Computer Networks (CS F303)

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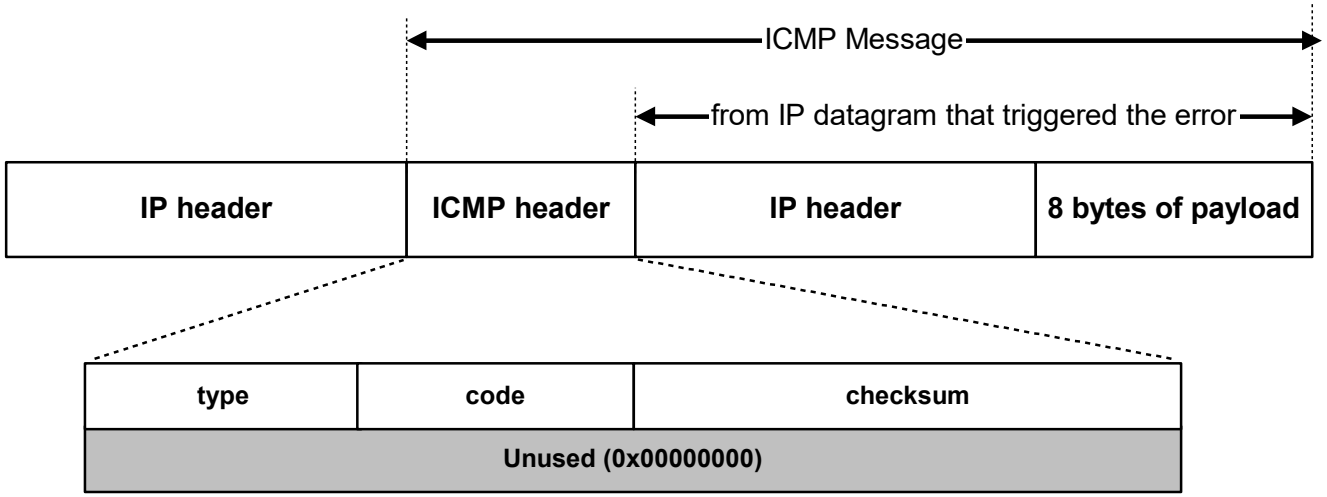
Module-4 <Network Layer>

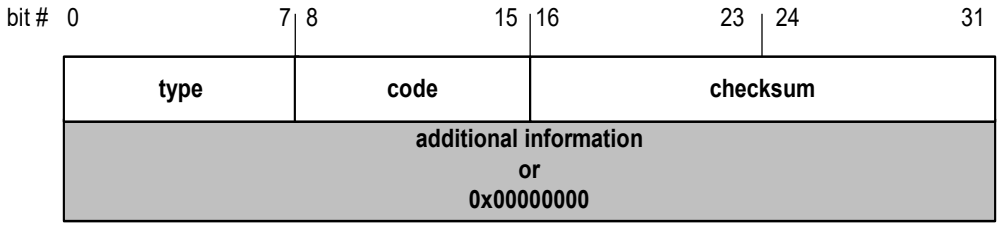
Agenda

- Routing Algorithms
  - Dijkstra (Link State Routing) and Bellman ford (Distance Vector Routing)
- Routing Protocols
  - OSPF

ICMP Protocol

- The **Internet Control Message Protocol (ICMP)** is a helper protocol that supports IP with facility for
  - Error reporting and Simple queries
  - Used by hosts and routers to communicate network layer information to each other
- ICMP lies just above IP
  - ICMP messages are encapsulated as IP datagrams





When a host receives an IP packet with ICMP specified as the upper layer protocol, it de-multiplexes the packet to ICMP, just as it would de-multiplex a packet to TCP/UDP

ICMP Message Types

Type	Message Type	Description
3	Destination Unreachable	Packet could not be delivered
11	Time Exceeded	Time to live field hit 0
12	Parameter Problem	Invalid header field
4	**Source Quench**	Choke Packet
5	Redirect	Teach a router about geography
8	Echo	Ask a machine if it is alive
0	Echo Reply	Yes, I am alive
13	Timestamp Request	Same as Echo request, but with timestamp
14	Timestamp Reply	Same as Echo reply, but with timestamp

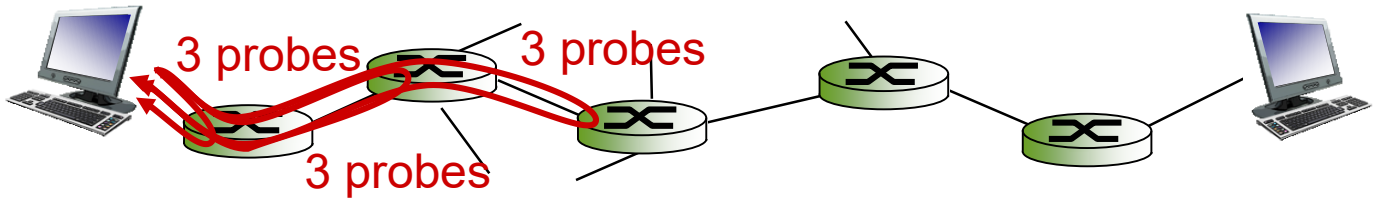
Code	Definition
0	Net Unreachable
1	Host Unreachable
2	Protocol Unreachable
3	Port Unreachable
4	Fragmentation needed & Don't Fragment was set
5	Source Route failed
6	Destination Network Unknown
7	Destination Host Unknown
8	Source Host Isolated
9	Communication Destination Network is Administratively Prohibited
10	Communication Destination Host is Administratively Prohibited
11	Destination Network Unreachable for Type of Service
12	Destination Host Unreachable for Type of Service
13	Communication Administratively Prohibited
14	Host Precedence Violation
15	Precedence Cutoff Violation

Traceroute and ICMP

- Source sends series of UDP segments to dest
  - first set has TTL =1
  - second set has TTL=2, etc.
  - unlikely port number
- When *n*th set of datagrams arrives to nth router:
  - router discards datagrams
  - and sends source ICMP messages (type 11, code 0)
  - ICMP messages includes name of router & IP address
- When ICMP messages arrives, source records RTTs

Stopping criteria:

- UDP segment eventually arrives at destination host
- Destination returns ICMP "port unreachable" message (type 3, code 3)
- Source stops



Routing

- Typically a host is attached directly to one router which is called as default router
- The default router connected to the source host is called as source router
- The problem of routing a packet from source host to the destination host boils down to the routing the packet from source router to the destination router

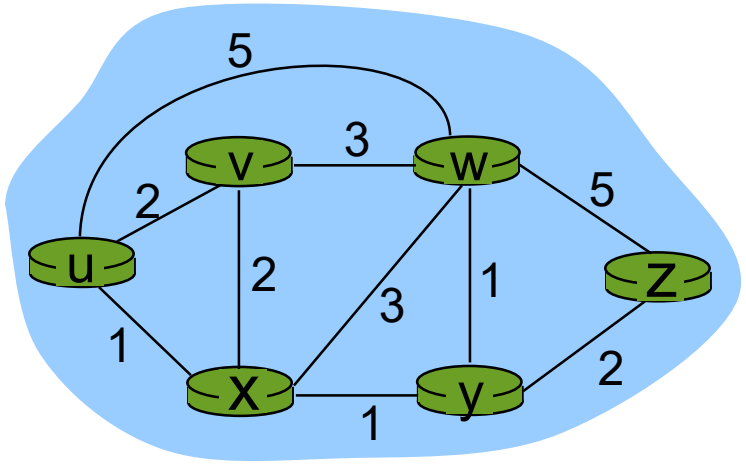
Routing Algorithm Taxonomy [.1]

- Global or Centralized Routing Algorithms
  - Each node has the complete information about connectivity and link costs (Link State Algorithms)
- Decentralized Routing Algorithms
  - Each node begins with only the knowledge of the costs of its own directly attached links
  - Then uses an iterative process of calculation to find the least cost paths to a set of destinations or all

Routing Algorithm Taxonomy [..2]

- Static Routing Algorithms
  - Routes change very slowly over time
- Dynamic Routing Algorithms
  - Routes change due to the traffic load and/or change in topology
- Load sensitive Vs. Load-insensitive
  - Link cost changes due to change in congestion level of the link

Routing Abstraction

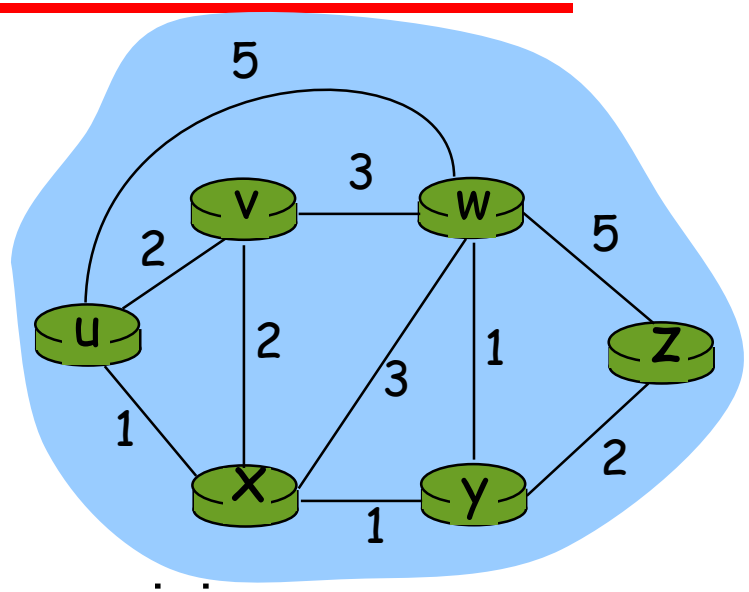


Graph: G = (N,E)

N = set of routers = { u, v, w, x, y, z }

E = set of links ={ (u,v), (u,x), (v,x), (v,w), (x,w), (x,y), (w,y), (w,z), (y,z) }

Dijsktra's Algorithm

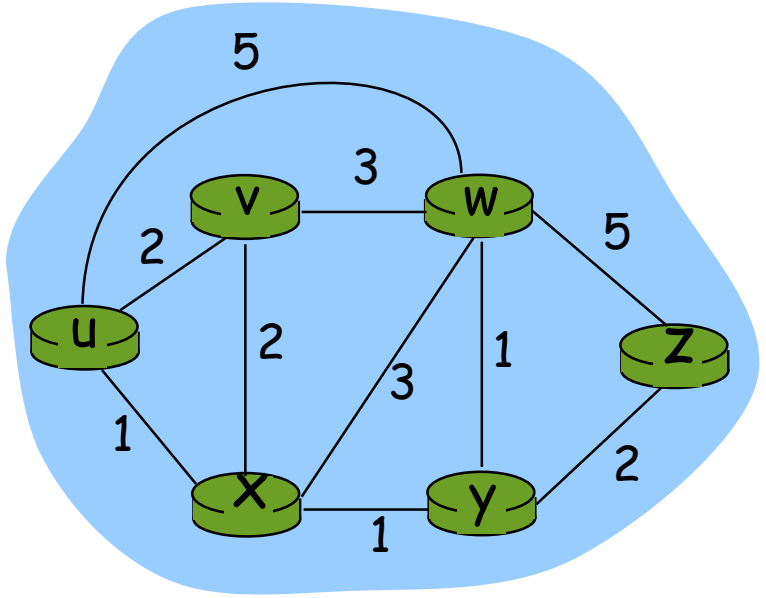



```
1  Initialization:
2    N' = {u}
3    for all nodes p
4      if p adjacent to u
5           then D(p) = c(u,p)
6      else D(p) = ∞

7    Loop
8      find q not in N' such that D(q) is a minimum
9      add q to N'
10     update D(p) for all p adjacent to q and not in N' :
11        D(p) = min( D(p), D(q) + c(q,p) )
12     /* new cost to p is either old cost to p or known
          shortest path cost to q plus cost from q to p */
13   until all nodes in N'
```

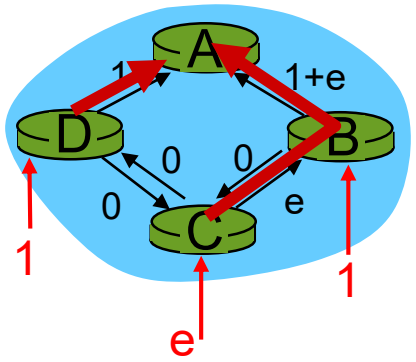
Link State Routing: Example

Step	N'	D(v),p(v)	D(w),p(w)	D(x),p(x)	D(y),p(y)	D(z),p(z)
0	u	2,u	5,u	1,u	∞	∞
1	ux	2,u	4,x		2,x	∞
2	uxy	2,u	3,y			4,y
3	uxyv		3,y			4,y
4	uxyvw					4,y
5	uxyvwz					

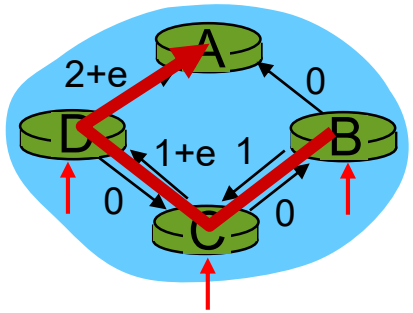


Route Oscillations

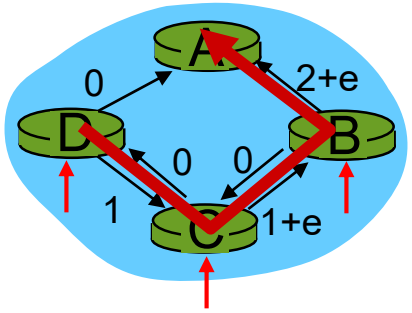
- Link cost is equal to the load carried on the link
- Link costs are not symmetric



initially



given these costs, find new routing…. resulting in new costs



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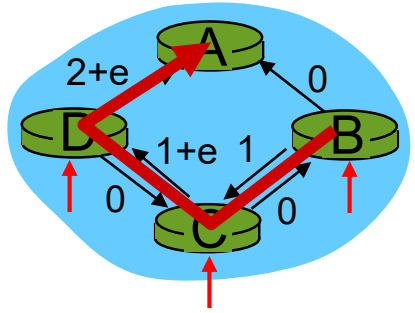

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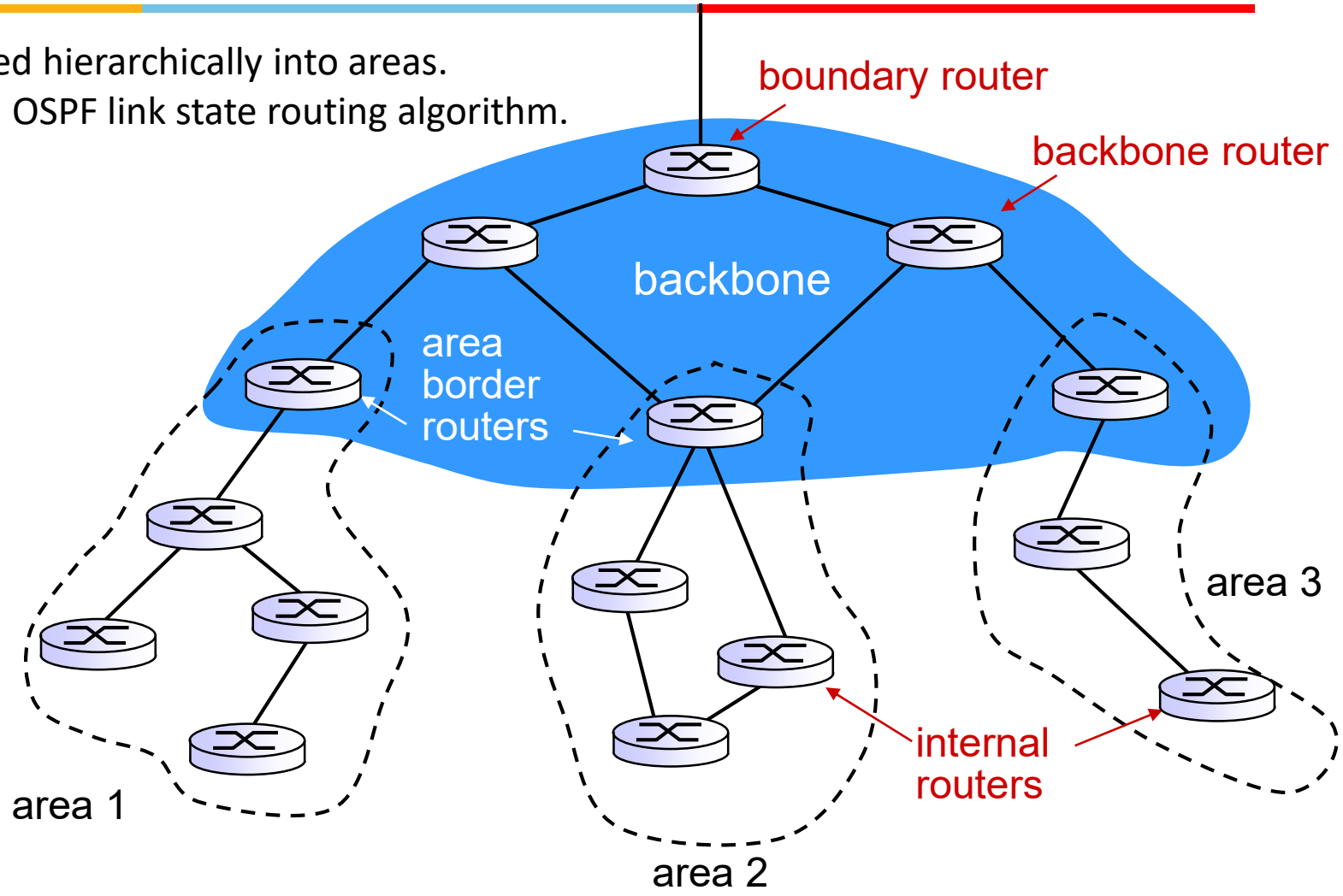
OSPF Protocol

- "open": publicly available
- Uses link state algorithm
  - LS packet dissemination
  - Topology map at each node
  - Route computation using Dijkstra's algorithm
- OSPF advertisement carries one entry per neighbor
- Advertisements flooded to *entire* AS
  - Carried in OSPF messages directly over IP (rather than TCP or UDP)
  - Link state broadcast and reliable message transfer must be implemented in the OSPF itself
  - Broadcasts LSA whenever there is a change in link's state and also send Periodic updates (after every 30 mints)

Hierarchical OSPF Routing

An AS can be configured hierarchically into areas.
Each area runs its own OSPF link state routing algorithm.



OSPF Messages

- HELLO
  - To check whether links are operational or not
- Database Description
  - contain descriptions of the topology of the AS or area
- Link State Request
  - used by one router to request updated information about a portion of the Link State Database Description (LSDB) from another router
- Link State Update
  - contain information about an updated portion of the LSDB. These messages are sent in response of a Link State Request message
- Link State Acknowledgement
  - acknowledges a Link State Update message

Thank You!