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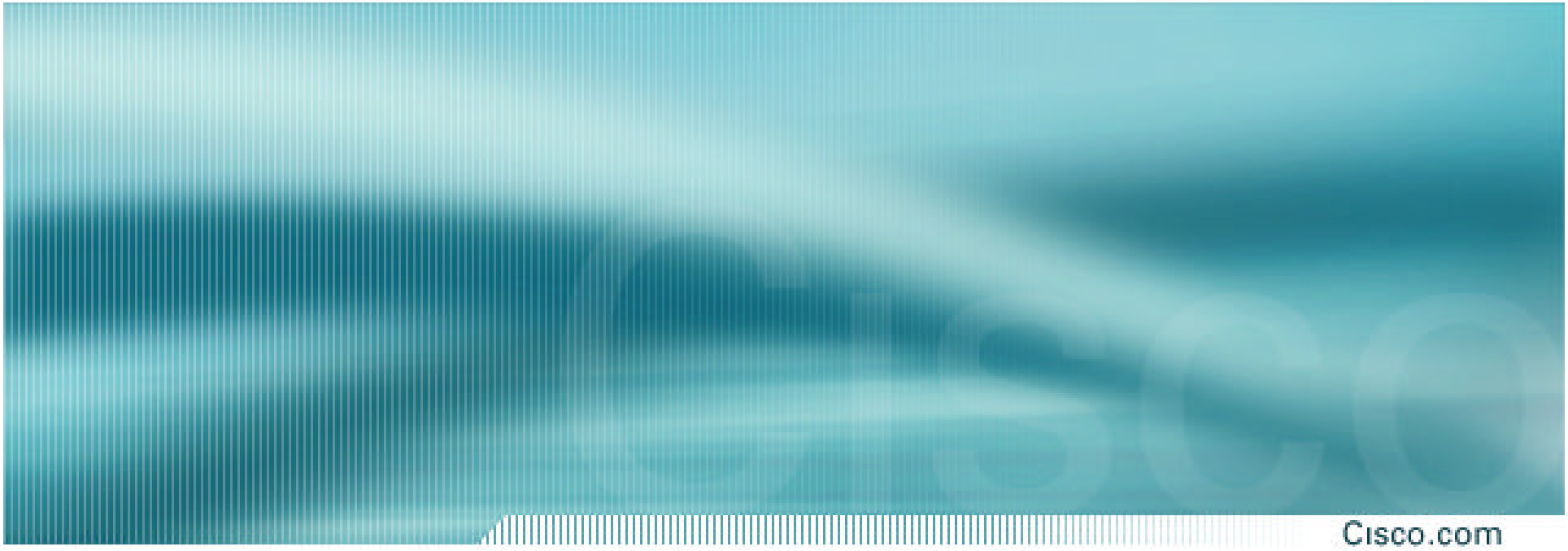

Introduction to Link State Protocols

Session RST-103

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Agenda

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

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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

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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

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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

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Dijkstra Protocols

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

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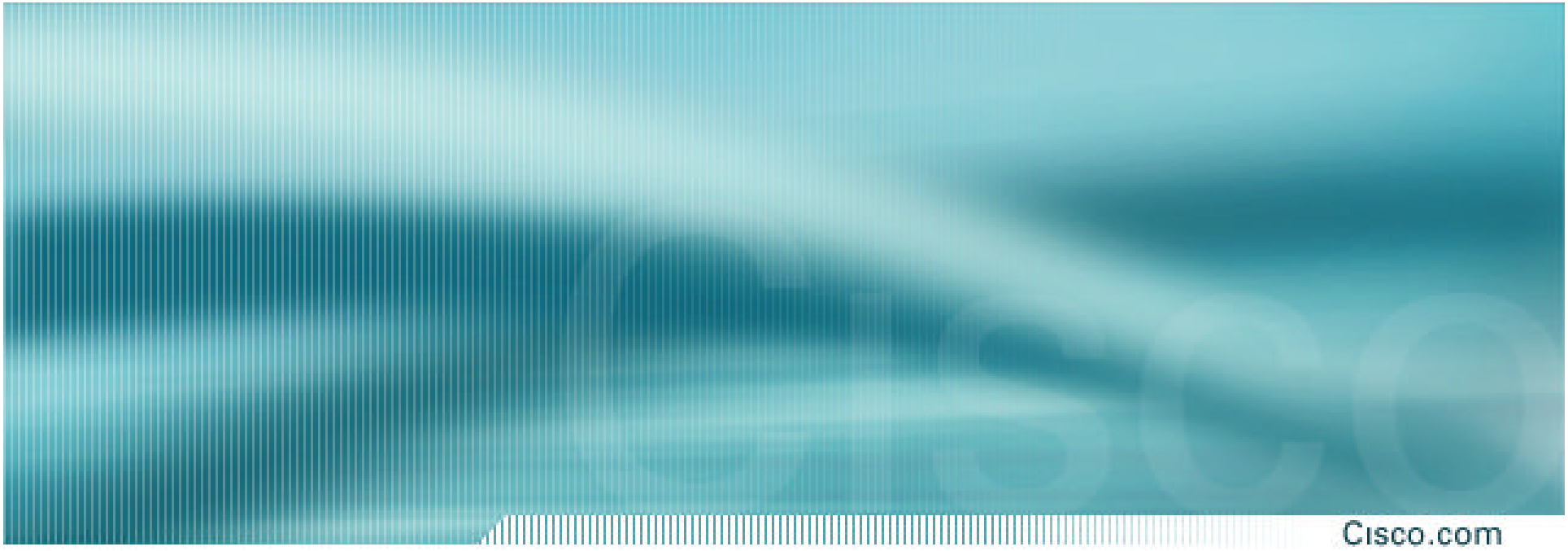

Common Concepts

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Metrics

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

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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

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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

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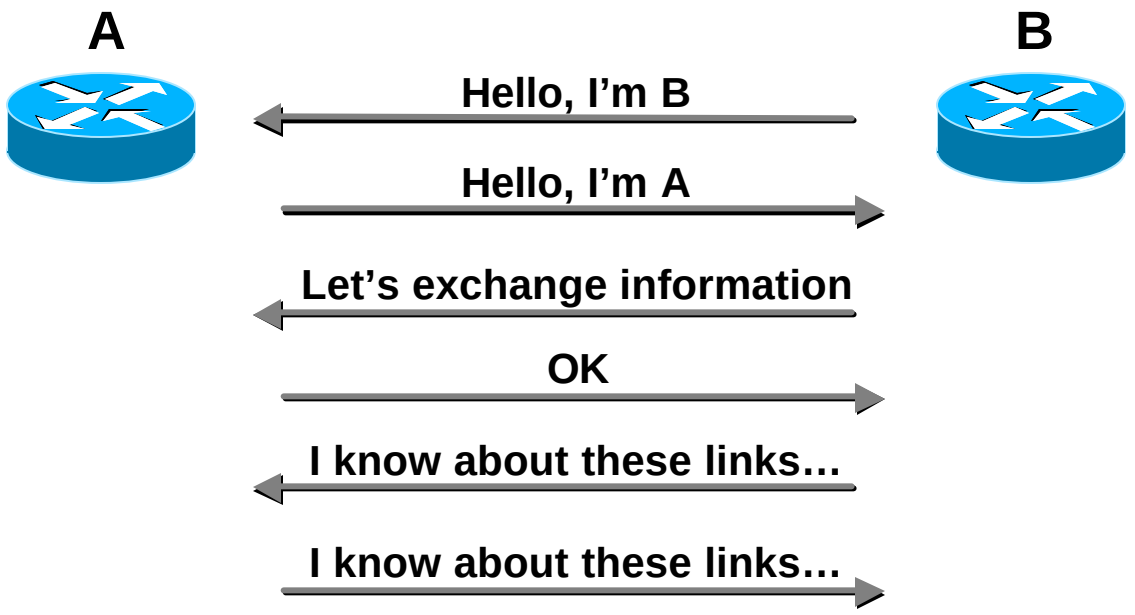
Building the Database

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



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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

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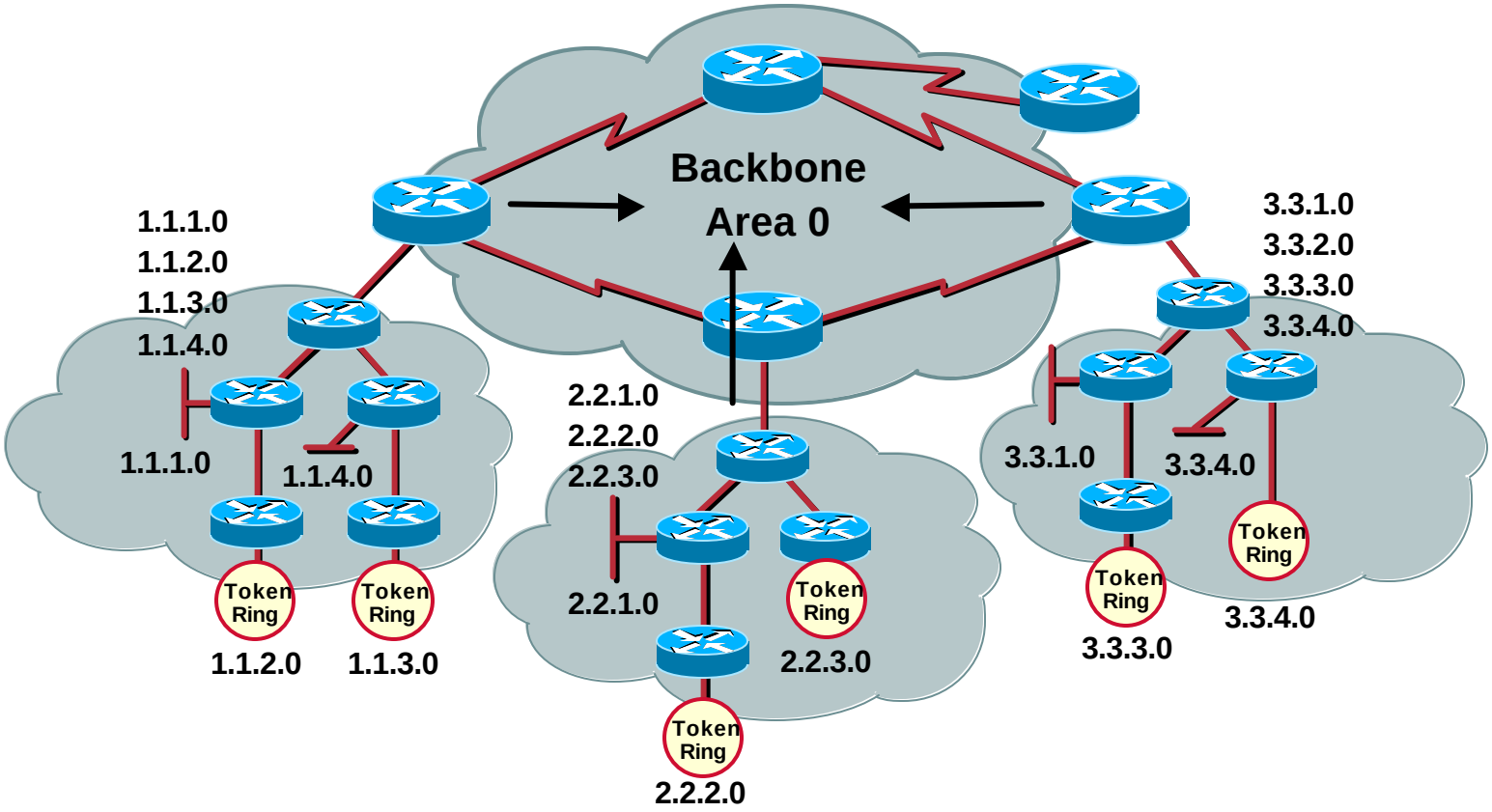
Not Summarized: Specific Links



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

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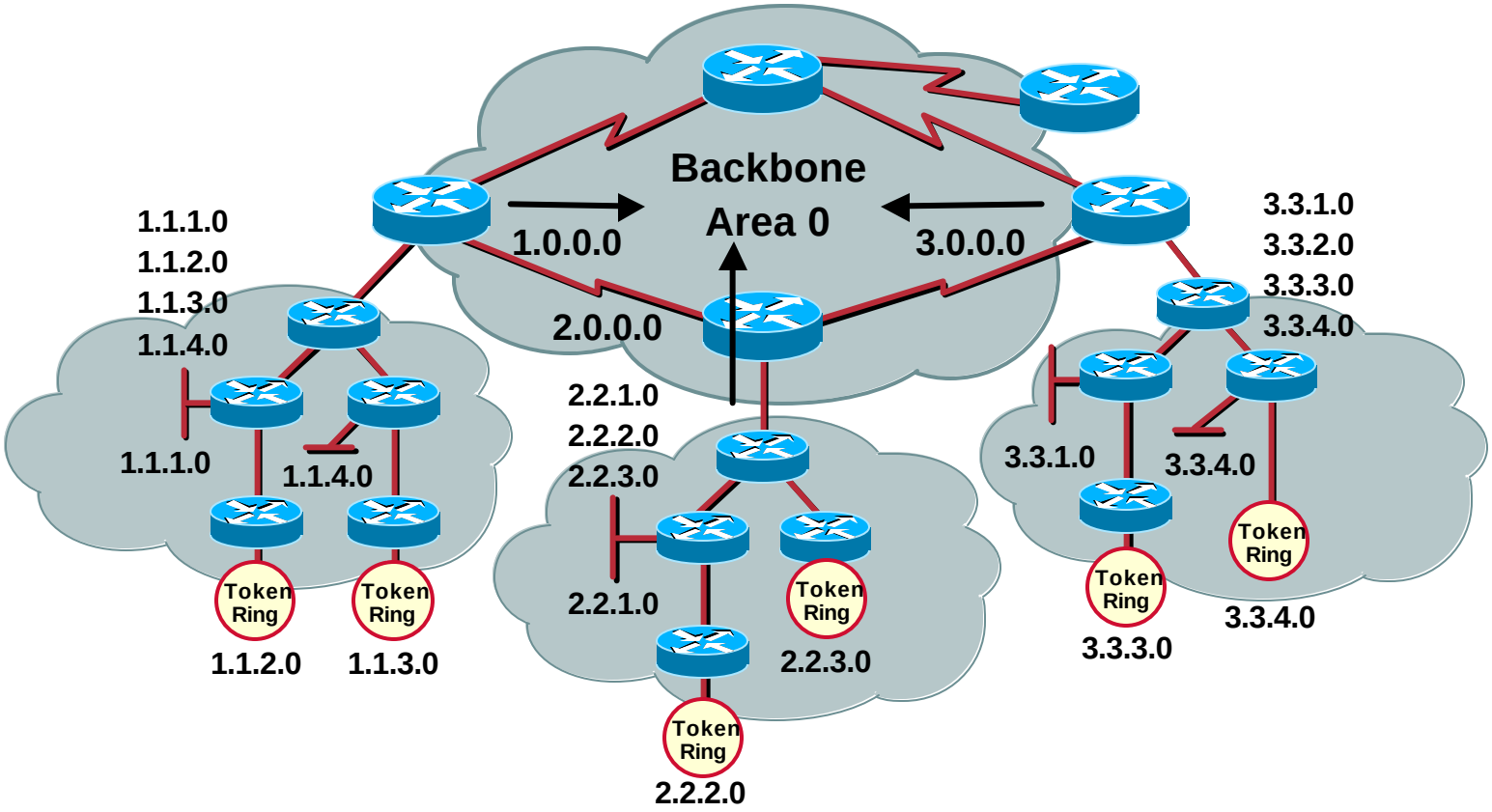
Summarized: Summary Links



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

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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

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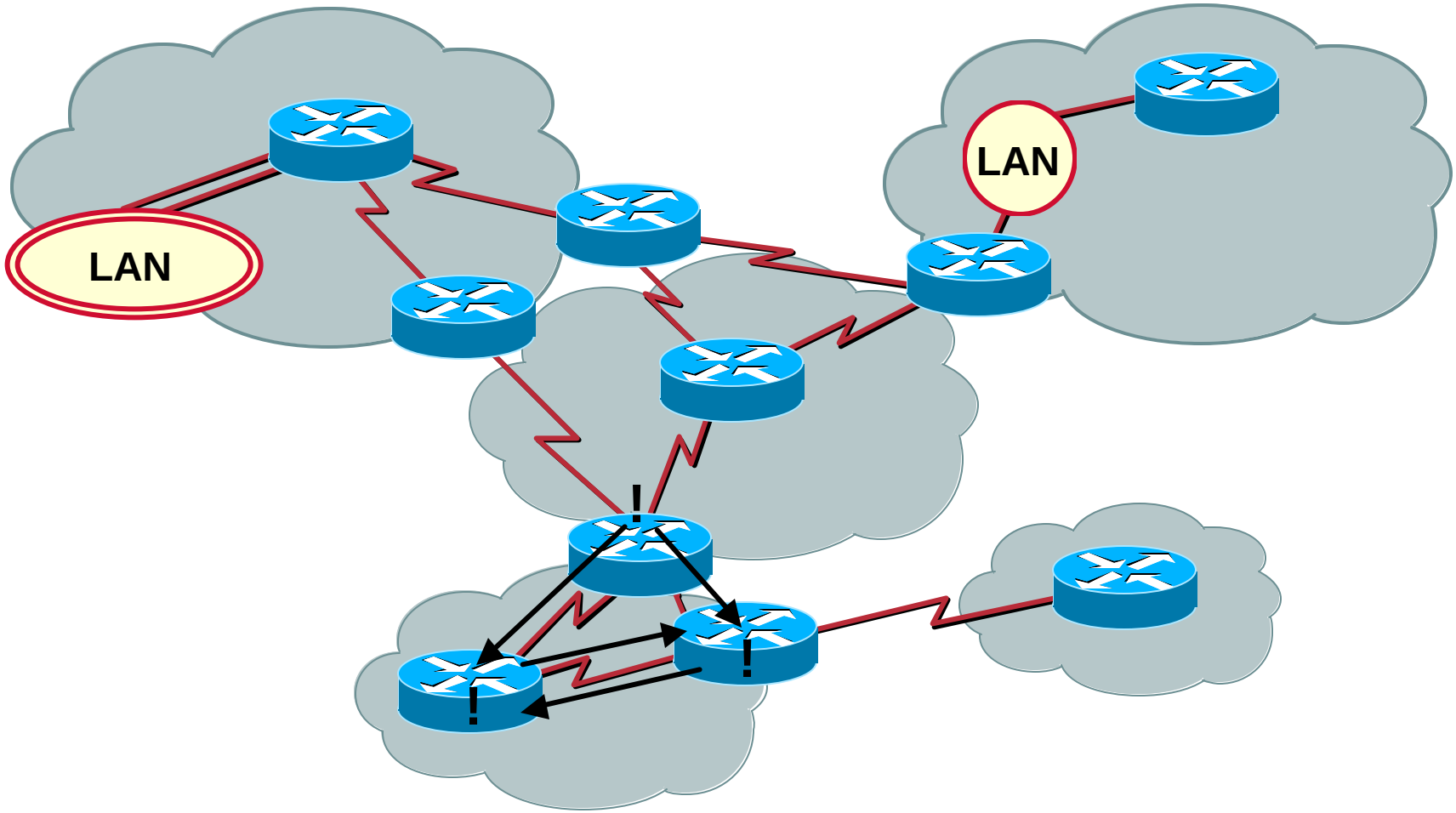
Flooding



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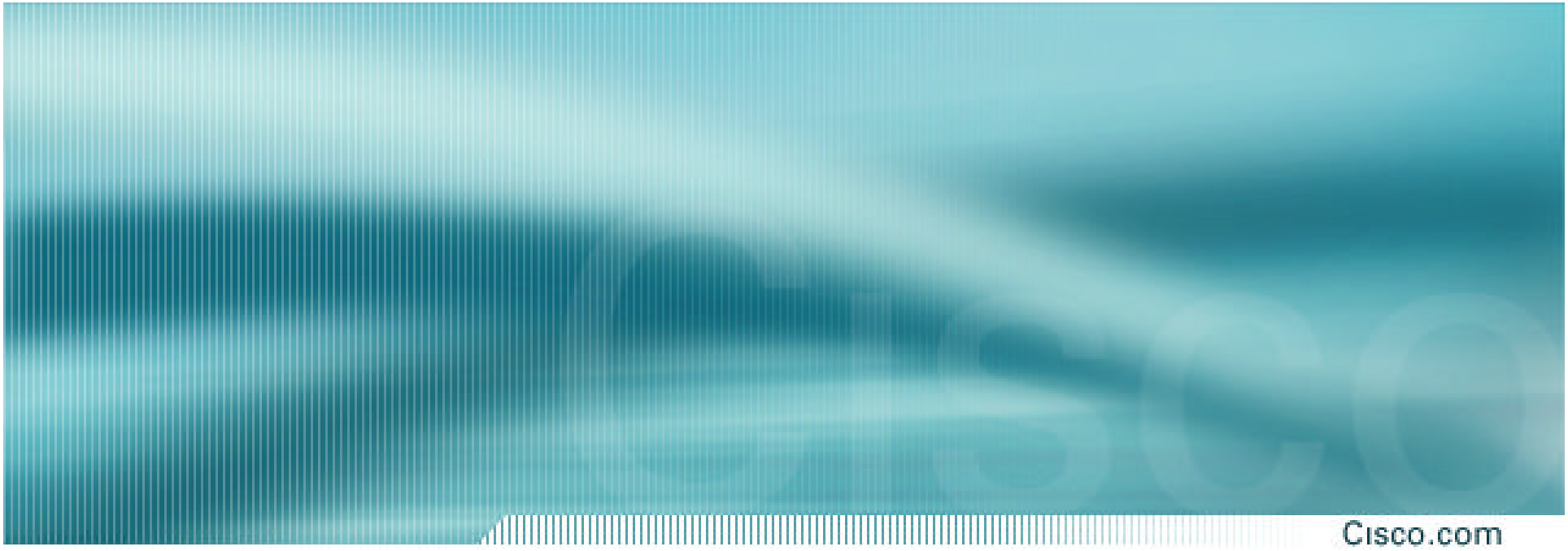

The Djikstra Algorithm

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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

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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)

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Dijkstra (SPF) Overview

- **PATH database**

  Best path triples
  (ID, path cost, direction)

- **Forwarding database**

  Aka the routing table

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Dijkstra (SPF) Overview (Cont.)

- 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

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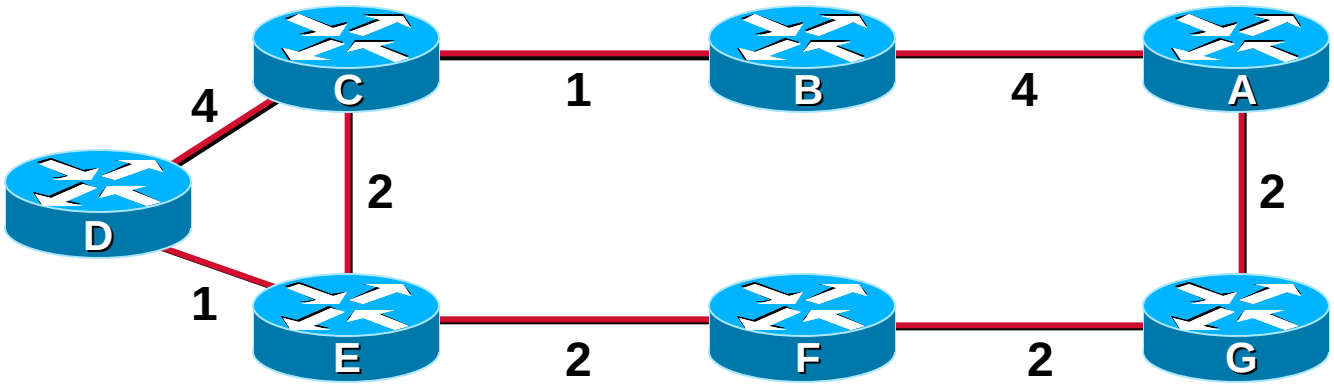
Dijkstra Basics



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

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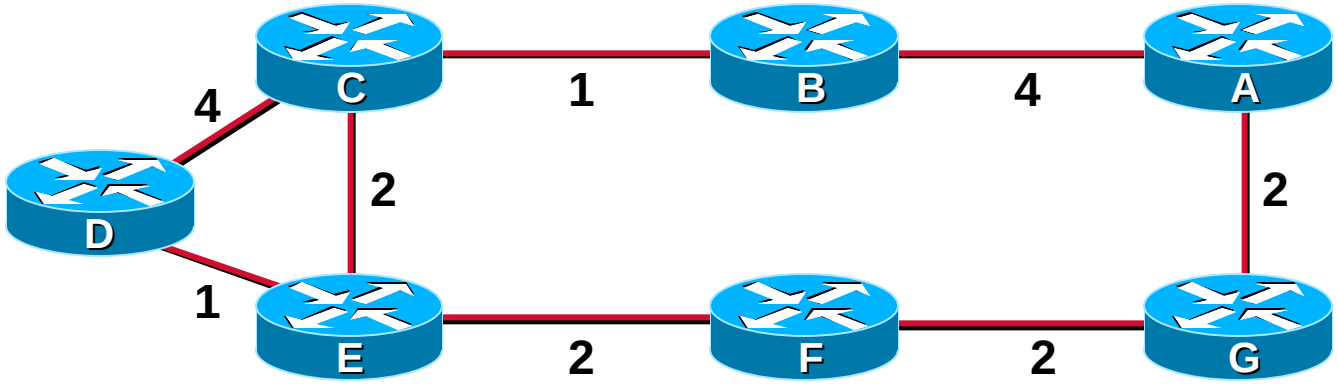
LSP Data

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		



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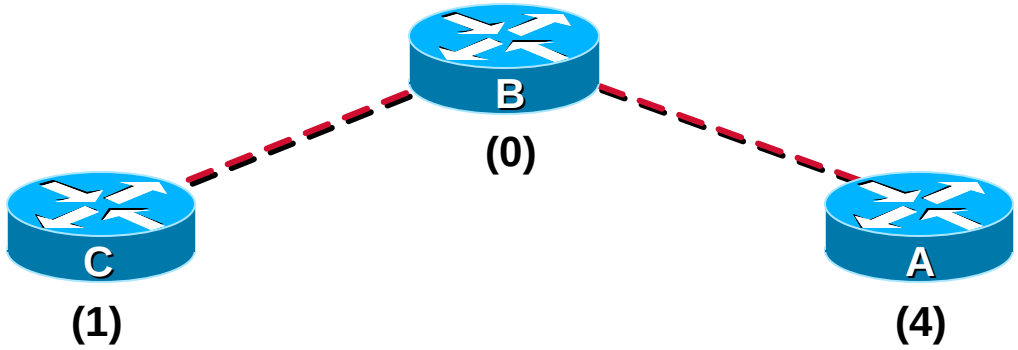
Dijkstra Example—1/7



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

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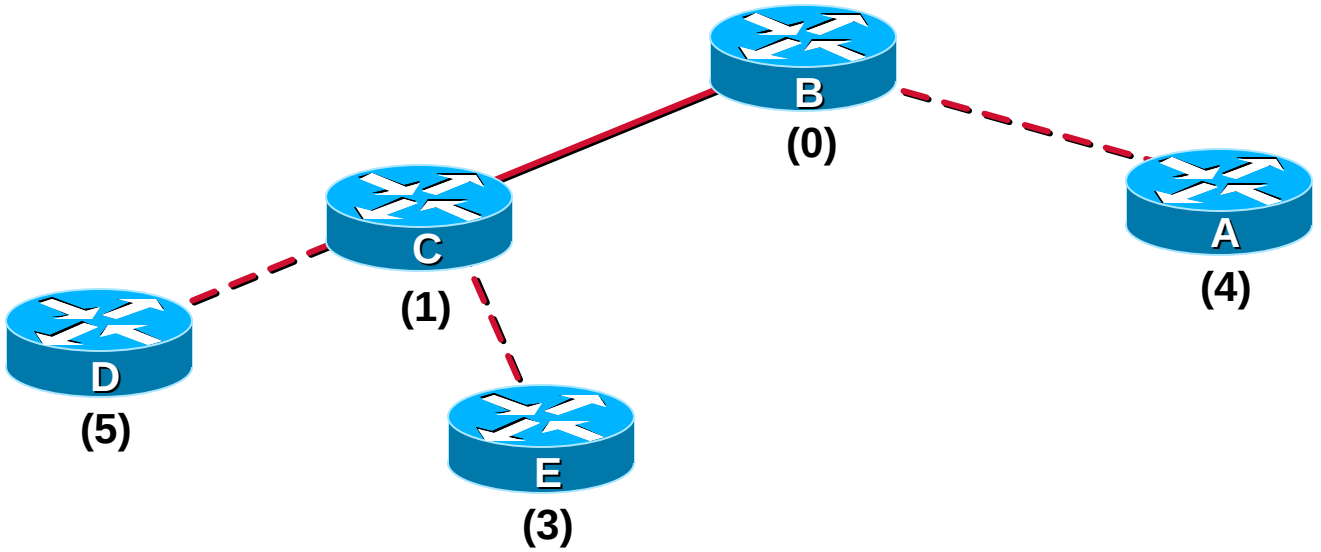
Dijkstra Example—2/7



- 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		

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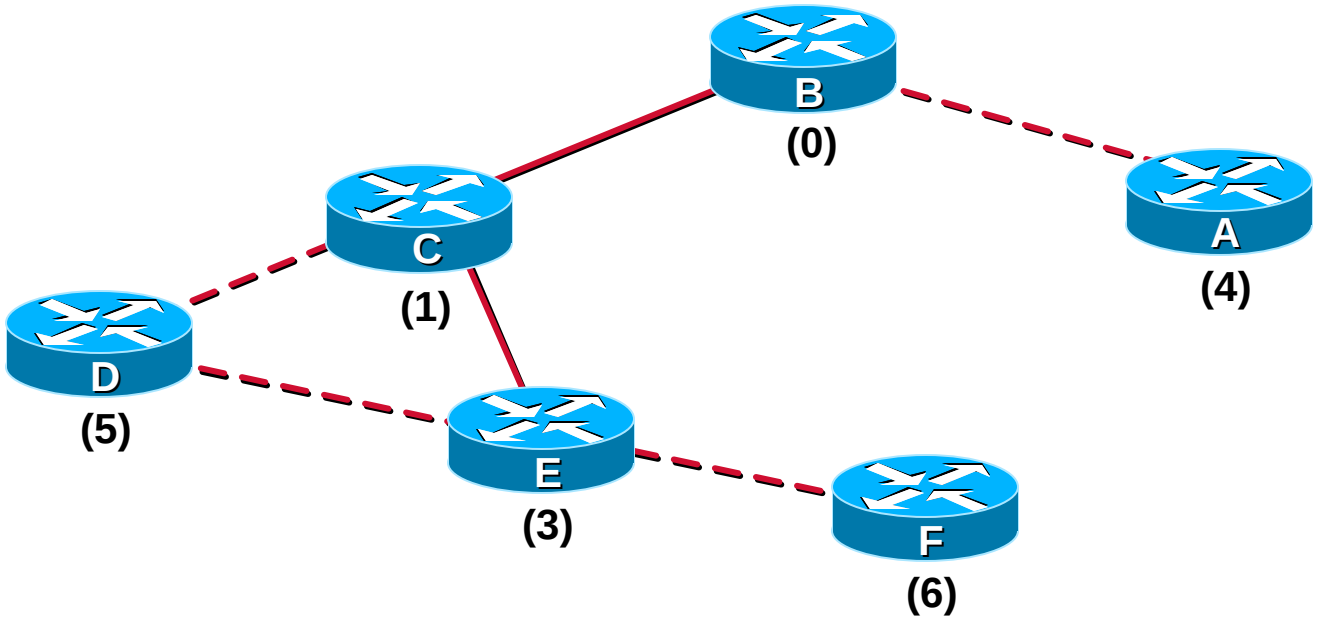
Dijkstra Example—3/7



- 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		

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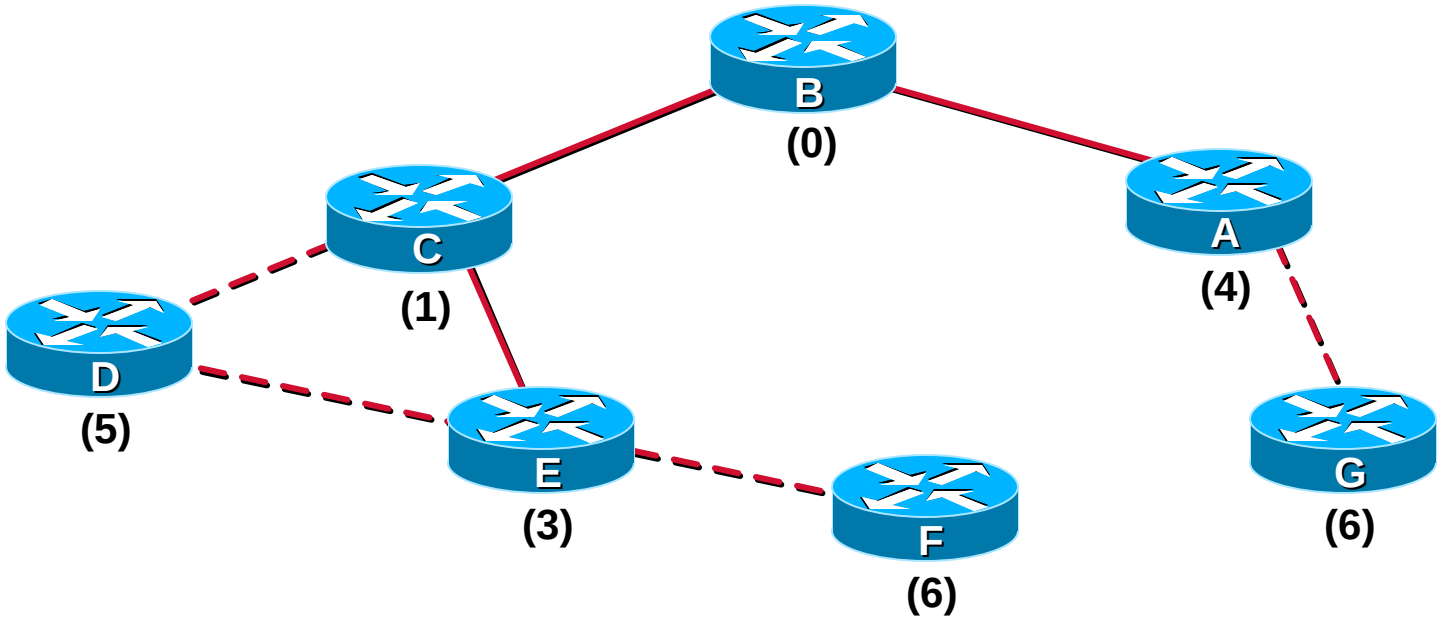
Dijkstra Example—4/7



- 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		

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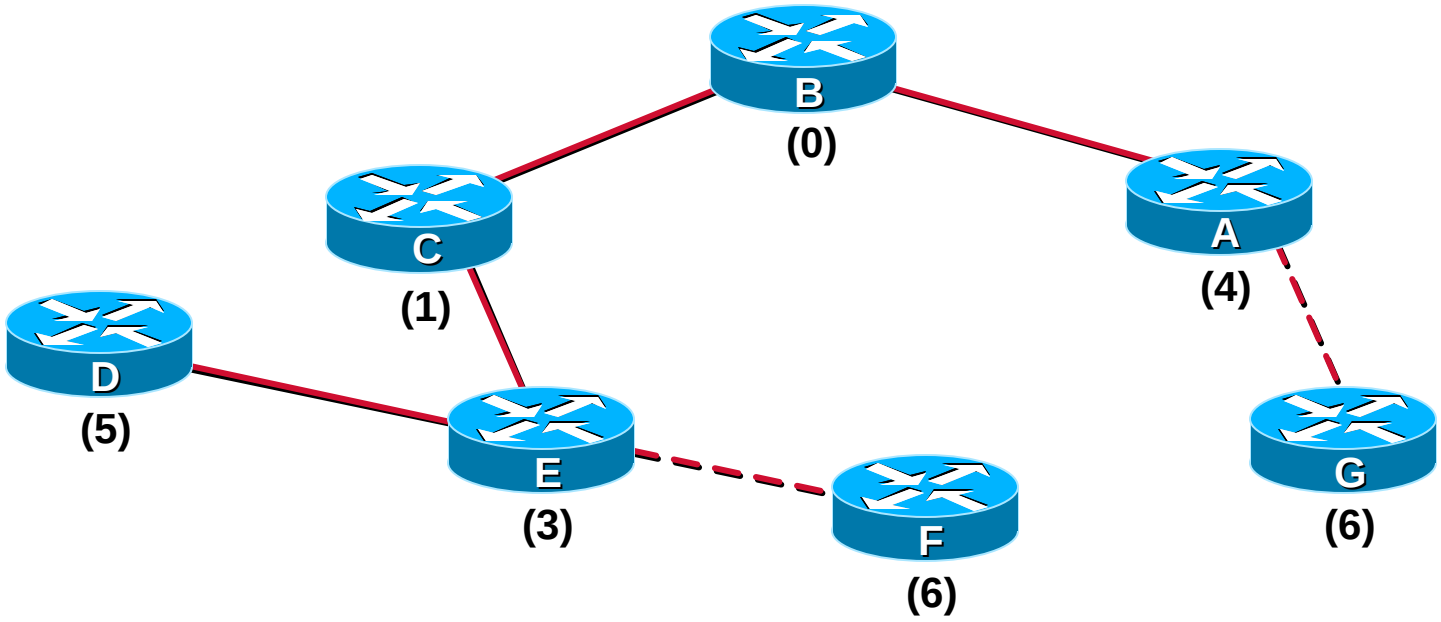
Dijkstra Example—5/7



- 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		

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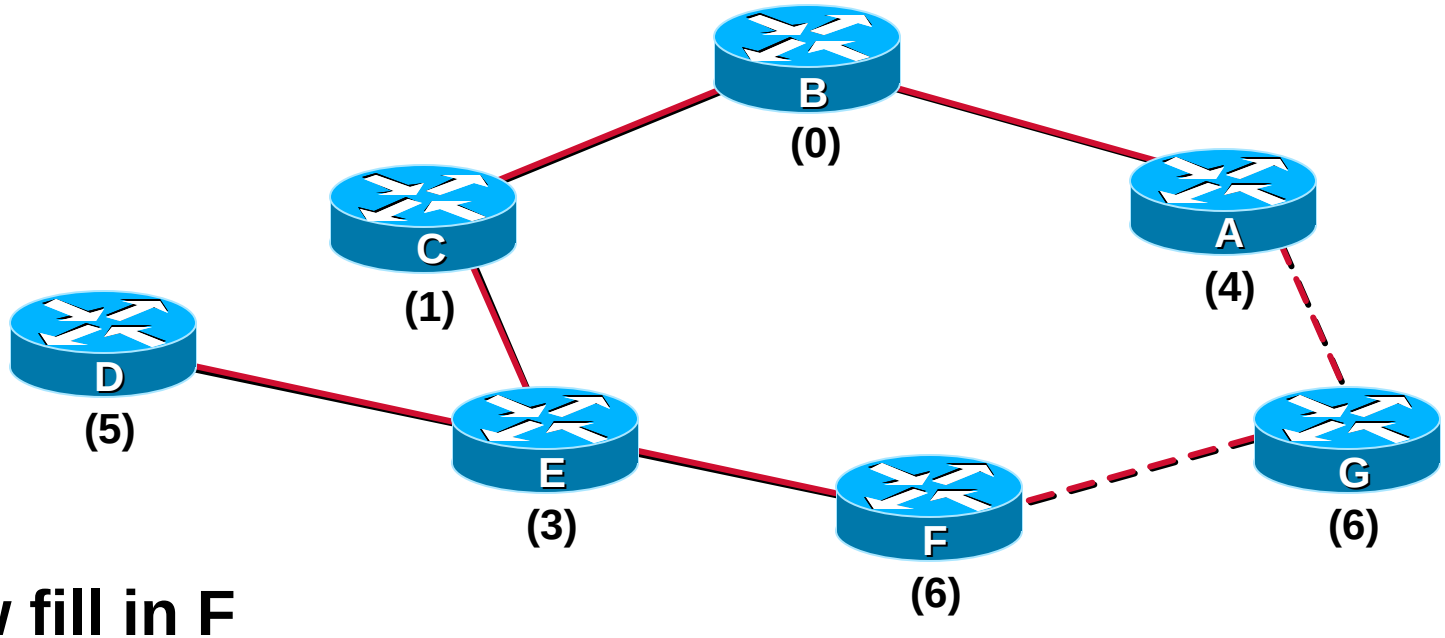
Dijkstra Example—6/7



- 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		

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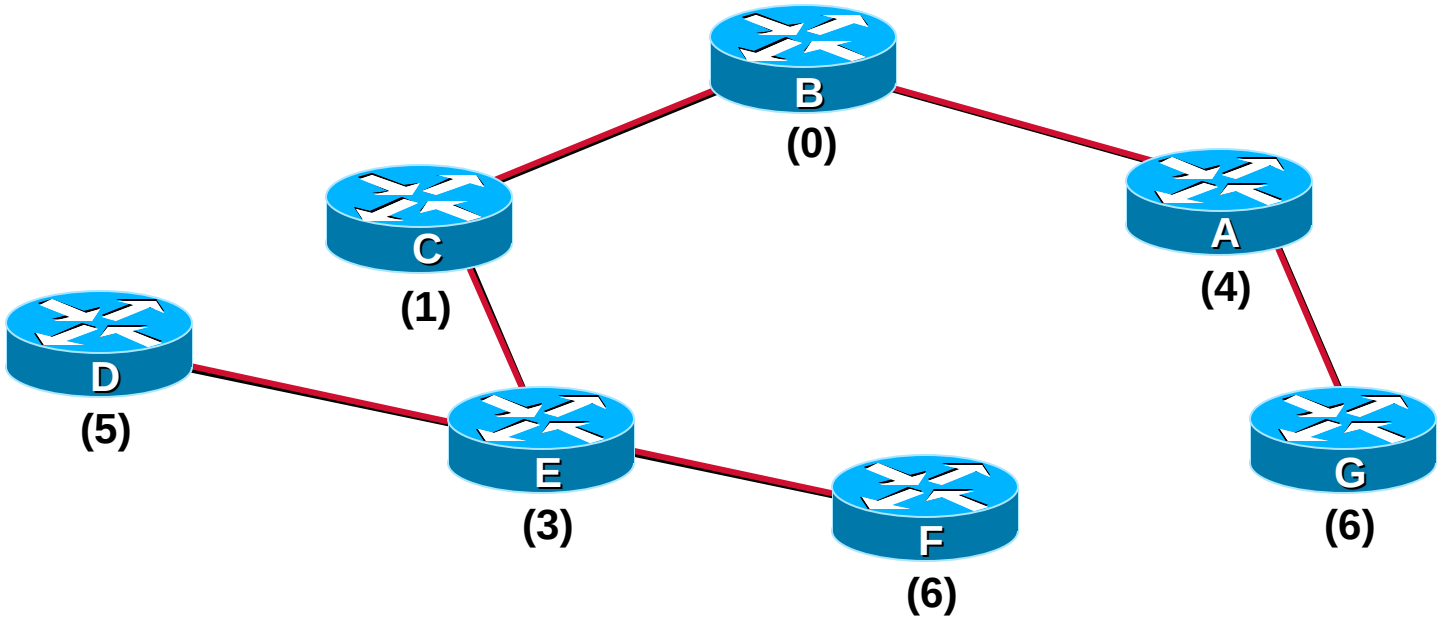
Dijkstra Example—7/7



- 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		

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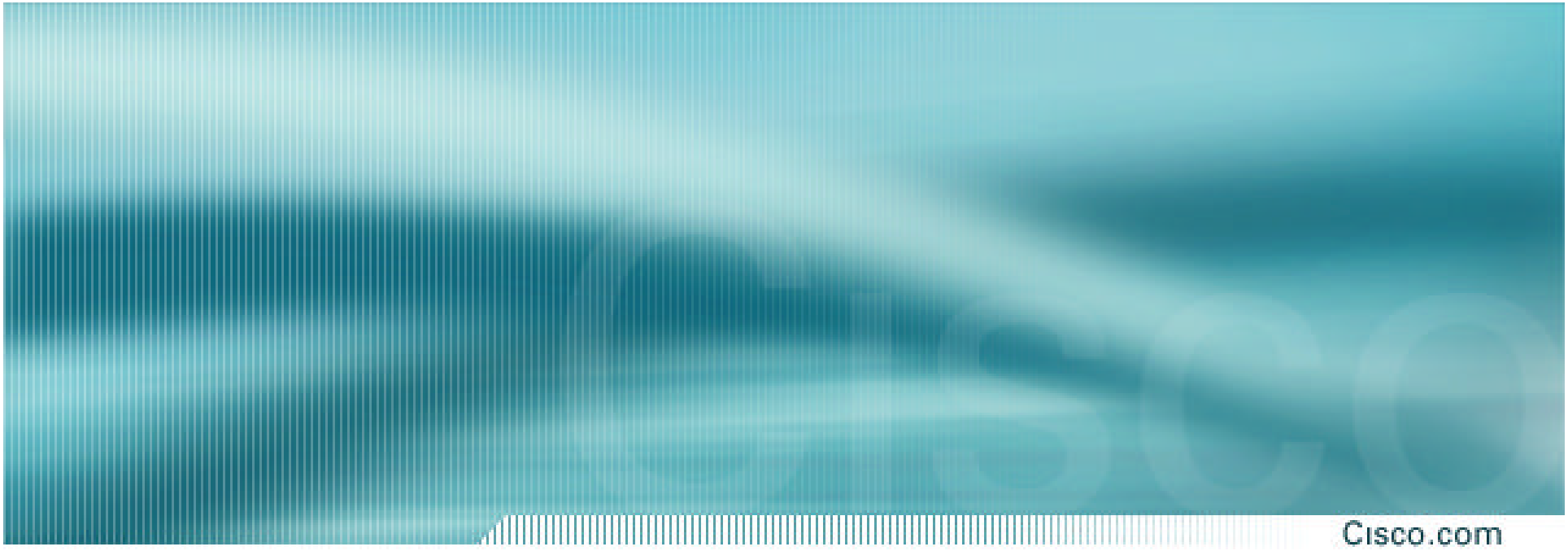

IP Link State Protocols

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Terminology in IP LSPs

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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)

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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

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Media Handling

OSPF

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

OSPF

- Point-to-point
- Broadcast

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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)

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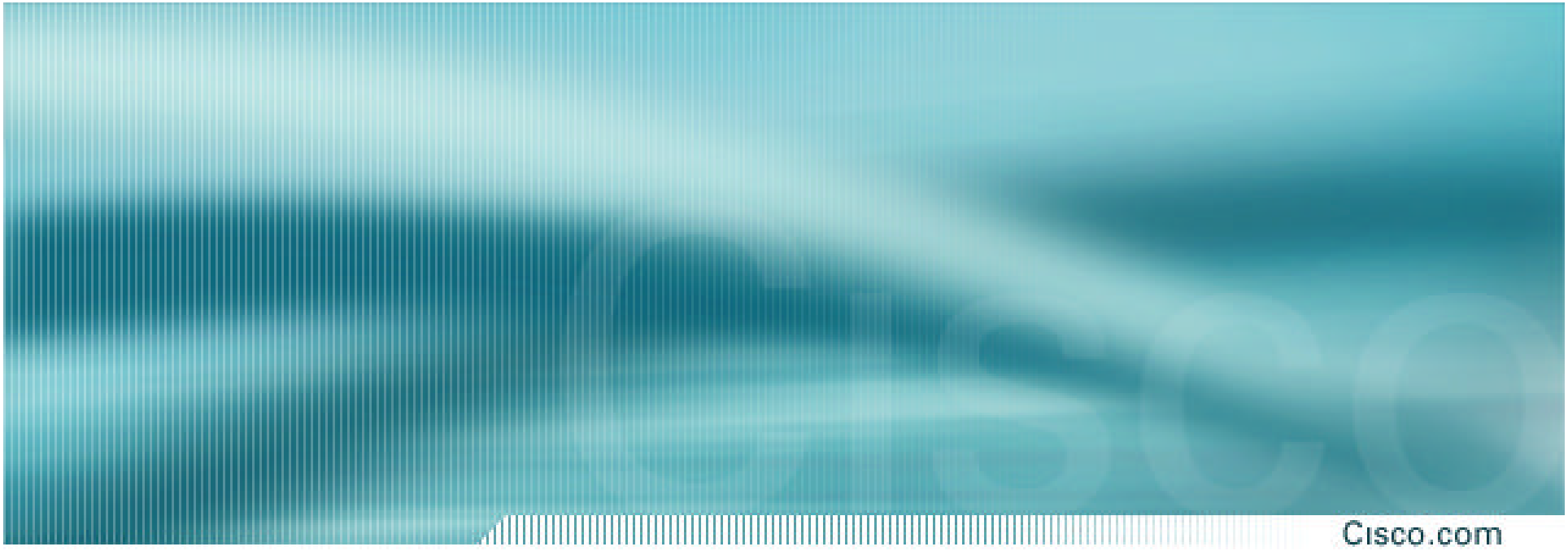

Choosing an IP Link State Protocol

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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**

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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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