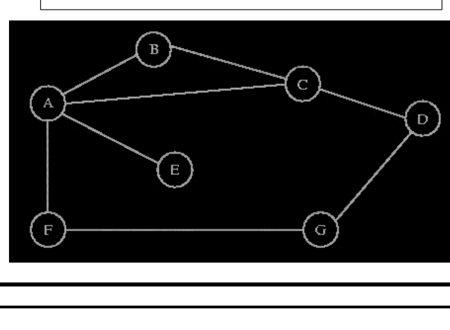
Routing Protocols

Distance Vector Routing

- Initially A believes B is one hop away and D is unreachable.
- A sends its believes to its direct neighbors.
- B learns from A that it can reach E at a cost of 2 by going through A. B modifies its record.
- In the next cycle B passes on this information to C. For C the cost to go to E via B is 3.
- By now C has found a way to go to E via A at the cost of 2. So C rejects the path through B.

	A	B	C	D	E	F	G
A	0	1	1	X	1	1	X
B	1	0	1	X	X	X	X
C	1	1	0	1	X	X	X
D	X	X	1	0	X	X	1
E	1	X	X	X	0	X	X
F	1	X	X	X	X	0	1
G	X	X	X	1	X	1	0



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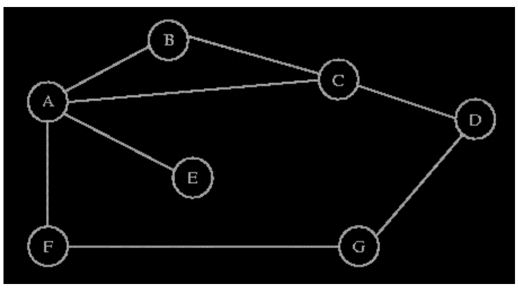
Final Vector Routing

	A	B	C	D	E	F	G
A	0	1	1	X	1	1	X
B	1	0	1	X	X	X	X
C	1	1	0	1	X	X	X
D	X	X	1	0	X	X	1
E	1	X	X	X	0	X	X
F	1	X	X	X	X	0	1
G	X	X	X	1	X	1	0

	A	B	C	D	E	F	G
A	0	1	1	2	1	1	2
B	1	0	1	2	2	2	3
C	1	1	0	1	2	2	2
D	2	2	1	0	3	2	1
E	1	2	2	3	0	2	3
F	1	2	2	2	2	0	1
G	2	3	2	1	3	1	0



	B	Next Hop
A	1	A
C	1	C
D	2	C
E	2	A
F	2	A
G	3	A

Routing Table at node B

- Besides the cost every node also keeps track of the next hop.

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Per-Node Perspective

- As far as one is concerned:
- Each node maintains a table with three columns.
  - Destination, Cost, Next Hop.
- Each node periodically sends update with a list of pairs:
  - Destination, Cost.
- Whenever, a node receives an update from a neighbor that includes a route that is better than one of its current route, it changes the route in its forwarding table.
- A Node sends update:
  - periodically (in few seconds or in several minutes).
  - Triggered update, when a node changes its routing table entry.

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Quiz

Quiz: 205: A graph has 20 nodes and a speaker node has 3 immediate neighbors. In Distance Vector Protocol this speaker node will send information about how many nodes?

Example of Update

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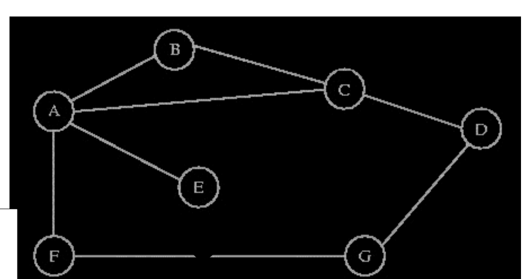
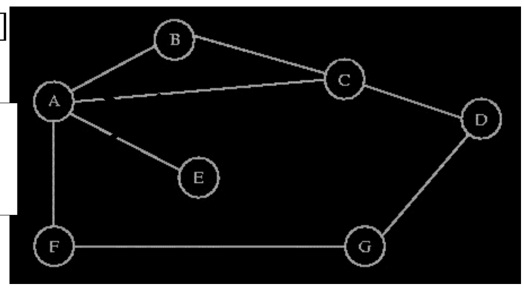
- F knows [G=1], and A knows [G=2 via F]
- F detects that its link to G has failed.
- F advertises [G=x]
- A updates [G=x]
- C advertises [G=2]
- A notes [G=3 via C]
- F notes [G=4 via A]



Finally the network stabilizes.

Problem!

- A knows [E=1], and B knows [E=2 via A]
- A detects that its link to E has failed.
- A advertises [E=x]
- But B and C advertises [E=2], based on who is fast..
- B hears [E=2], updates [E=3 via C], and advertizes to A
- A thinks [E=4 via B!] and advertises to C
- C thinks [E=5 via A!]



The cycle will continue until the distance is too large!

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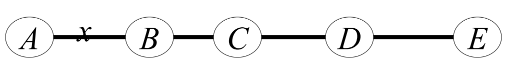
Count to Infinity Problem (Propagation of good news)



A	B	C	D	E	
	inf.	inf.	inf.	inf.	initial state
	1	inf.	inf.	inf.	after exchange 1
	1	2	inf.	inf.	after exchange 2
	1	2	3	inf.	after exchange 3
	1	2	3	4	after exchange 4

Suppose initially A to B link was down so every body knows distance to A is infinity. Now the link comes up.

Good news propagates fast!

Good news propagates in few steps.

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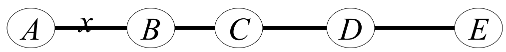
Count to Infinity Problem (propagation of bad news!)



A	B	C	D	E	
	1	2	3	4	initial state
	3	2	3	4	after exchange 1
	3	4	3	4	after exchange 2
	5	4	5	4	after exchange 3
	5	6	5	6	after exchange 4
	Inf.	Inf.	Inf.	Inf.	In many steps

Suppose initially A to B was up. So every body knows distance to A. Now the link is down. But every body gets wrong information from neighbor. Bad news propagates in many steps.

Good news propagates fast!

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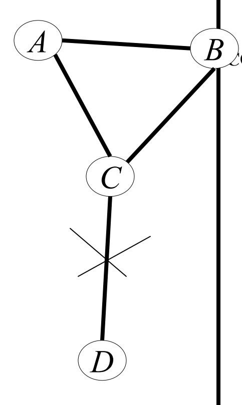
Split-Horizon Technique

- Initially A and B both has distance to D=2.
- Now D to C disconnects.
- Using split-horizon both A and B tells C that they cannot reach D.
- C concludes it cannot reach D and reports that to A and B.
- But B says to A that it can reach to D by Hop 3. So A concludes it has a path to D with 4 hop via B!
- This is however count-to-infinity problem!



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Link State Routing

- The problem with distance vector routing was the nodes were advertising paths which they were not sure about!
- They were advertising only to their neighbors.
- In link state, nodes advertise only the information about which they are sure.
- But they advertise to everyone.

Reliable Advertising

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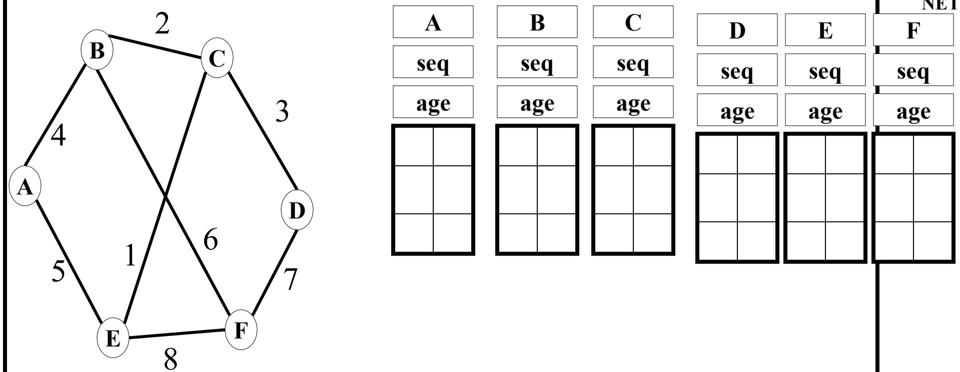
- Update packet link-state packet (LSP) contains
  - the ID of the creator node.
  - The list of directly connected neighbors.
  - A sequence number
  - a time to live (TTL).
- The first two items are for routing calculation.
- Sequence number is used to determine the most up-to-date information.
- TTL is used to make sure, LSP do not circulate for ever.

Link State Routing Example



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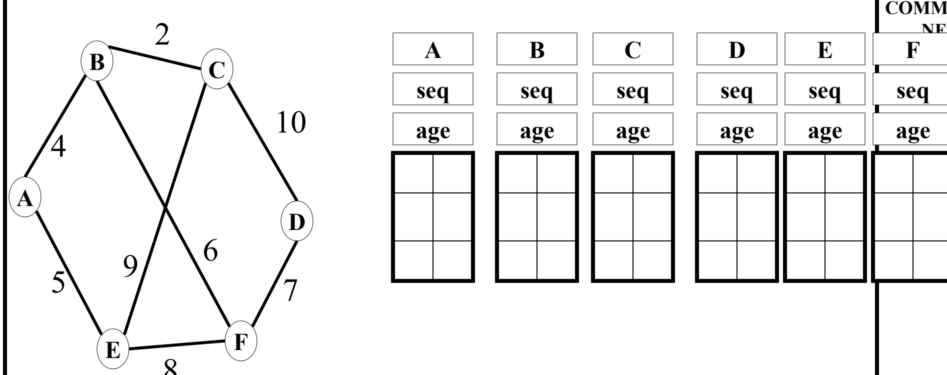
Link State Routing Example



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Link State Packet Buffer

			SEND FLAG			ACK FLAG			
SOURCE	SEQ	AGE	A	C	F	A	C	F	DATA
A	21	60	0	1	1	1	0	0	
F	21	60	1	1	0	0	0	1	
E	21	59	0	1	0	1	0	1	
C	20	60	1	0	1	0	1	0	
D	21	59	1	0	0	0	1	1	

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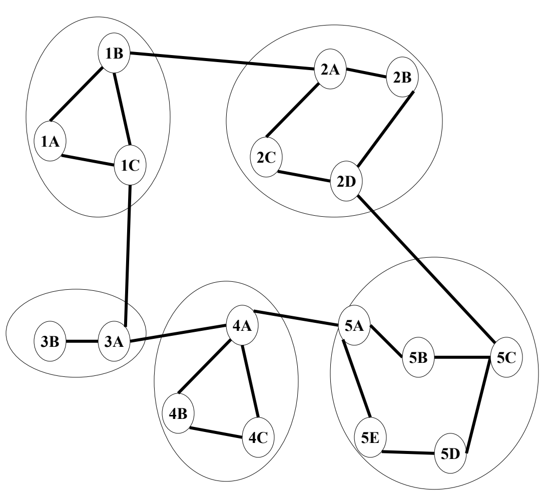
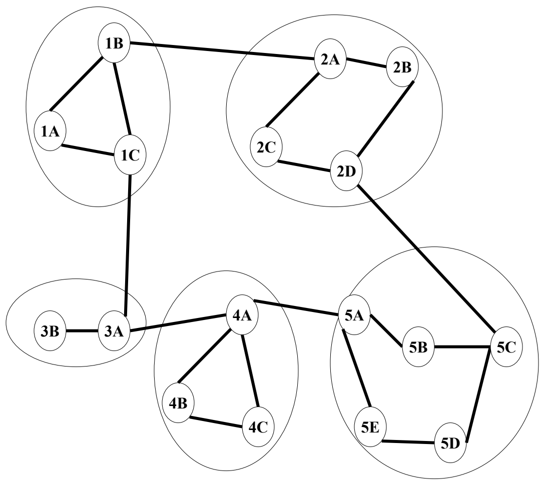
Hierarchical Routing



Full Table for 1A

Dest	Line	Hops
1A		
1B		
1C		
2A		
2B		
2C		
2D		
3A		
3B		
4A		
4B		
4C		
5A		
5B		
5C		
5D		
5E		

Hierarchical Routing



Hierarchical Table for 1A		
Dest	Line	Hops
1A		
1B		
1C		
2		
3		
4		
5		

Hierarchical Table for 2A		
Dest	Line	Hops
2A		
2B		
2C		
2D		
1		
3		
4		
5		

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Network Layer

- There are other network layer issues such as congestion control and quality of service.
- We will return to them later.

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