Advanced Computer Networks

Network Architectures

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Internet architectures

- Design principles
  - store-and-forward packet switching
  - end-to-end arguments
  - “best-effort” services
- “Hour glass” protocol model
  - application: telnet, ftp, email, web, voip, ...
  - transport: TCP, UDP, RTP, SCTP
  - network: IP/ICMP
  - subnetwork: Ethernet, ATM, FDDI, PPP, ...

New requirements

- Service
  - better than “best-effort”, quality of service (QoS)
- **Scalability (growth)**
  - next generation IP (IPv6) vs NAT
- Multicast
  - IP Multicast vs application/overlay multicast
- Mobility
  - Mobile IP (MIP)
- Security

Middle boxes

- Challenges to “end-to-end arguments”
- Application
  - e.g., web proxy, cache server, load balancer
  - e.g., SIP border controller
- Transport
  - e.g., SOCK
- Network
  - e.g., stateful firewall
  - e.g., network address translator (NAT)

How does NAT work?

- Address translation
  - address mapping creation
- Packet filtering
  - based on created address mapping
- NAT behaviors
  - full cone, restricted cone, port-restricted cone
  - symmetric

NAT: pros and cons

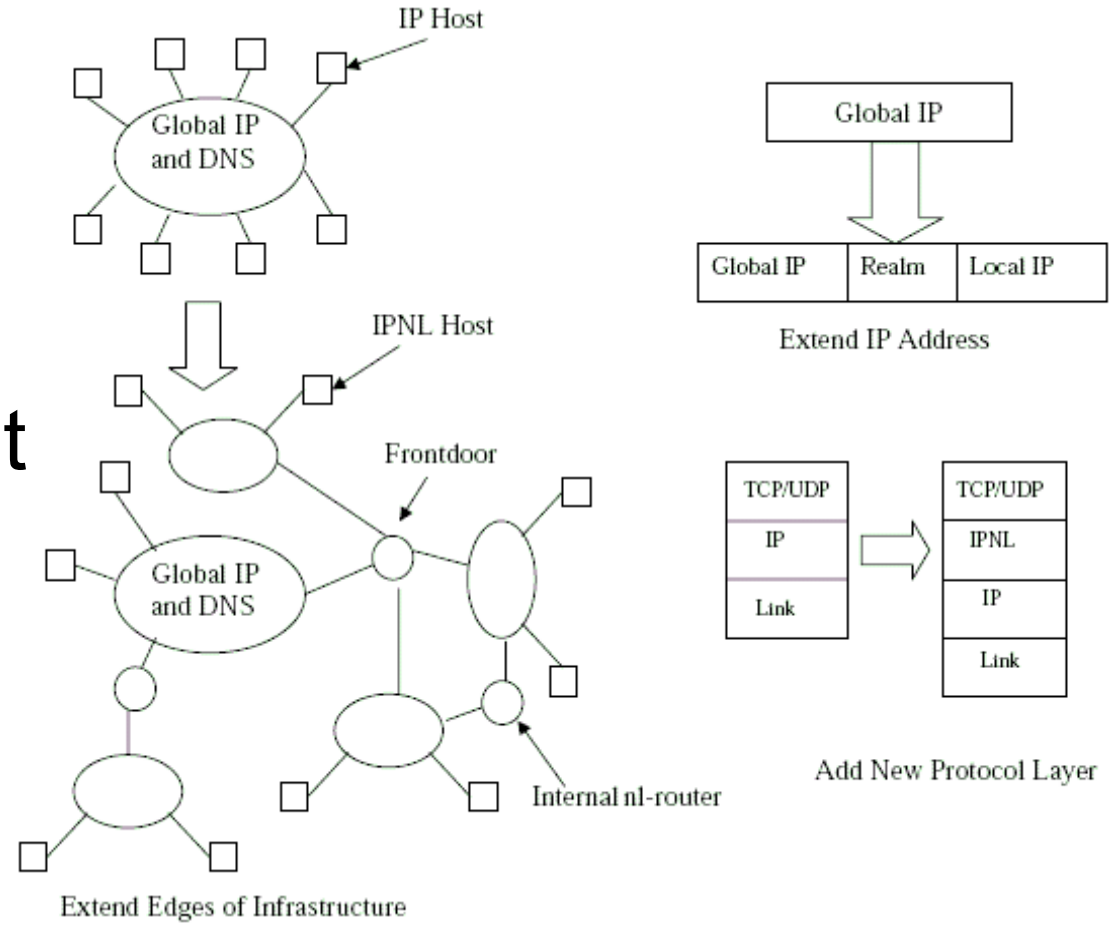
- Pros
  - extend IPv4 address space
  - make site renumbering easy
    - address isolation
- Cons
  - no longer always “global addressable”
    - need extra mechanisms (e.g., NAT traversal)
  - the loss of “end-to-end”
    - complicate network design and operation

What's next?

- Think out of the box!
- IP Next Layer (IPNL) [FG01]
  - reuse the existing infrastructure
    - IPNL is just above IPv4 and routed by NAT boxes
  - use FQDN as end-host identifier
    - fully qualified domain name
  - extend IP address space
    - global (unique) address + private (reusable) address
  - isolate site addressing
    - easy site renumbering

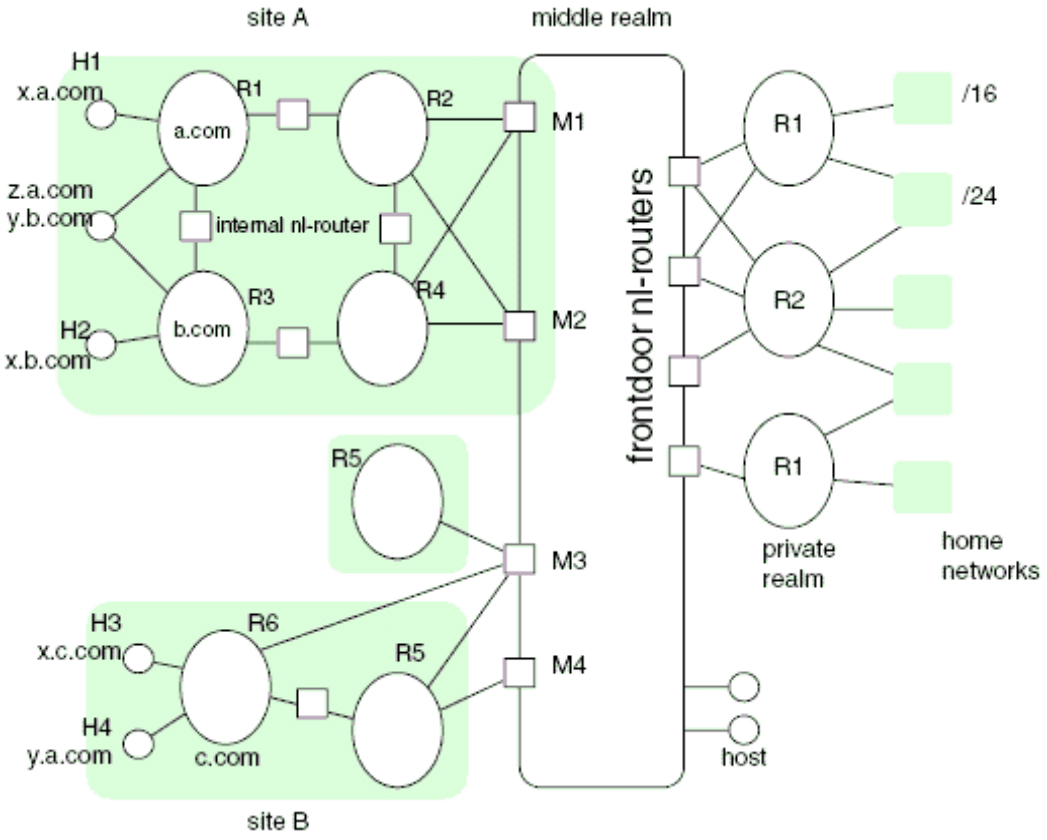
IPNL at the edge

- Growth at edge
  - front-door NL router
  - internal NL router
- IPNL only “visible” at
  - end-host
    - above IPv4
  - NL routers



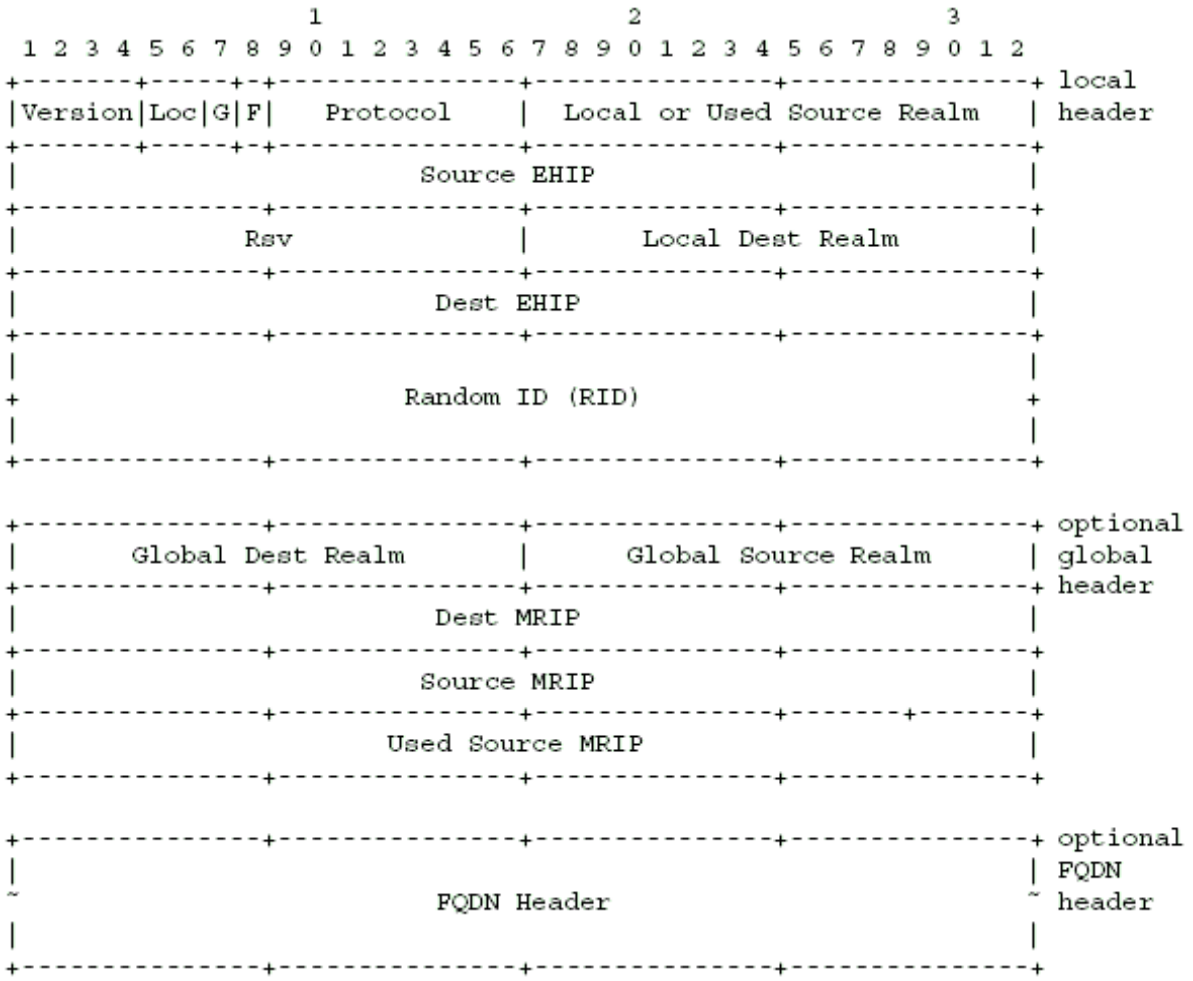
IPNL: more details

- Multi-homing
  - z.a.com
  - y.b.com
- Mobility
  - visiting: y.a.com
  - visited: c.com
- Realm vs site



IPNL routing: address and name

- MRIP
  - middle realm IP
  - frontdoor's
- RN
  - realm number
  - behind frontdoor
- EHIP
  - end-host IP
  - within a realm



Site address isolation

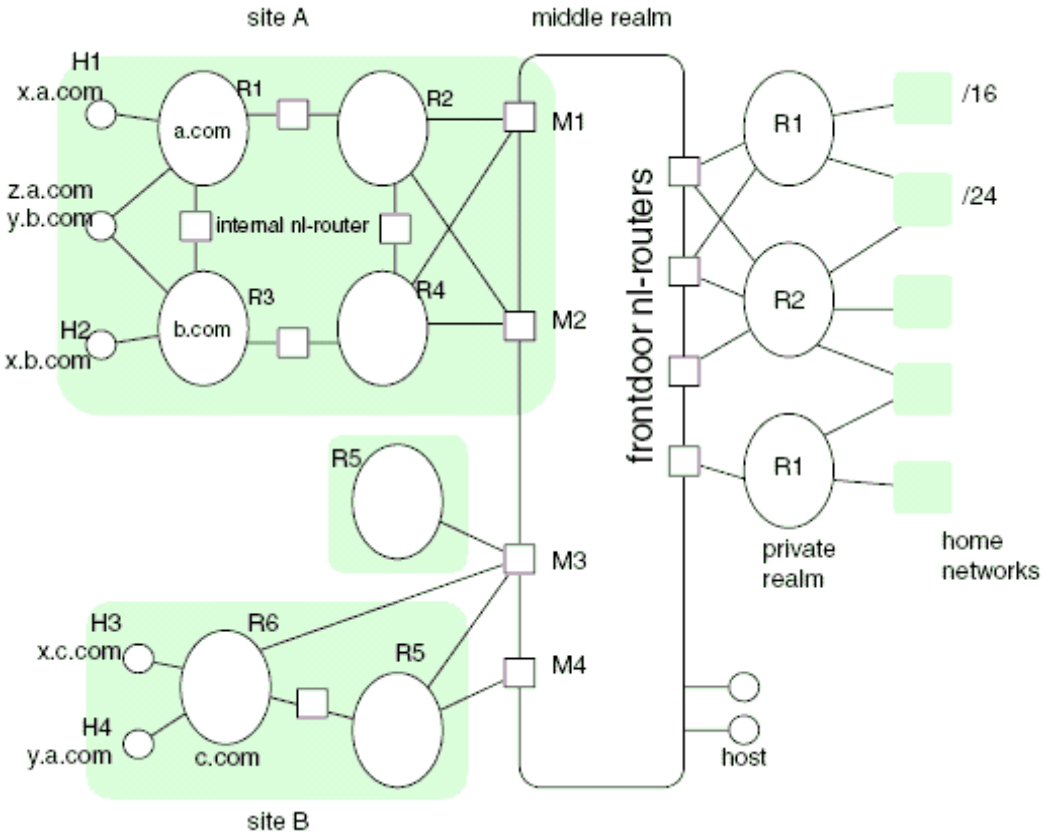
- Separate local vs global header
  - end-host is only configured with
    - EHIP: local identity in a realm
    - FQDN: global identity (long term, unique)
  - “local” packets have no MRIP
    - behind the same frontdoor
- Realm number independence
  - local vs global realm number
  - global RN allocated by the frontdoor

More on site isolation

- In-flight IPNL address resolution (late-binding)
  - End host should know the destination's FQDN
    - destination MRIP resolved by frontdoor
    - source RN and MRIP added by internal/frontdoor
      - received “used source” for return packets
    - destination RN and EHIP added by dest frontdoor/internal
- Location field (2-bit)
  - behind the source frontdoor
  - in the middle
  - behind the destination frontdoor

Examples

- H1-H4
  - through middle realm
- H1-H2
  - behind the same frontdoor
- H1-z.a.com
  - in the same realm
- H1-H3
  - “redirect”



Robustness

- In-band trace
  - learn how to send from what has been received
    - list of MRIP for the destination
    - list of MRIP+RN for the destination
    - the latest “used source MRIP+RN” for the destination
- Path discovery
  - progressive path discovery

Discussion

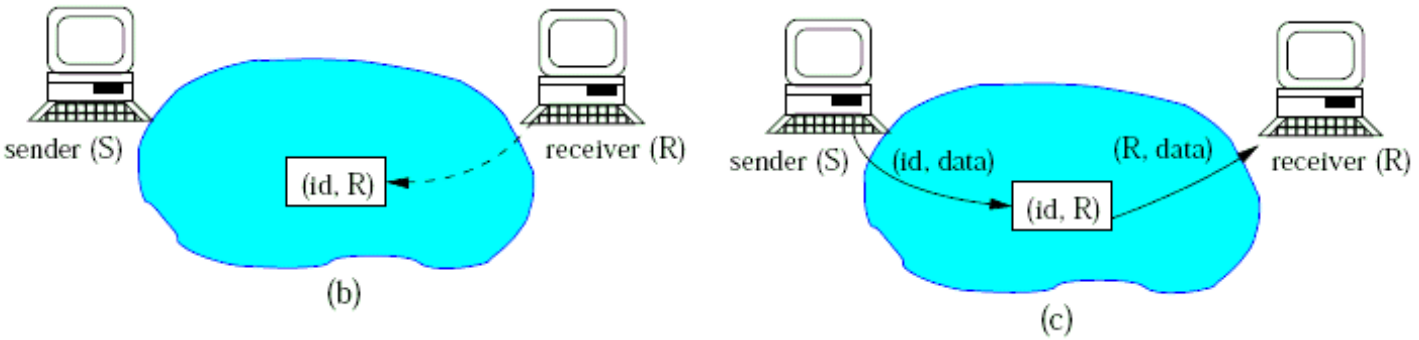
- Addressing and routing
  - IP address has both roles
    - 5-tuple for session identification
  - difficult to support mobility
  - discourage spoofing somehow
- IPNL approach
  - FQDN primarily as an identifier
  - IPNL address primarily as a locater
  - random ID (RID) for session protection

Internet Indirection Infrastructure [I3]

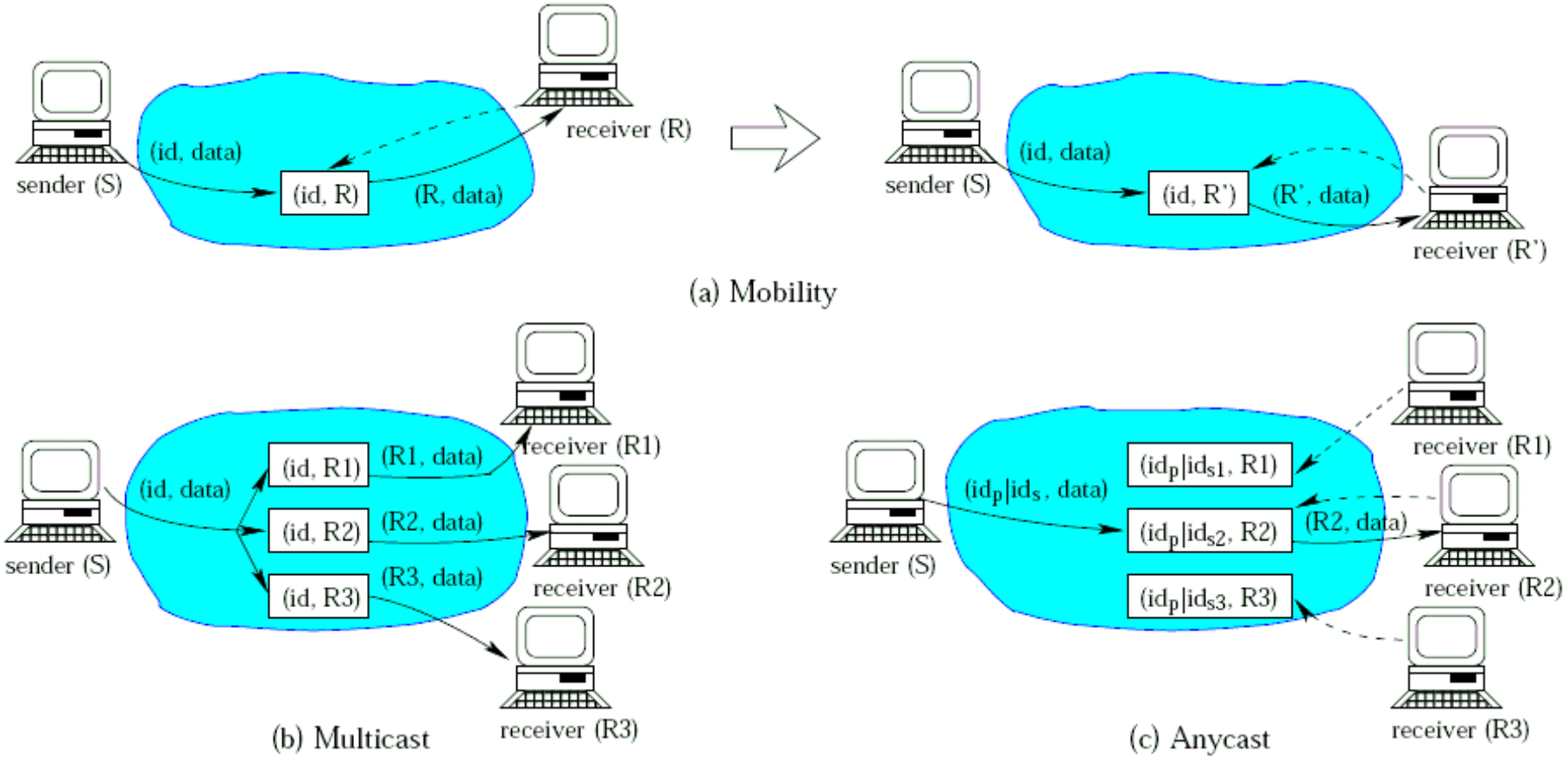
- “any computer science problems can be solved by introducing another layer of indirection...”
- Traditional client-server model
  - server should be ready first
  - client is active, server is passive
    - client request followed by server response
- Traditional send-receive model
  - receive should be ready first
  - send is active, receive is passive

Rendezvous-based communication

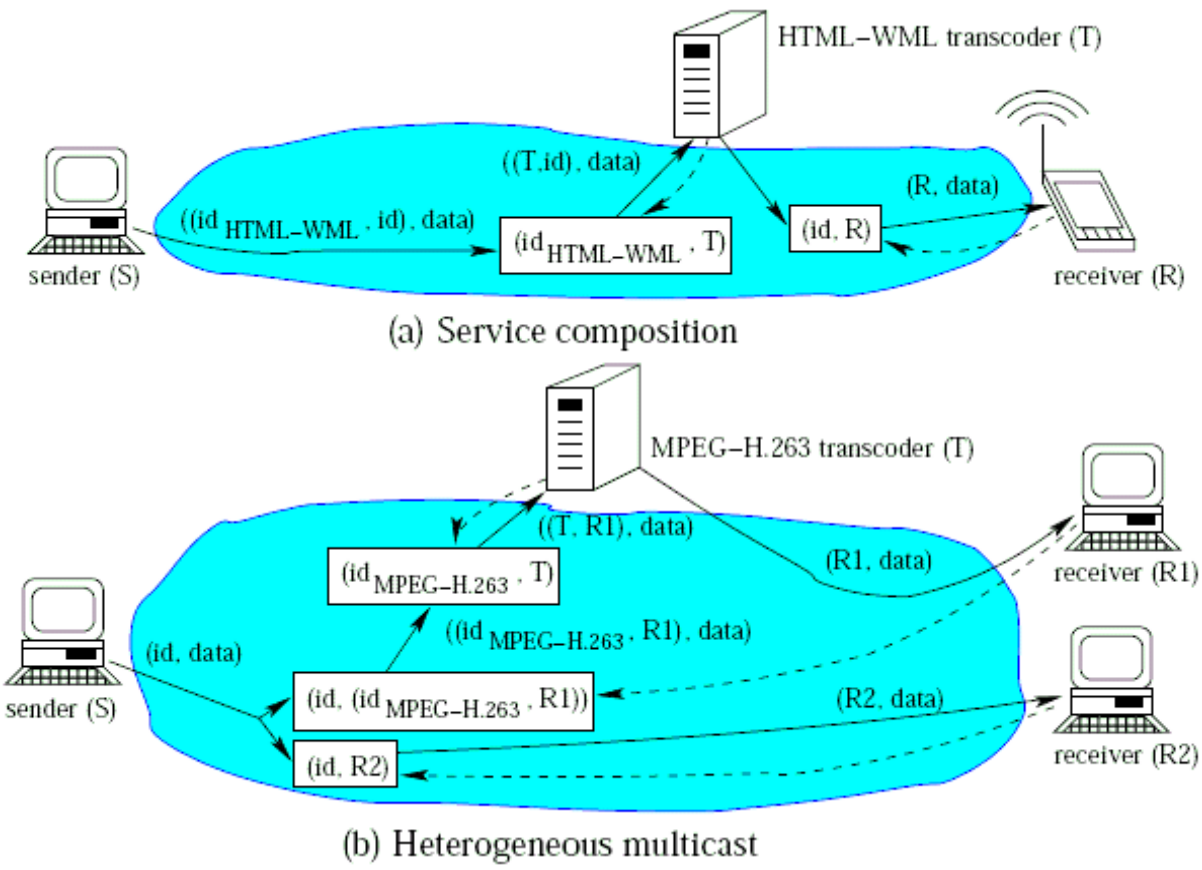
- insertTrigger(t);
- sendPacket(p);
- removeTrigger(t); // optional

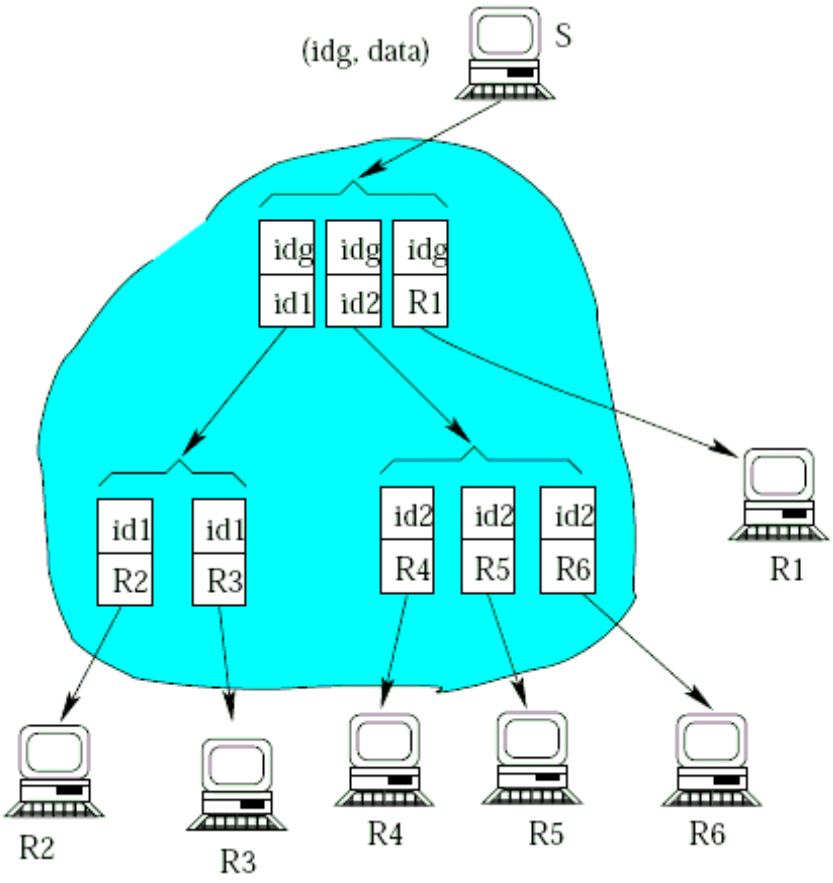


Some applications



More examples





This lecture

- (some new) Internet architecture designs
  - IPNL: an extension to NAT
  - I3: indirection
- A1: course project ideas
  - due Friday, May 18, to pan@uvic.ca
  - any topic related to computer networks
    - you should justify it and I can help
    - final deliverables: report+presentation plus prototype
  - next checkpoint (end of May)
    - 1-page project proposal

Next lectures

- Overlay and peer-to-peer networking
  - required reading
    - [ABKM01] D. Anderson, H. Balakrishnan, F. Kaashoek, R. Morris, Resilient Overlay Networks, In Proc. of SOSP '01. [RON]
    - [SMKKB01] Ion Stoica, Robert Morris, David Karger, Frans Kaashoek, Hari Balakrishnan, "Chord: A Scalable Peer-to-peer Lookup Service for Internet Applications," Proceedings of the 2001 ACM SIGCOMM Conference, August 2001. [Chord]