

## More on IP and the Network Layer

Kai Shen

10/1/2014

CSC 257/457 - Fall 2014

1

## The Internet Protocol

- Addressing, LAN grouping of addresses
- Packet format
- Hierarchical routing:
  - intra-AS (RIP, OSPF)
  - inter-AS (BGP)

10/1/2014

CSC 257/457 - Fall 2014

2

## IPv6

- A key motivation: address depletion
  - 128-bit addresses
- Additional motivation:
  - simplification help speed processing/forwarding
    - fixed-length 40 byte header
    - no fragmentation allowed in intermediate routers
  - header changes to facilitate QoS
    - flow label
  - new "anycast" address: route to one of a set of several servers

10/1/2014

CSC 257/457 - Fall 2014

3

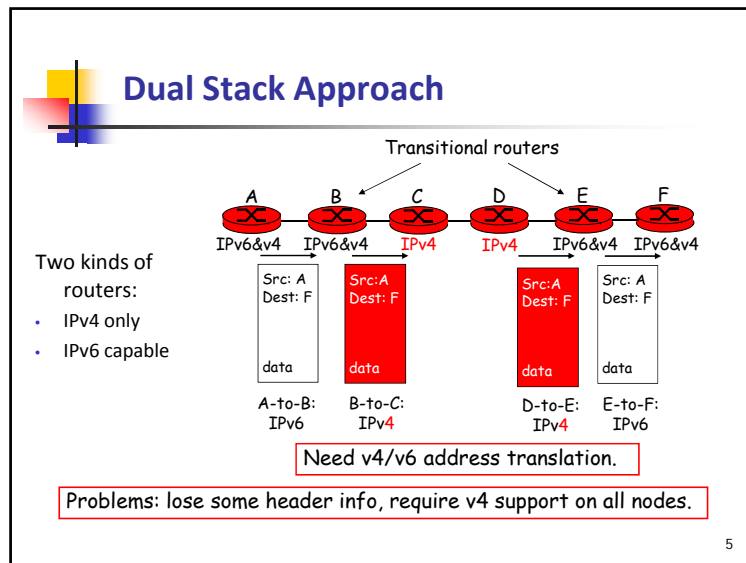
## Transition From IPv4 To IPv6

- It is difficult to change the network layer protocol
  - The large number of routers and administrative autonomy makes simultaneous change impossible.
  - Routers speaking different protocols do not naturally work together.
- Two proposed approaches:
  - Dual Stack: some routers with dual stack (v6, v4) can "translate" between formats.
  - Tunneling: IPv6 carried as payload in IPv4 packet among IPv4 routers.

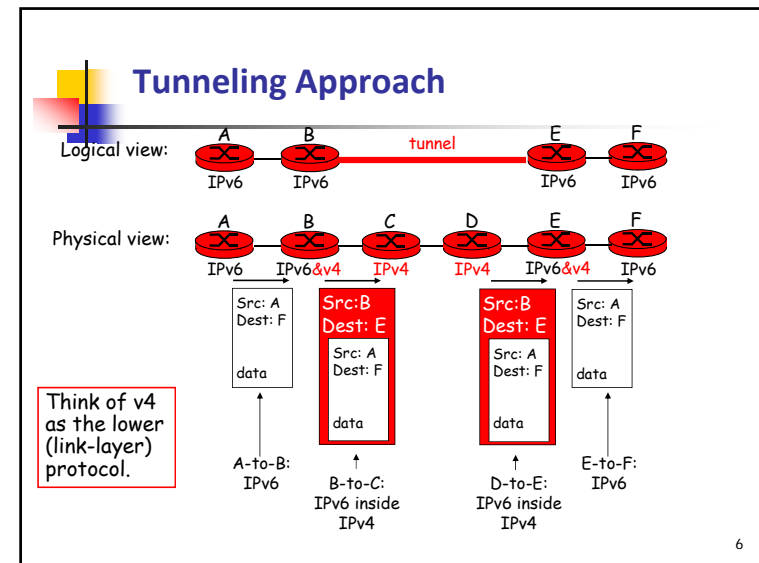
10/1/2014

CSC 257/457 - Fall 2014

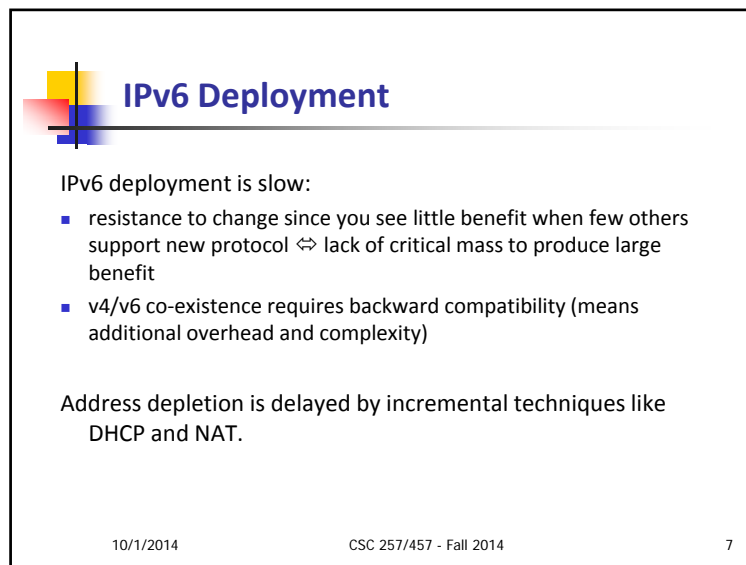
4



5



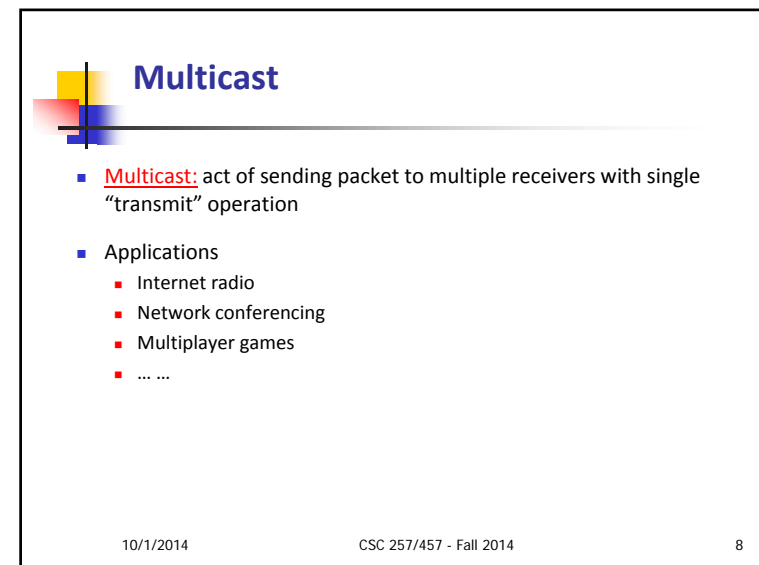
6



10/1/2014

CSC 257/457 - Fall 2014

7



10/1/2014

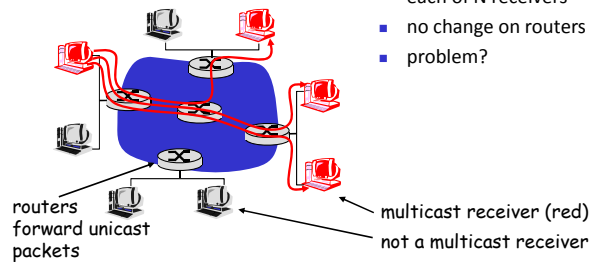
CSC 257/457 - Fall 2014

8

## Multicast via Multiple Unicasts

### Multicast via unicast

- source sends N unicast packets, one addressed to each of N receivers
- no change on routers
- problem?



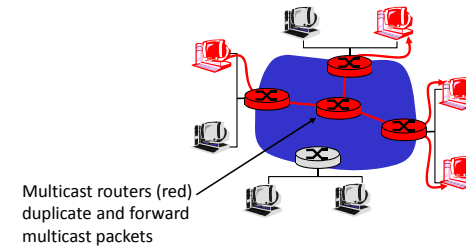
10/1/2014

CSC 257/457 - Fall 2014

9

## Ideal Network Multicast

Router actively participate in multicast, making copies of packets as needed and forwarding towards multicast receivers



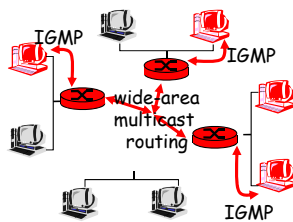
10/1/2014

CSC 257/457 - Fall 2014

10

## Local and Wide-Area Multicast Management

- Local:** host informs local mcast router of desire to join group
  - IGMP (Internet Group Management Protocol)
- Wide area:** local router interacts with other routers to receive mcast packet flow



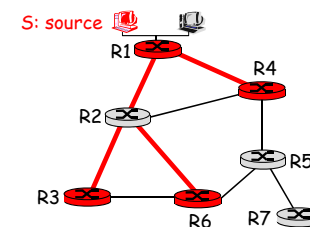
10/1/2014

CSC 257/457 - Fall 2014

11

## Shortest Path Tree

- Goal:** find path/paths (tree) connecting multicast routers having local mcast group members
- Tree of shortest path routes from source to all receivers
  - Dijkstra's algorithm (with complete network information)



10/1/2014

CSC 257/457 - Fall 2014

12

## Reverse Path Forwarding

What if we don't have complete network information?

Goal is to forward along shortest paths. **Heuristic:**

- not to forward when packets clearly have deviated from the shortest paths;
- rely on router's knowledge of unicast routing table.

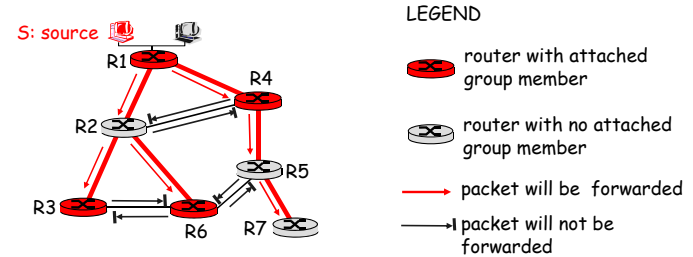
*if* (mcast packet received on incoming link on shortest path back to source)  
*then* flood packet onto all outgoing links  
*else* ignore packet

10/1/2014

CSC 257/457 - Fall 2014

13

## Reverse Path Forwarding: Example



- problem: reaching routers that are not in the group

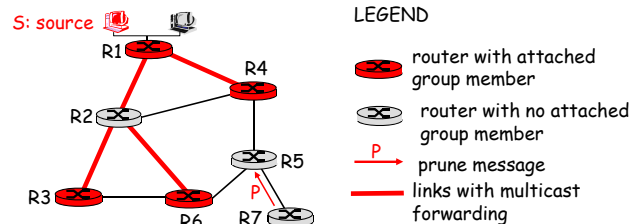
10/1/2014

CSC 257/457 - Fall 2014

14

## Reverse Path Forwarding: Pruning

- forwarding tree contains subtrees with no mcast group members
  - "prune" msgs sent upstream by router with no downstream group members



10/1/2014

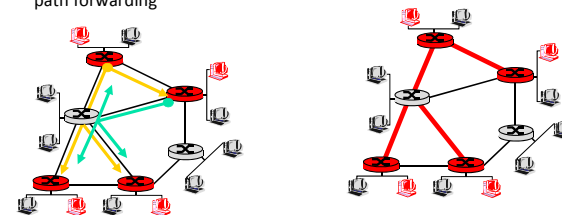
CSC 257/457 - Fall 2014

15

## Wide-area Multicast Routing

**Goal:** find path/paths (tree) connecting multicast routers.

- **source-based tree:** one tree per source
  - shortest path trees, reverse path forwarding
- **group-shared tree:** group uses one tree



10/1/2014

CSC 257/457 - Fall 2014

16



## Shared-Tree Multicast

- Assume complete global network information is available, derive minimum cost tree connecting all relevant routers
  - Steiner tree
  - problem is NP-complete

10/1/2014

CSC 257/457 - Fall 2014

17



## A Distributed Solution: Center-based Tree

- One router identified as “center” of tree
- To join:
  - edge router sends unicast *join-msg* addressed to center router
  - *join-msg* “processed” by intermediate routers and forwarded towards center
  - *join-msg* either hits existing tree branch for this center, or arrives at center
  - path taken by *join-msg* becomes new branch of tree for this router

10/1/2014

CSC 257/457 - Fall 2014

18



## Comparison

Compare reverse path forwarding with center-based tree

- Better multicast delivery along shortest paths produced by reverse path forwarding
- Too much pruning in a “sparse” system with relatively few interested routers

10/1/2014

CSC 257/457 - Fall 2014

19



## Internet Multicast Routing

- **DVMRP**
  - distance vector multicast routing protocol, based on reverse path forwarding with pruning
- **PIM**
  - in a **sparse** mode where reverse path forwarding with pruning doesn't do well, it uses center-based trees
- IP multicast deployment?

10/1/2014

CSC 257/457 - Fall 2014

20



## Disclaimer

- Parts of the lecture slides contain original work of James Kurose, Larry Peterson, and Keith Ross. The slides are intended for the sole purpose of instruction of computer networks at the University of Rochester. All copyrighted materials belong to their original owner(s).