent a technological measure that effectively controls access to a work protected under this title.**

- **(A) to "circumvent a technological measure" means to descramble a scrambled work, to decrypt an encrypted work, or otherwise to avoid, bypass, remove, deactivate, or impair a technological measure, without the authority of the copyright owner; and**

- **(B) a technological measure "effectively controls access to a work" if the measure, in the ordinary course of its operation, requires the application of information, or a process or a treatment, with the authority of the copyright owner, to gain access to the work.**

No trafficking

- **(1) No person shall manufacture, import, offer to the public, provide, or otherwise traffic in any technology, product, service, device, component, or part thereof, that —**

- **(A) is primarily designed or produced for the purpose of circumventing protection afforded by a technological measure that effectively protects a right of a copyright owner under this title in a work or a portion thereof;**
- **(B) has only limited commercially significant purpose or use other than to circumvent protection afforded by a technological measure that effectively protects a right of a copyright owner under this title in a work or a portion thereof; or**
- **(C) is marketed by that person or another acting in concert with that person with that person's knowledge for use in circumventing protection afforded by a technological measure that effectively protects a right of a copyright owner under this title in a work or a portion thereof.**

DMCA test cases

- **Grokster**
  - peer to peer software makes copyright infringement easy; are its distributors violating the DMCA?
- **Diebold**
  - internal emails reveal flaws in voting machine software; is posting of the emails a violation of DMCA?
- **SDMI**
  - does demonstration of how to remove digital watermarking on audio files violate DMCA?
- **Lexmark**
  - cryptography used to prevent 3rd parties from supplying replacement ink cartridges; is reverse engineering a violation of DMCA?
- **Viacom v Google**
  - YouTube shows numerous copyrighted clips; is it sufficient that Google responds to individual takedown notices?
- **DeCSS**
  - Content Scrambling System protects DVDs from copying; does publication of code to defeat it violate DMCA?

DRM: Digital Rights (Restrictions?) Management

- **techniques to control access to and use of digital material**
- **conflicts with fair use**
  - prevents legitimate operations like time/space shifting, media conversion, backup, ...
  - a form of vendor lock-in?
  - obsolescent technology may cause things to be lost
- **incompatible systems make users unhappy**
  - may cause more trouble that it's worth
- **pragmatically, DRM doesn't work and probably can't**
  - Sony rootkit on audio CDs (2005): discovered immediately
  - iTunes FairPlay: cracked in 2006
  - Windows Media DRM: cracked in 2006-7
  - AACS (advanced access control system) encrypts HD-DVD and Blu-Ray: cracked in 2007
  - CSS (content scramble system) encrypts DVDs to prevent playing except on licensed players (and thus prevent copying): cracked in 1999
  - the analog hole as the last resort