Peer-to-peer Networks

- Peer-to-peer systems:
  - distributed systems of no hierarchy, equal-status.

- Desirable properties:
  - Scalability: able to support large number of nodes.
  - Fault-tolerance: tolerant of node and link failures.

- Peer-to-peer object location discovery in large-scale distributed systems:
  - query flooding: Gnutella.
  - hash + heuristics-based routing:
    - Content-addressable Networks and Chord.

Overlay Networks

Overlay networks: A logical network laid on top of the Internet
- nodes are Internet end hosts
- links are virtual Internet paths

Multiplayer Interactive Games over Wide-area Networks

- Some basics:
  - A virtual 2/3-dimensional gaming space with many objects
  - Player-initiated actions: moving your objects, attacking some other objects, etc.

- Main challenges:
  - Multi-player: may need to support a large number of players
  - Interactive: real-time constraint in synchronizing the actions and their impact on the gaming space
  - Wide-area network: limited network resources
Know your application!

A straightforward way to do it

Scalability

- What are the potential problems when the number of players scales up?

- Network bandwidth connecting the server is the main problem
  - incoming or outgoing bandwidth?

- How to solve this?
  - multicast
  - distribute the server

Distribute the Server
Distribute the Server (cont.)

Problems:
- load imbalance
- handoff between partitions is tricky

Multicast

Multicast: act of sending data to multiple receivers.
- Network-layer multicast: router actively participate in multicast, making copies of packets as needed and forwarding towards multicast receivers.

Multicast routers duplicate and forward multicast datagrams

Reality of Network-layer Multicast

Practical problems:
- requires routers to maintain per-group state: complicates the router design and implementation;
- vulnerable to flooding attacks without complex network management;
- hard to provide reliability, congestion control, etc.

Reality:
- slow to be widely adopted;
- a case for overlay (or end-system) multicast.

Overlay Multicast

Overlay multicast
- end systems communicate through an overlay structure
- assuming only unicasts paths provided by the Internet
- how?

- still remember our problem?
Network-layer vs. Overlay Multicast

Overlay Multicast: One Approach

Two steps:
- Forming an overlay mesh network with good links, don’t worry about loops at this step
  - too dense a mesh results in too much overhead in the second step; more probable to have high link stress
  - too sparse a mesh restricts what the second step can do
- For each multicast source, generating a shortest path tree or "reverse-path forwarding" on top of the overlay mesh

Revisiting the Concept of Overlay Networks

Applications to Overlay Networks

Overlay networks: A logical network laid on top of the Internet.
- Key advantages over networks with physical links:
  - can be formed spontaneously
  - can be easily maintained and changed
- Key disadvantage compared with networks with physical links:
  - performance

Overlay networks = peer-to-peer networks?

- multi-player interactive games
- multicast: network conferencing
- software/news/files distribution
- ... ...
Software/News/Files Distribution on Demand

Software distribution:
- Microsoft is distributing a new version of Windows and many licensed users would like to get the new software in a short period of time;
- All interested users download from a central Microsoft distribution site won't work.

Content distribution network
- Having a group of dedicated servers forming an overlay structure - efficiently distributing the content over these servers;
- Interested users connect to one of the nearby servers to get the copy.