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Introduction to Link State Protocols

Session RST-103

Agenda

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- **Overview of Link State Protocols**
- **Concepts in Link State Protocols**
- **The Dijkstra Algorithm**
- **IP Link State Protocols**
- **Choosing an IP Link State Protocol**

Why Is It Called a Link State Protocol?

- **Traditional distance vector protocols relay information regarding their relative distance to a destination**
- **Link State Protocols relay specific link characteristics and state information**
- **Only changes or updates are sent across the network**
- **Each router uses that information to build a routing table on it's own**

Link State Protocols

- **Rely on the Dijkstra shortest path first (SPF) algorithm to calculate path tree**
- **Maintain a database of network information for a complete “picture” of the network**
- **Form adjacencies between neighboring devices and flood to exchange database information**
- **Utilize a hierarchal design to enable scalability**

Advantages of a Link State Protocol

- **Uses metrics (costs) to calculate path**
- **Typically displays faster convergence than distance vector routing protocols**
- **Typically more scalable due to hierarchical nature**

Dijkstra Protocols

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- **IS-IS**
- **OSPF**
- **CLNS/DECnet
phase 5**
- **NLSP**

Common Concepts

Metrics

- **Metric=path cost**
- **Numeric value that can be administrator assigned, or calculated using link characteristics information**
- **More flexible than hops used in DVRPs**

Topology/Link State Database

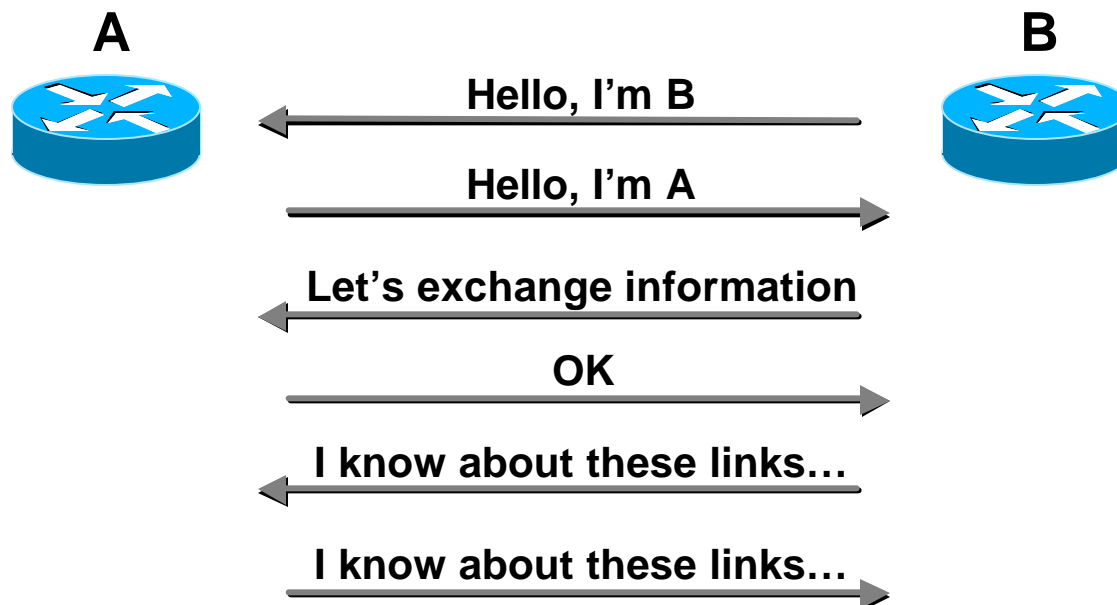
- **The LSDB contains information regarding all links and routers within a logical area**
- **A router has a separate LS database for each area to which it belongs**
- **All routers belonging to the same area have identical database**
- **SPF calculation is performed separately for each area**

Adjacencies

- **Routers participating in a Link State Protocol are uniquely identified throughout the network with a router ID (some form of address)**
- **Link state protocol routers “discover” their adjacent neighbors with some form of Hello protocol**
- **Once discovered neighbors form a relationship to exchange/synchronize LSDB information between them**

Building the Database

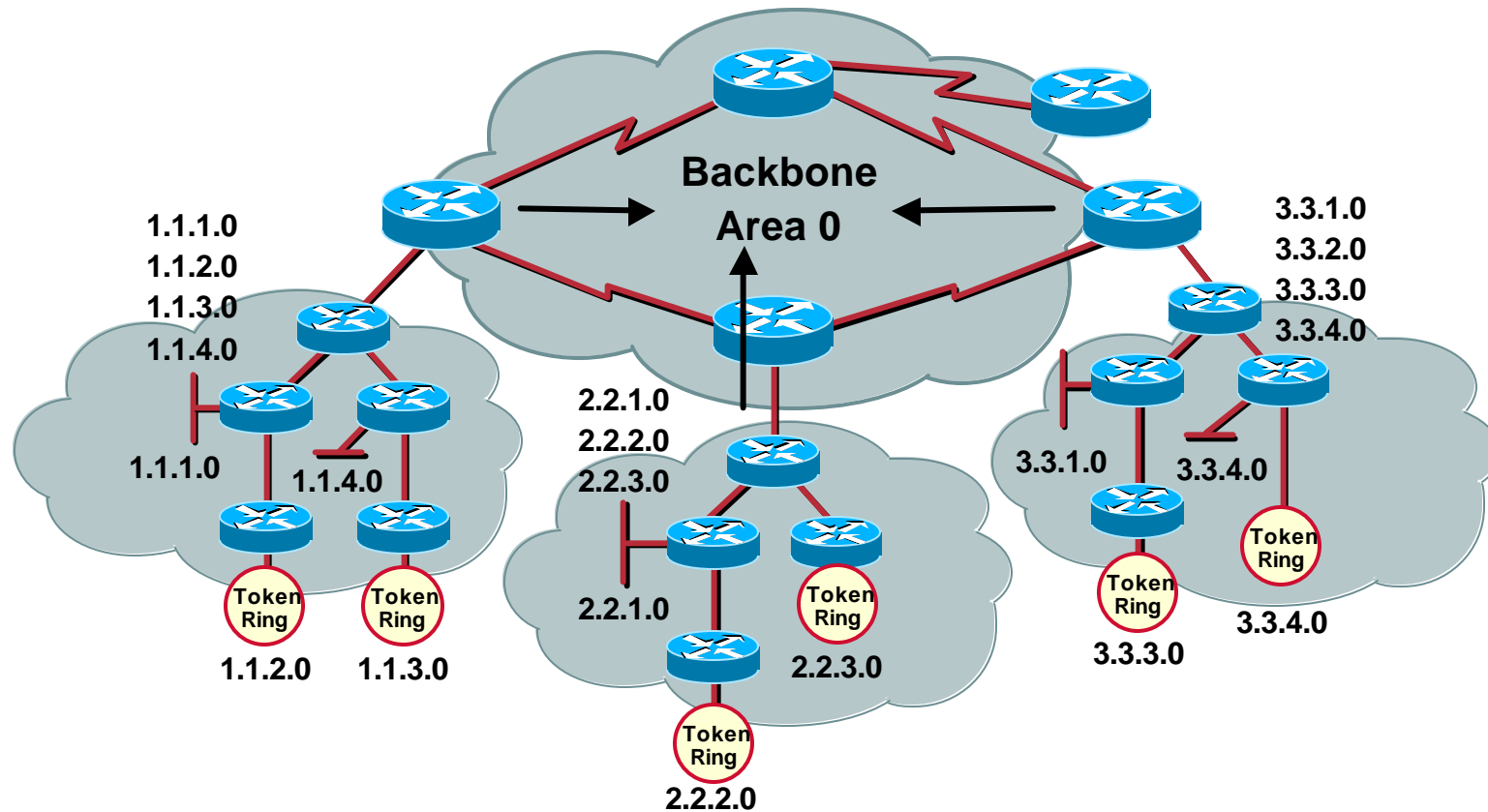
- Hello packets discover neighbors
- Once neighbors are discovered LSDB information is exchanged



Logical Hierarchy

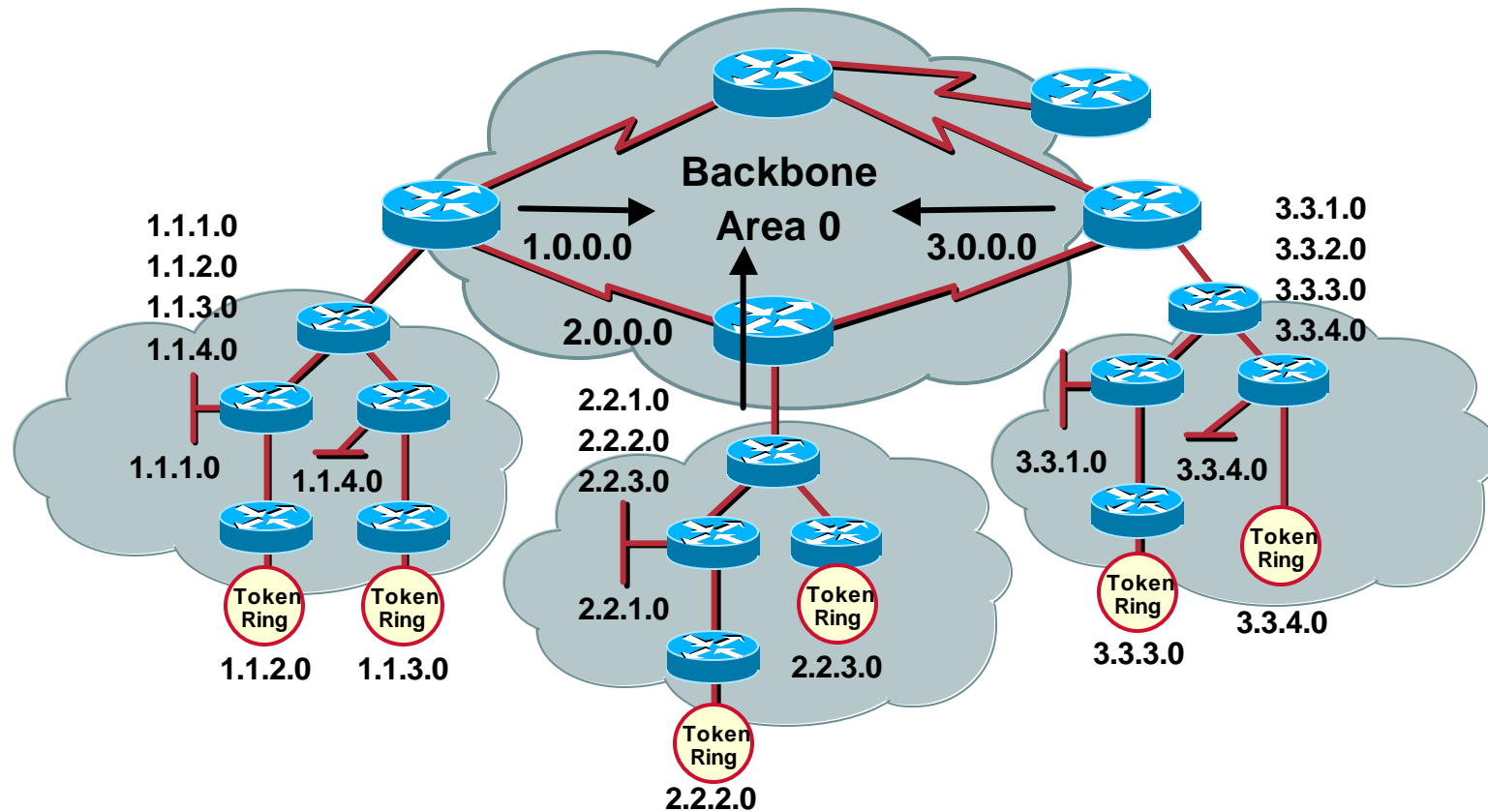
- **Link State Protocols deploy a logical hierarchy in their design**
- **Typically consists of two levels**
- **Usually consists of the concept of a “backbone” level and another sub-level**
 - OSPF: Backbone area (area 0), regular areas**
 - IS-IS: L2 areas, L1 areas**
- **Enables scalability by summarizing and abstracting, thereby reducing, information from lower level areas into the higher level area**

Not Summarized: Specific Links



- Only summary LSA advertised out
- Link-state changes do not propagate

Summarized: Summary Links

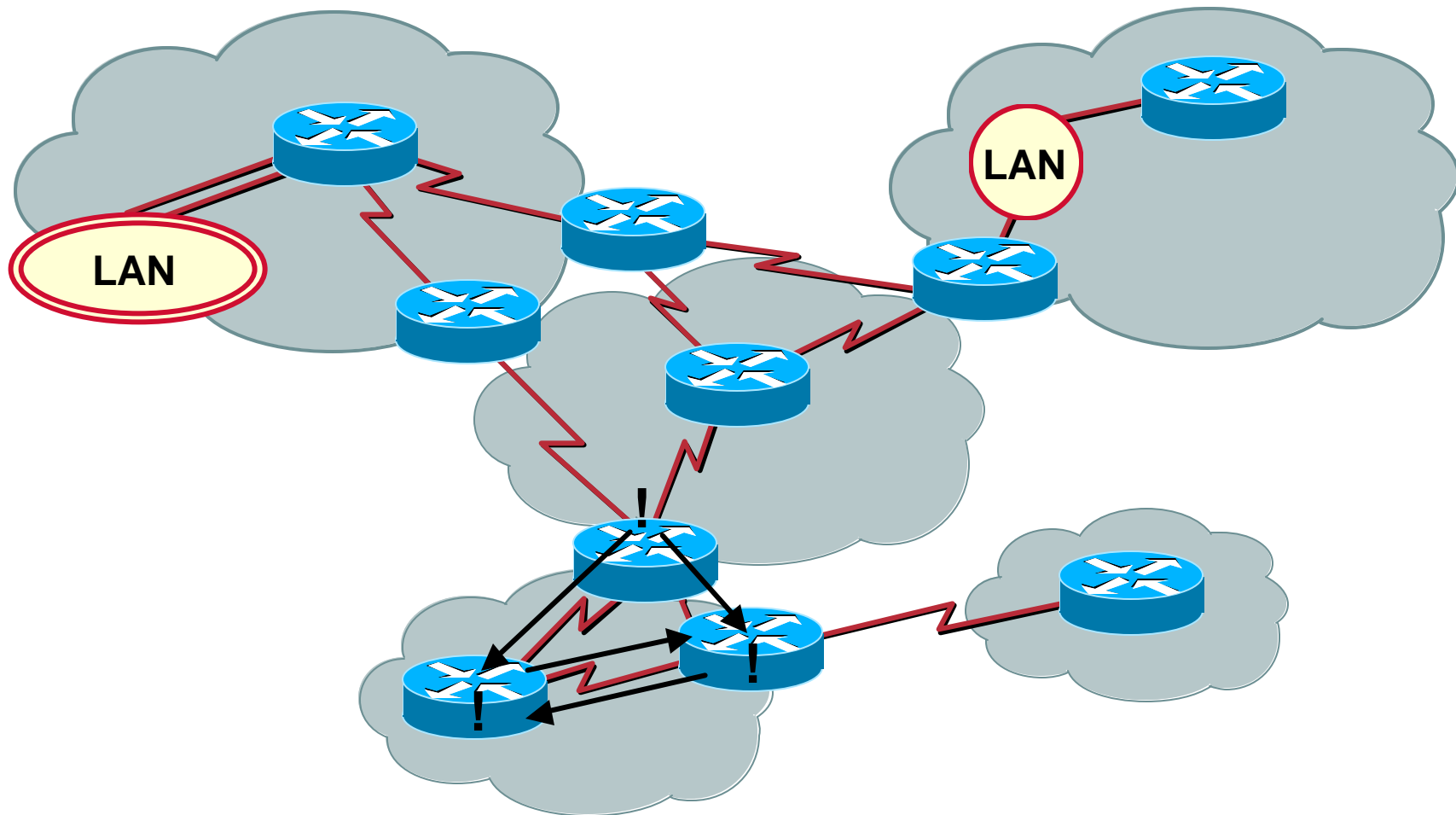


- Only summary LSA advertised out
- Link-state changes do not propagate

Flooding

- **Information that changes or is learned from a neighbor is “flooded” across a logical network area**
- **This is done to maintain consistency of the LSDB across all routers**

Flooding



The Dijkstra Algorithm

Dijkstra

Shortest Path First (SPF) Algorithm

- **Dijkstra is a path finding algorithm**
- **Will find the shortest path from A to B given intermediate path and cost information**
- **One of many path finding algorithms:
Dijkstra, best path, A*, etc**

Dijkstra

Shortest Path First (SPF) Algorithm

- **Link state database**
Created with link state packets (LSPs) from each router
- **TENT database**
Tentative triples (ID, path cost, direction)

Dijkstra (SPF) Overview

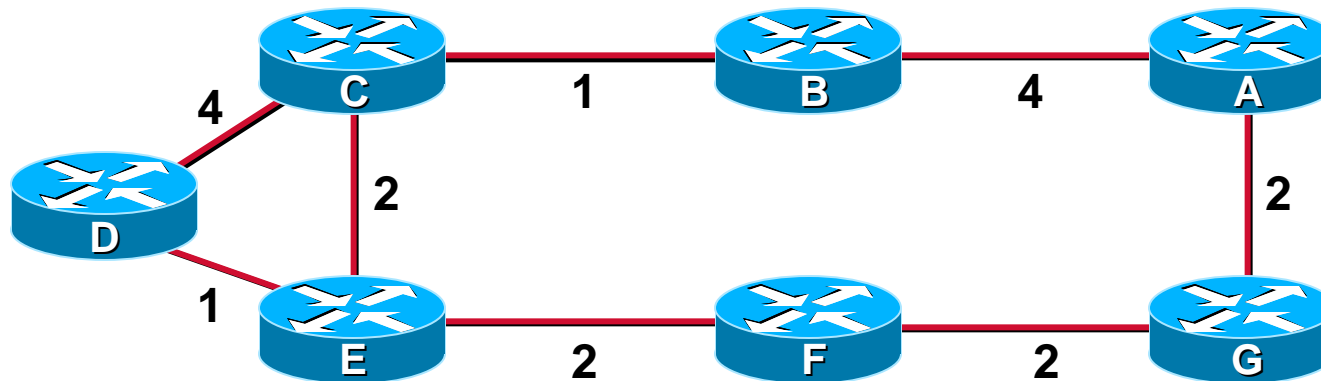
- **PATH database**
Best path triples
(ID, path cost, direction)
- **Forwarding database**
Aka the routing table

Dijkstra (SPF) Overview (Cont.)

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- **All routers exchange Link State Packets (LSPs)**
- **Each starts with itself as root**
- **Tent is built from LSPs**
- **Path is created by examining and comparing tent triples**
- **Once path is final the forwarding table is populated**

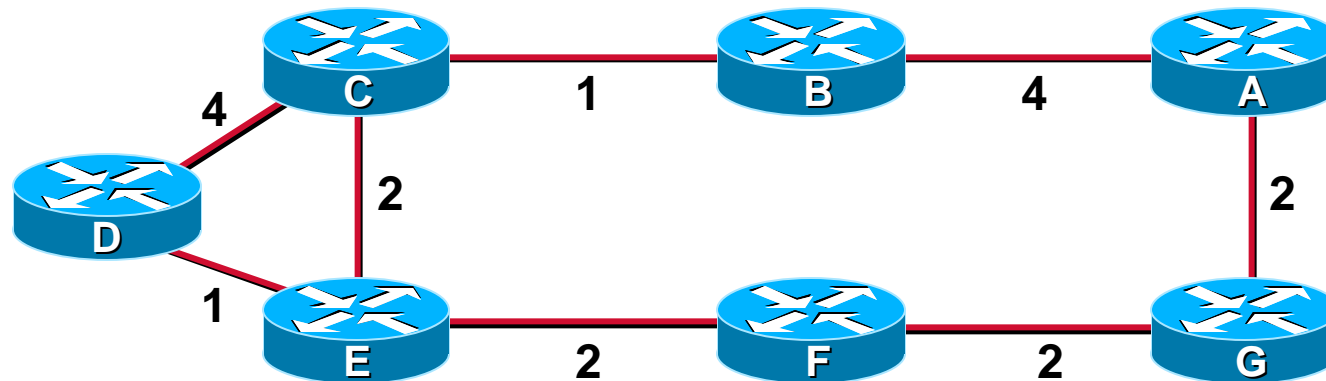
Dijkstra Basics



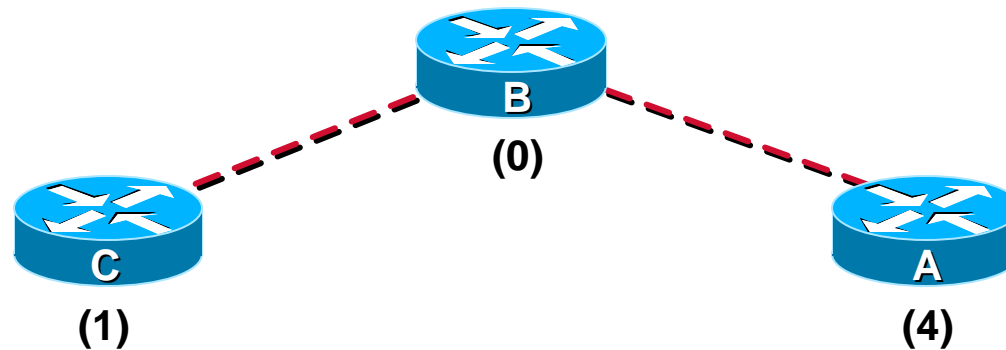
- Router IDs are alphabetic
- Costs are numeric
- Lowest cost best

LSP Data

A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		



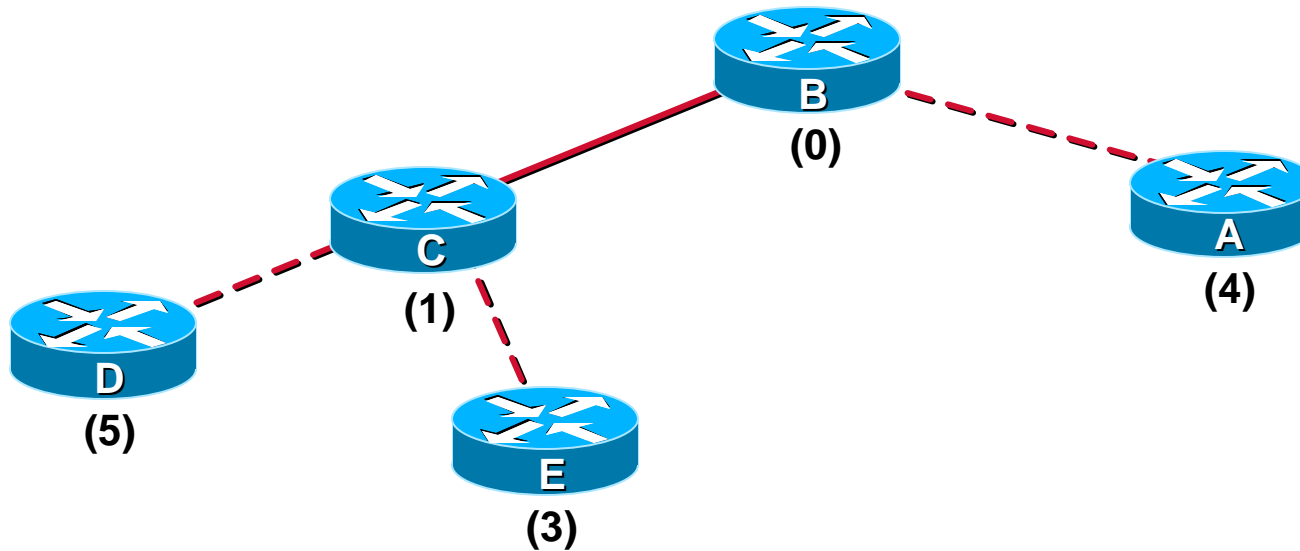
Dijkstra Example—1/7



A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		

- As an example start with B
- A and C costs are tent

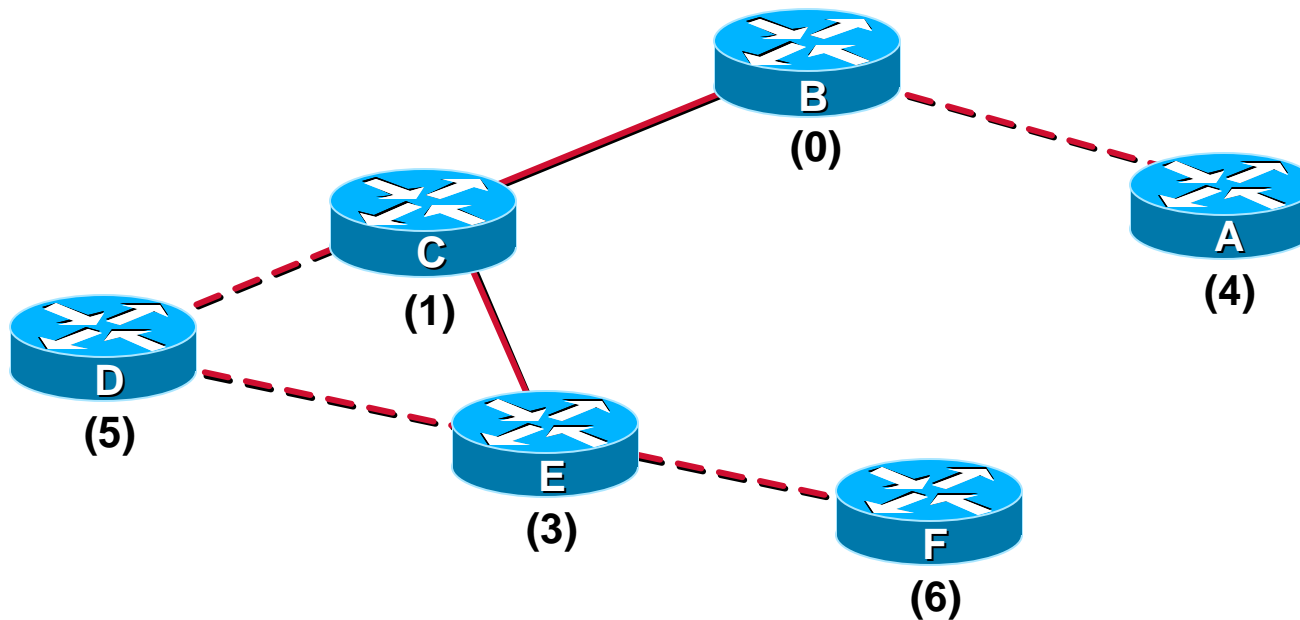
Dijkstra Example—2/7



- Now fill in C
- D,E are in tent
- BC is now in path

A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		

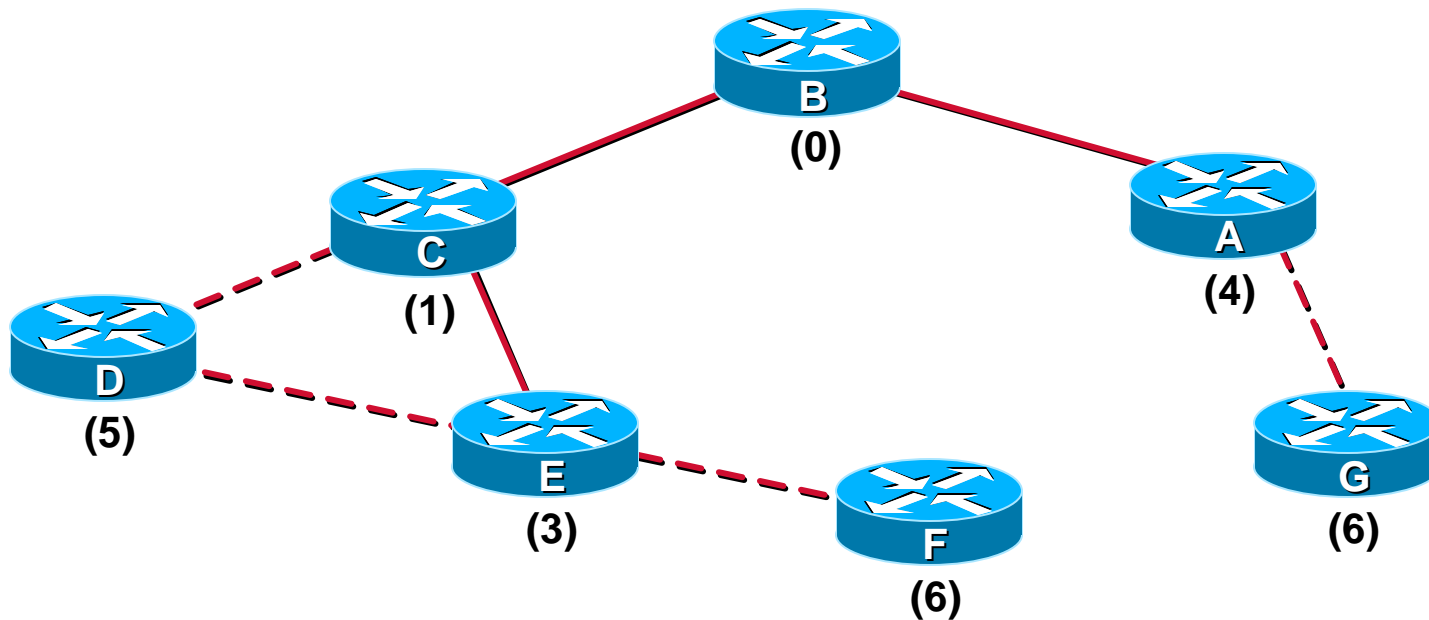
Dijkstra Example—3/7



- Now fill in C
- D,E are in tent
- BC is now in path

A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		

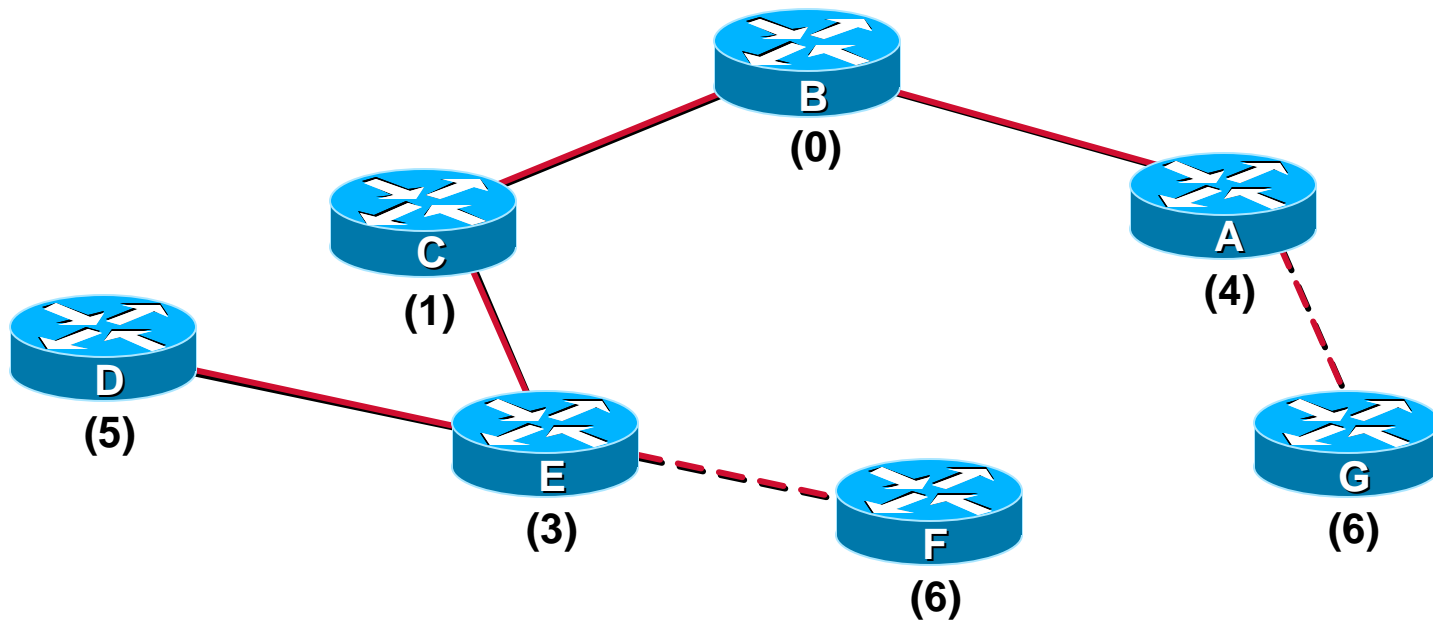
Dijkstra Example—4/7



- Now fill in A
- G is in tent
- BA is now in path

A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		

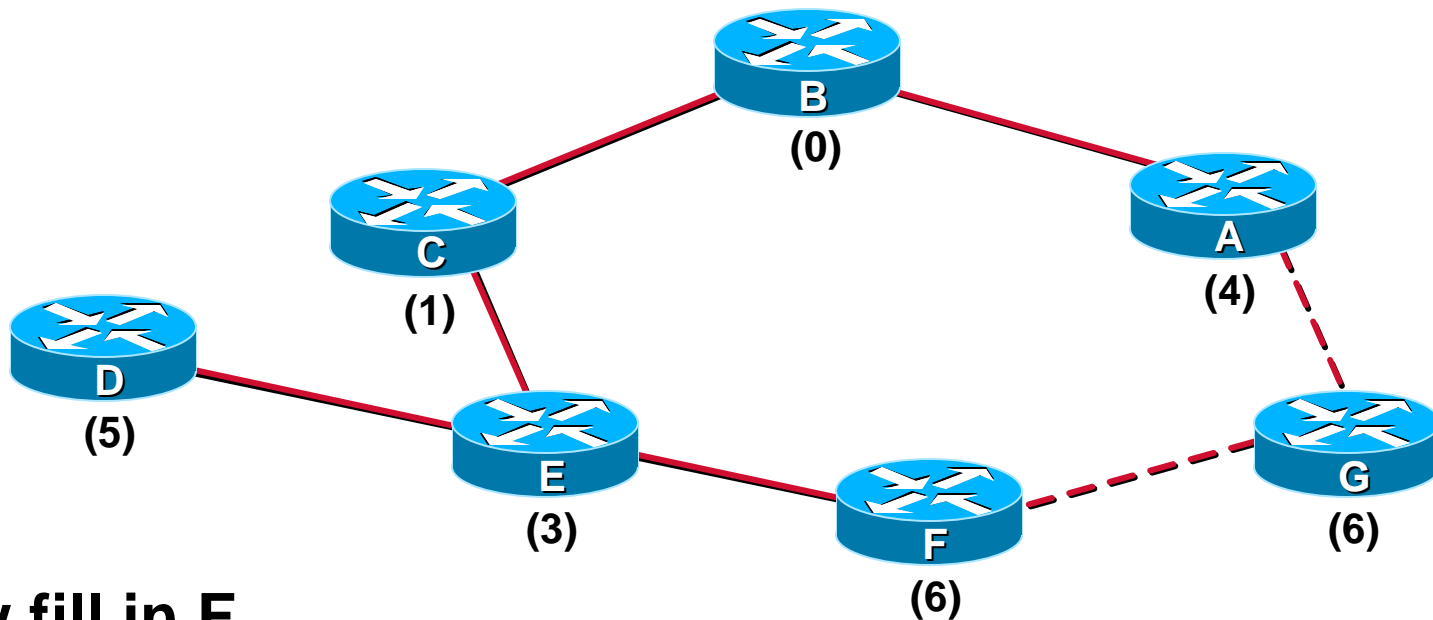
Dijkstra Example—5/7



- CD is removed
- ED is placed in path

A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		

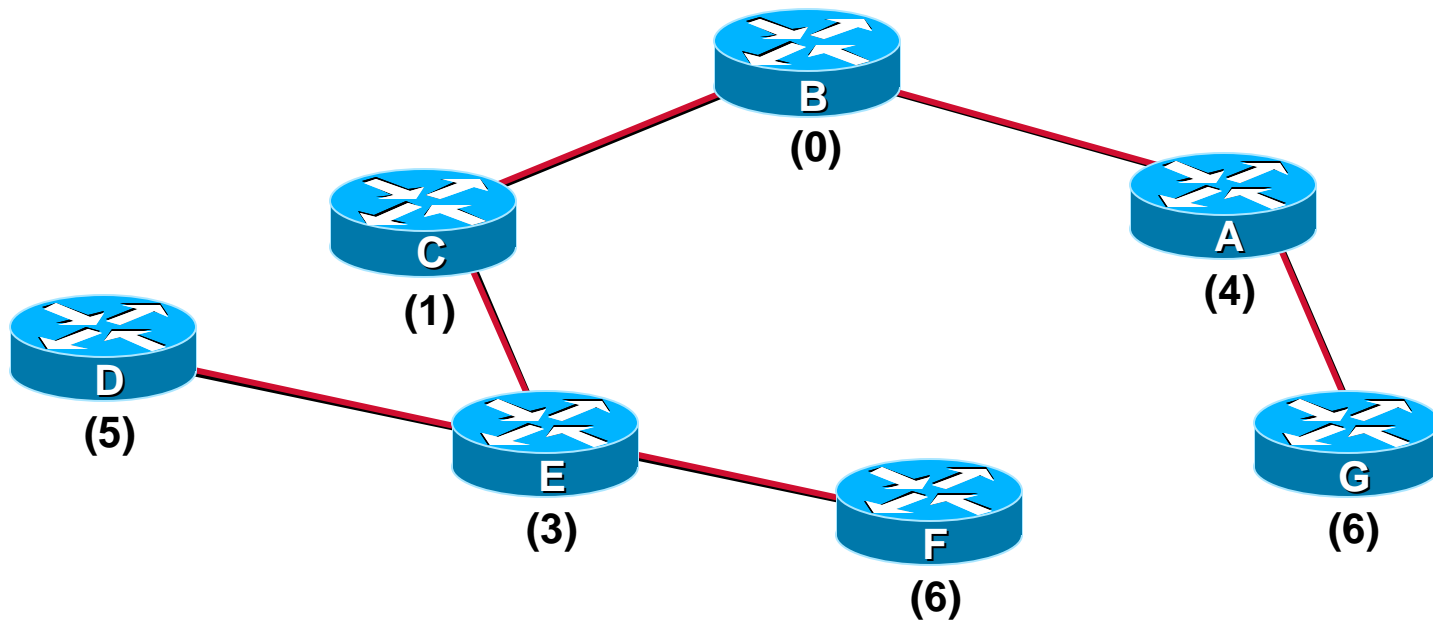
Dijkstra Example—6/7



- Now fill in F
- G is Tent
- GF does not provide better path
- EF is in path

A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		

Dijkstra Example—7/7



- Now fill in G
- FG is removed
- AG is in path

A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		

IP Link State Protocols

Terminology in IP LSPs

OSPF

- Host
- Router
- Link
- Packet
- Designated router (DR)
- Backup DR (BDR)
- Link-State Advertisement (LSA)
- Hello packet
- DataBase Description (DBD)

ISIS

- End System (ES)
- Intermediate System (IS)
- Circuit
- Protocol Data Unit (PDU)
- Designated IS (DIS)
- N/A (no BDIS is used)
- Link-State PDU (LSP)
- IIH PDU
- Complete sequence number PDU (CSNP)

Terminology (Cont.)

OSPF

- Area
- Non-backbone area
- Backbone area
- Area Border Router (ABR)
- Autonomous System Boundary Router (ASBR)

ISIS

- Sub domain (area)
- Level-1 area
- Level-2 Sub domain (backbone)
- L1L2 router
- Any IS

Media Handling

OSPF

- Point-to-point
- Broadcast (LAN segments)
- Non-broadcast
- Point-to-multipoint

OSPF

- Point-to-point
- Broadcast

LSDB Management

OSPF

- **OSPF counts up to MaxAge (60 minutes)**
- **It is not configurable**
- **Thus, every LSA needs to be refreshed every LSRefreshTime period (30 minutes)**
- **Refresh is a fixed constant**

ISIS

- **ISIS counts down to 0**
- **LSPs get flushed when age reaches 0**
- **LSPs are originated with a configurable non-zero value**
- **Thus refreshment interval is configurable (default is 15 minutes)**

Choosing an IP Link State Protocol

Choosing an IP LSP

- **Both protocols are over 10 years old, using graph theory that's at least 40 years old**
- **Both protocols are (even still) works in progress**
- **OSPF is more granular so you need to know the flooding behavior of different types of LSA's**
- **ISIS can be simpler once you get over the NSAP addresses**

* Dave Katz June 2000 NANOG19

Choosing an IP LSP

- **So which one is better ?**

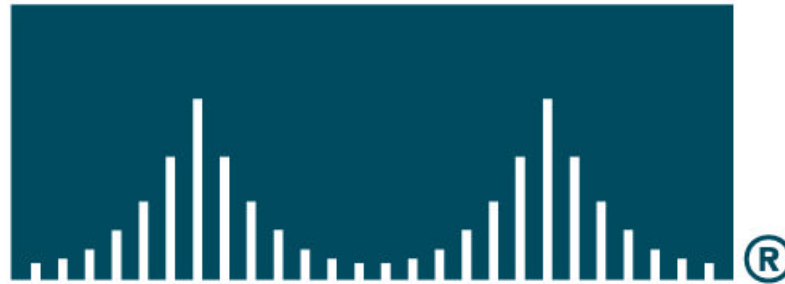
**Depends on your comfort level
and understanding**

Both scale equally well

**Do not implement them the
same way**

**Neither one will compensate
for poor design**

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