Overlays

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Requirements for Today's Internet

- Quality-of-service (QoS) for applications
  - fast response time, adequate quality for VoIP, IPTV, etc.
- Scalability
  - millions or more of users, devices, …
- Mobility
  - untethered access, mobile users, devices, …
- Security (and Privacy)
  - protect against malicious attacks, accountability of user actions
- Manageability
  - configure, operate and manage networks
  - trouble-shooting network problems
- Flexibility, Extensibility
  - ease of new service creation and deployment?

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Overlay Networks

- A “logical” network built on top of a physical network
  - Overlay links are tunnels through the underlying network
- Many logical networks may coexist at once
  - Over the same underlying network
  - And providing its own particular service
- Nodes are often end hosts
  - Acting as intermediate nodes that forward traffic
  - Providing a service, such as access to files
- Who controls the nodes providing service?
  - The party providing the service (e.g., Akamai)
  - Distributed collection of end users (e.g., peer-to-peer)

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Overlay and IP/Internet

- IP Network/Internet started as an Overlay
  - over various physical networks, in particular telephone networks
  - There are now many “overlays” over today’s Internet physical infrastructure
- Use tool for incremental enhancements to IP
  - IPv6
  - Security, e.g., VPNs
  - Mobility
  - Multicast
- 2.5G/3G Cellular Data Network as an Overlay
- CDNs and P2P Networks, …
- Question: where a function belongs?

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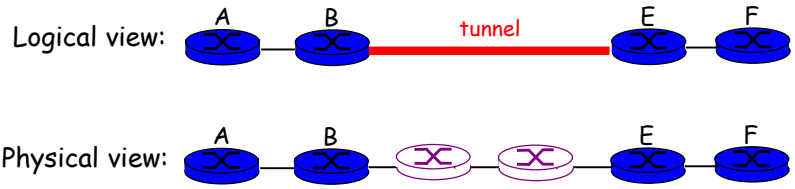
IP Tunneling to Build Overlay Links

- IP tunnel is a virtual point-to-point link
  - Illusion of direct link between two separated nodes



- Encapsulation of packet inside an IP datagram
  - Node B sends a packet to node E
  - … containing another packet as the payload

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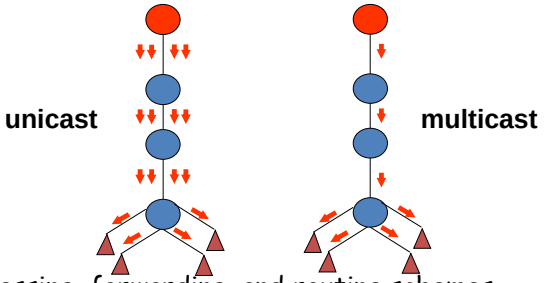
IP Multicast & MBone

- Multicast
  - Delivering the same data to many receivers
  - Avoiding sending the same data many times



- IP multicast
  - Special addressing, forwarding, and routing schemes
  - Not widely deployed, so MBone tunneled between nodes

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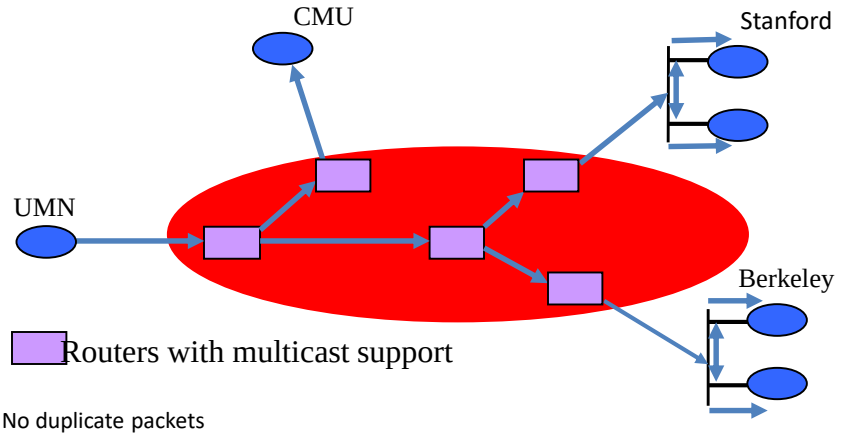
IP Multicast



- No duplicate packets
- Highly efficient bandwidth usage

Key Architectural Decision: Add support for multicast in IP layer

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Key Concerns with IP Multicast

- Scalability with number of groups
  - Routers maintain per-group state
  - Aggregation of multicast addresses is complicated
- Supporting higher level functionality is difficult
  - IP Multicast: best-effort multi-point delivery service
  - Reliability and congestion control for IP Multicast complicated
- Deployment is difficult and slow
  - ISPs reluctant to turn on IP Multicast

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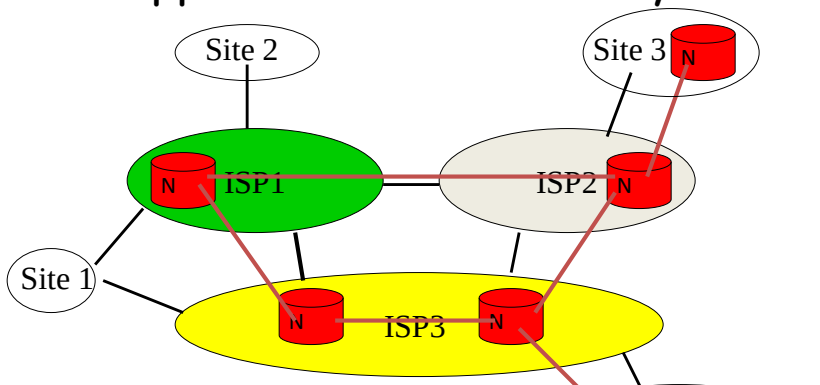
Application-level Overlays



- One per application
- Nodes are decentralized
- Network operations/management may be centralized

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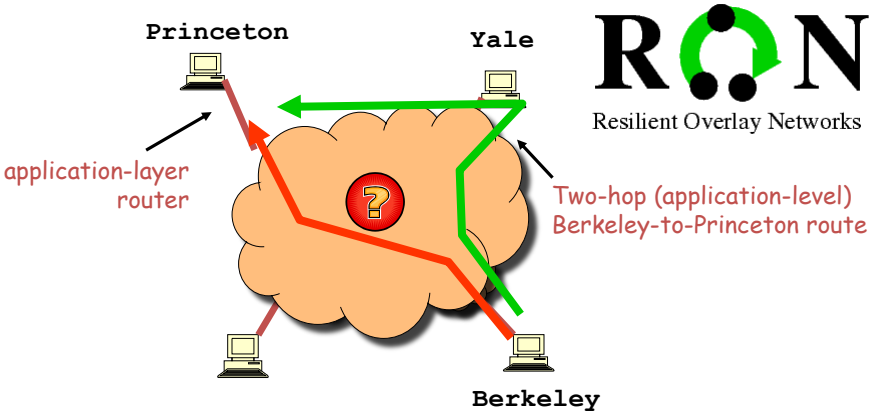
RON: Resilient Overlay Networks

Premise: by building application overlay network, can increase performance and reliability of routing



RON
Resilient Overlay Networks

http://nms.csail.mit.edu/ron/

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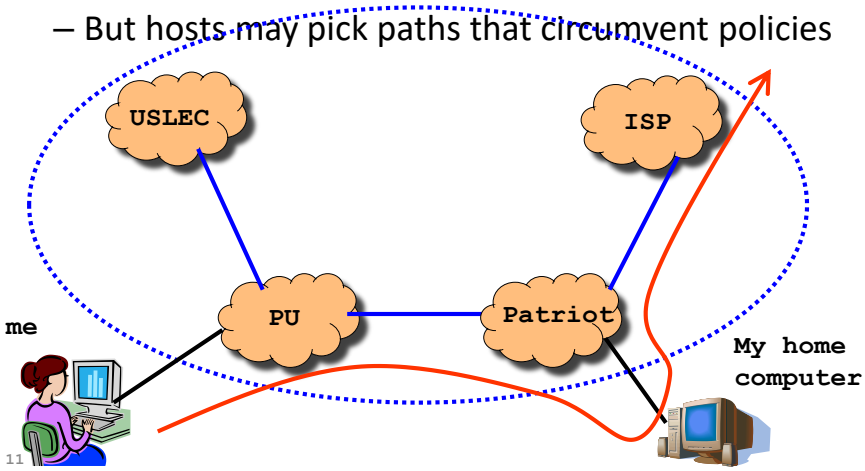
RON Circumvents Policy Restrictions

- IP routing depends on AS routing policies
  - But hosts may pick paths that circumvent policies



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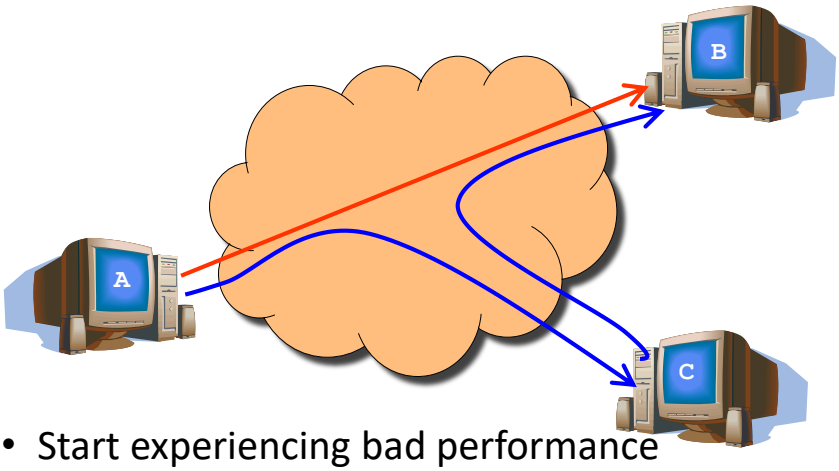
RON Adapts to Network Conditions



- Start experiencing bad performance
  - Then, start forwarding through intermediate host

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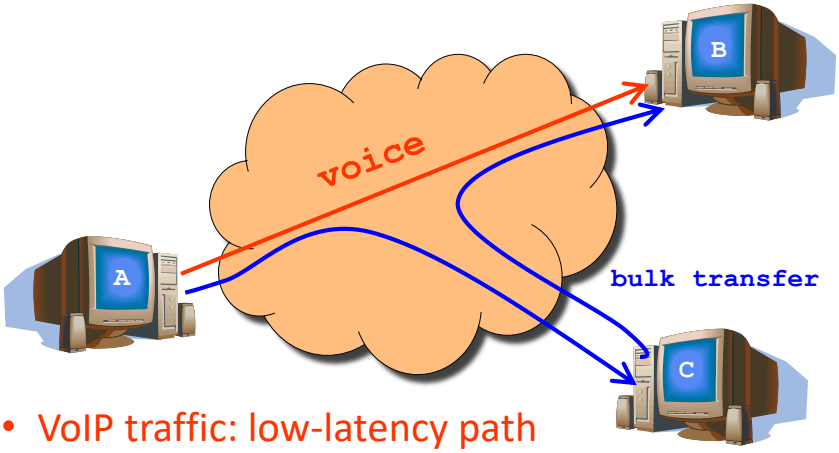
RON Customizes to Applications



- VoIP traffic: low-latency path
- Bulk transfer: high-bandwidth path

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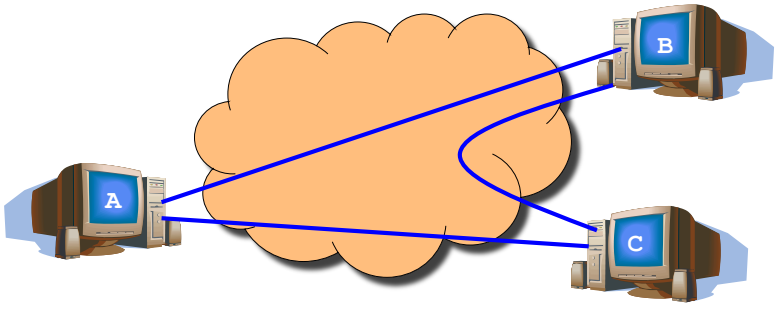
How Does RON Work?

- Keeping it small to avoid scaling problems
  - A few friends who want better service
  - Just for their communication with each other
  - E.g., VoIP, gaming, collaborative work, etc.
- Send probes between each pair of hosts



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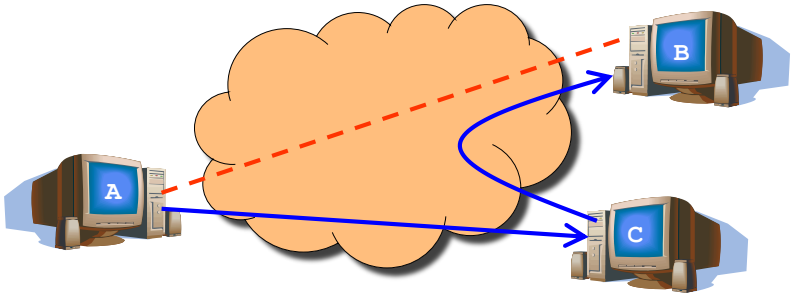
How Does RON Work?

- Exchange the results of the probes
  - Each host shares results with every other host
  - Essentially running a link-state protocol!
  - So, every host knows the performance properties
- Forward via intermediate host when needed



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RON Works in Practice

- Faster reaction to failure
  - RON reacts in a few seconds
  - BGP sometimes takes a few minutes
- Single-hop indirect routing
  - No need to go through many intermediate hosts
  - One extra hop circumvents the problems
- Better end-to-end paths
  - Circumventing routing policy restrictions
  - Sometimes the RON paths are actually shorter

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RON Limited to Small Deployments

- Extra latency through intermediate hops
  - Software and propagation delays for forwarding
- Overhead on the intermediate node
  - Imposing CPU and I/O load on the host
- Overhead for probing the virtual links
  - Bandwidth consumed by frequent probes
  - Trade-off between probe overhead & detection speed
- Possibility of causing instability
  - Moving traffic in response to poor performance
  - May lead to congestion on the new paths

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