



Internet Overlay Networks



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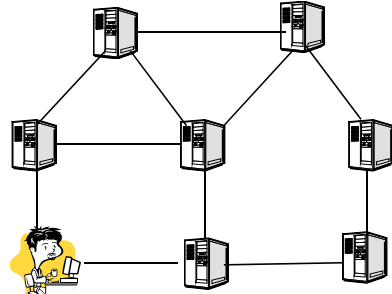
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Overlay Networks




Overlay networks: A logical network laid on top of the Internet

- nodes are Internet end hosts
- links are virtual Internet paths

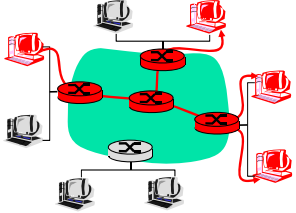


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Multicast



- **Multicast**: act of sending data to multiple receivers.




Remember the protocols?

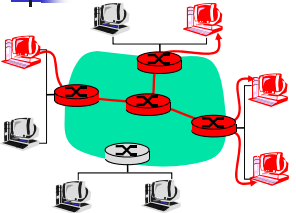
Practical problem of network-layer multicast

- complicates the router design and implementation; requires routers to maintain per-group state;
- slow to be widely adopted.

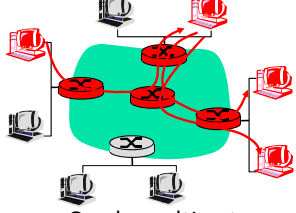
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Network-layer vs. Overlay Multicast





Network-layer multicast



Overlay multicast

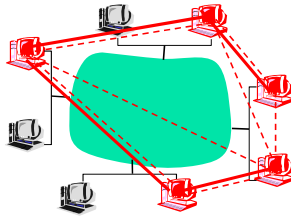
- Any better than multiple unicasts?
- Performance issues for overlay multicast
 - Limit the bandwidth consumption of individual physical links
 - Minimize the source-to-end latency

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Overlay Multicast: One Approach

Two steps:

- Forming an overlay mesh network, 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



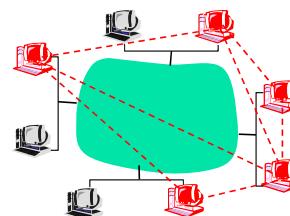
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Overlay Mesh Network

- Network properties
 - Density
 - Connectivity
 - Real link latency
- Self-maintenance and self-organization
- Node join
 - Add links to some randomly chosen existing members
 - Or some neighbors that are nearby?
- Node departure
 - Break links to departing node
 - Make up with additional links

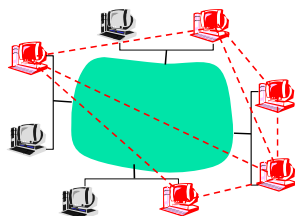


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Overlay Mesh Network



- How do find a random node on the network (with uniform probability of finding each node)?
 - Random walk

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Revisit the Concept of Overlay Networks

Overlay networks: A logical network laid on top of the Internet.

Advantages over networks with physical links:

- can be formed spontaneously
- can be easily maintained and changed

Disadvantage compared with networks with physical links:

- performance

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Applications to Overlay Networks

- multicast: network conferencing
- peer-to-peer file sharing
- domain name systems
- multi-player interactive games
- files/news/software distribution
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- Internet overlay networks = peer-to-peer networks?

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Multiplayer Interactive Games over Wide-area Networks

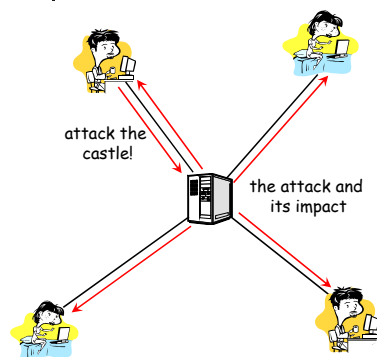
- Some basics:
 - A virtual 2/3-dimensional gaming space with many objects
 - Player-initiated actions: moving your objects, attacking some other objects, etc.
- Main challenges:
 - **Scalability**: supporting many players
 - **Interactivity**: real-time constraint in synchronizing the actions and their impact on the gaming space
 - **Wide-area network**: limited network resources

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A straightforward way to do it



- A server and multiple client (each for a player)
- All player-initiated actions get to the server and its impact is propagated to all players (with bounded delay)
- Actions can be aggregated when too many come too quickly

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

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Scalability

- What are the potential problems when the number of players scales up?
 - Computation at the server
 - Network bandwidth connecting the server
- Solutions:
 - multicast
 - distribute the server

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Distribute the Server

How do we know which server is in charge of a given area?

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Improves the Internet Routing

- More than enabling new applications
- Possible to improve Internet performance through overlay routing?
 - Triangular inequality doesn't hold for Internet latency
- How to build a real system?
- Practically significant?

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Improves the Internet Routing

- Internet isn't perfectly robust
 - Routers may fail
 - Default paths may be subject to sudden congestion
- Better Internet robustness through overlay routing?
- Why can't these robustness measures be put into the Internet routing itself?

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