

شبکه های کامپیوتری ۲

درس ۶ فصل ۵

**Inter AS Routing Protocols:
BGP**

دانشگاه صنعتی اصفهان
دانشکده مهندسی برق و کامپیوتر

Chapter 5

Network Layer:

The Control Plane

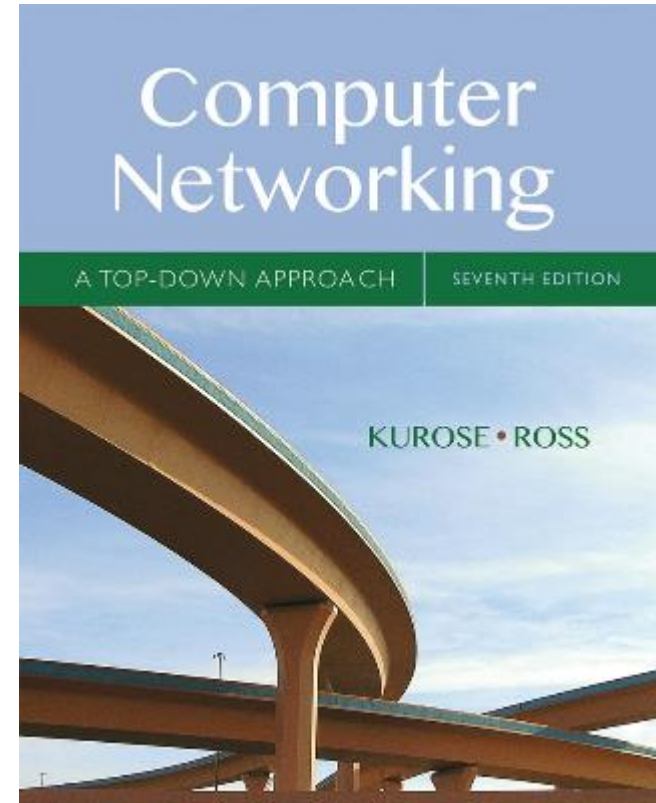
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Computer Networking: A Top Down Approach

7th edition

Jim Kurose, Keith Ross

Pearson/Addison Wesley

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Chapter 5: outline

5.1 introduction

5.2 routing protocols

- link state
- distance vector

5.3 intra-AS routing in the Internet:
OSPF

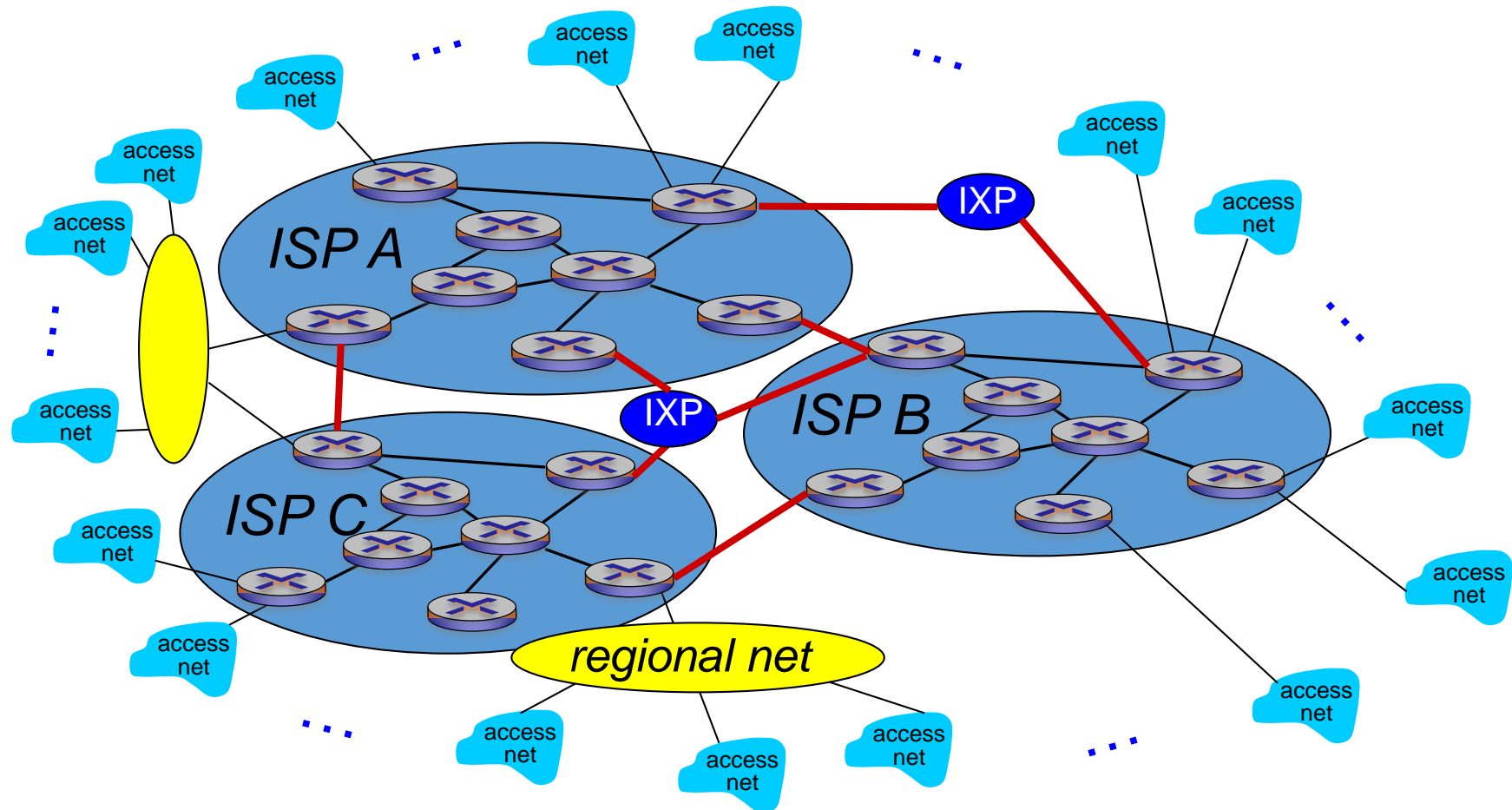
5.4 routing among the ISPs: BGP

5.5 The SDN control plane

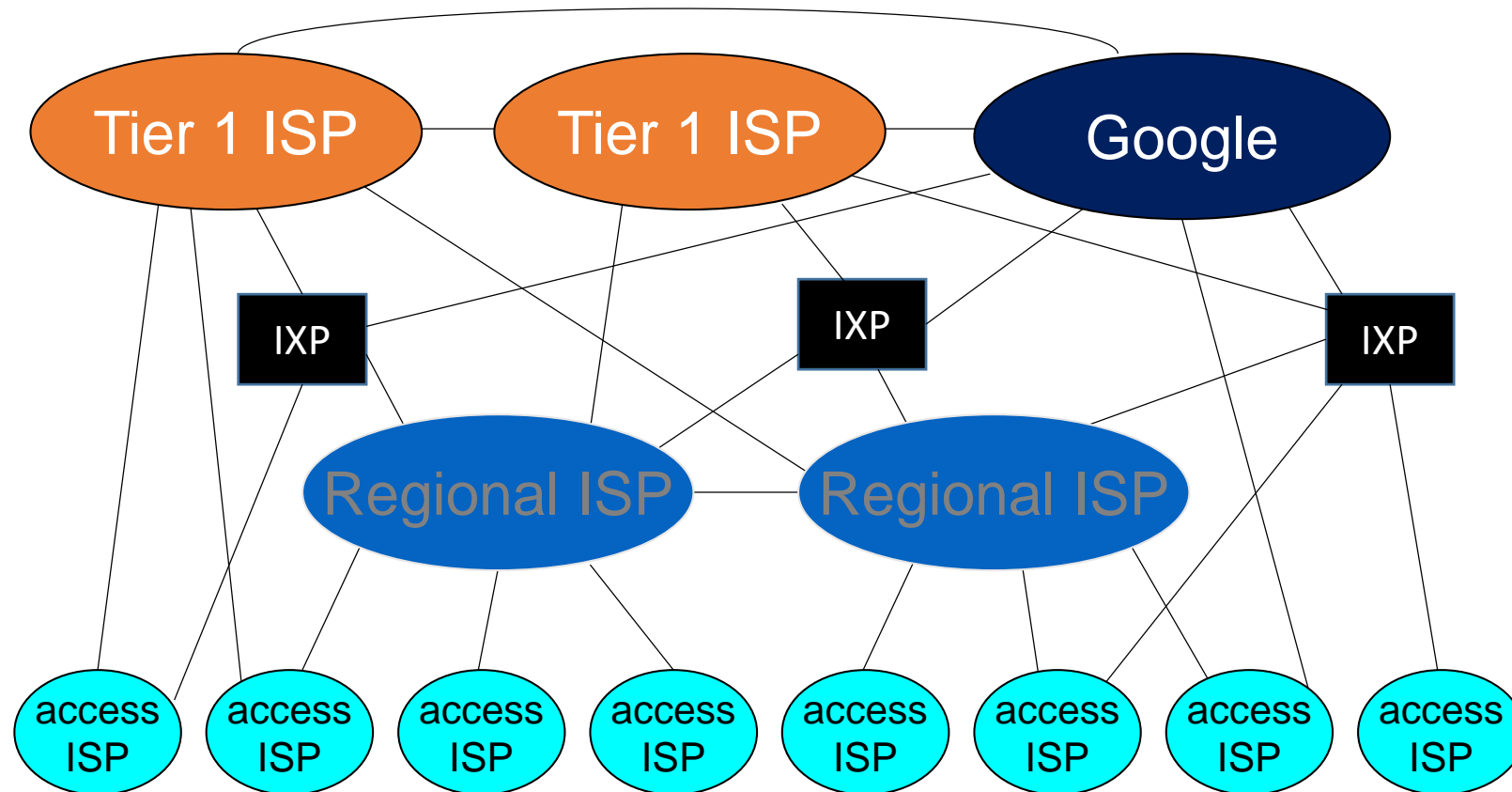
5.6 ICMP: The Internet Control Message
Protocol

5.7 Network management and SNMP

Internet structure: network of networks

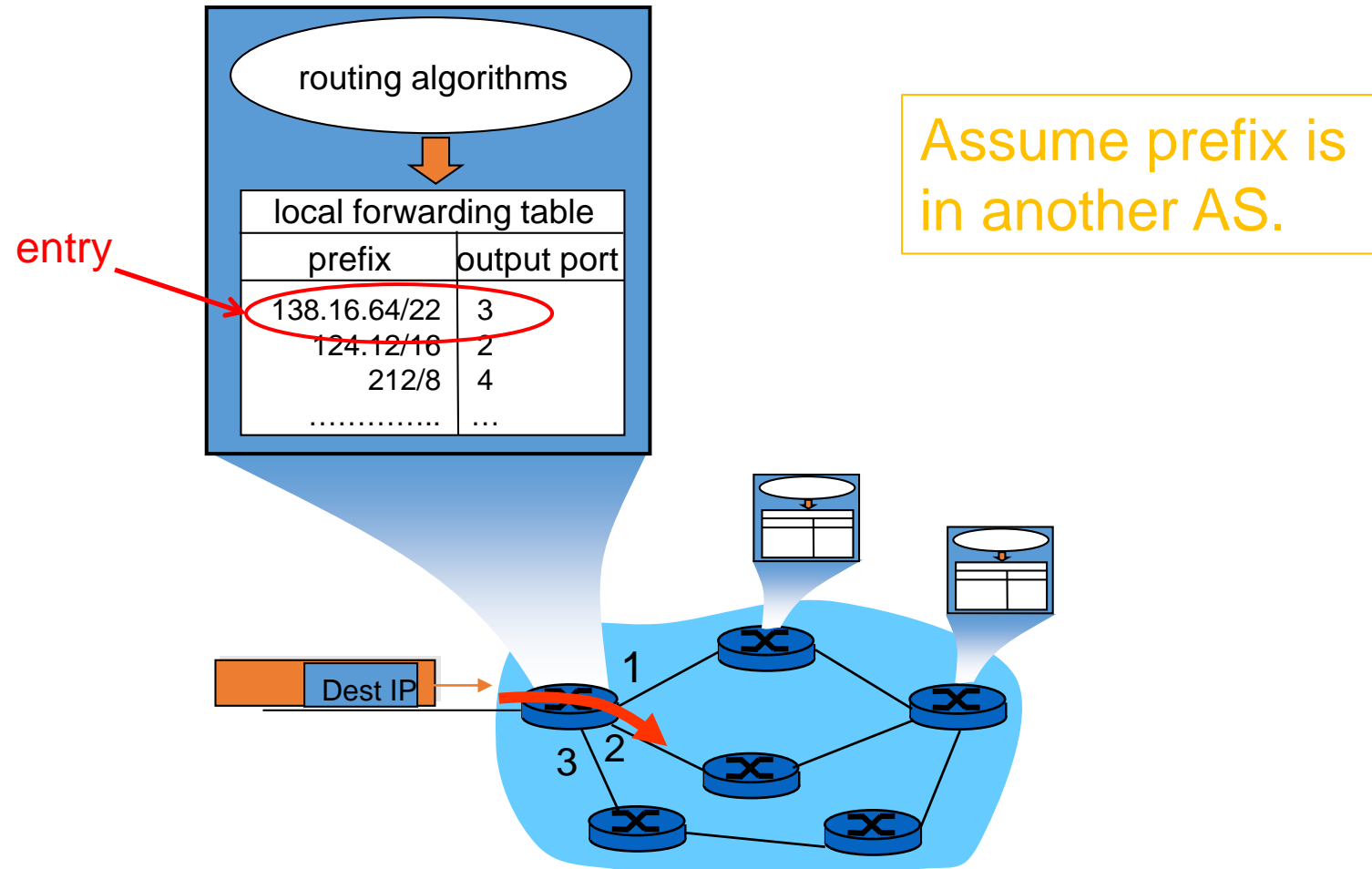


Internet structure: network of networks



- at center: small # of well-connected large networks
 - “tier-1” commercial ISPs (e.g., Level 3, Sprint, AT&T, NTT), national & international coverage
 - ... and regional networks may arise to connect access nets to ISPs

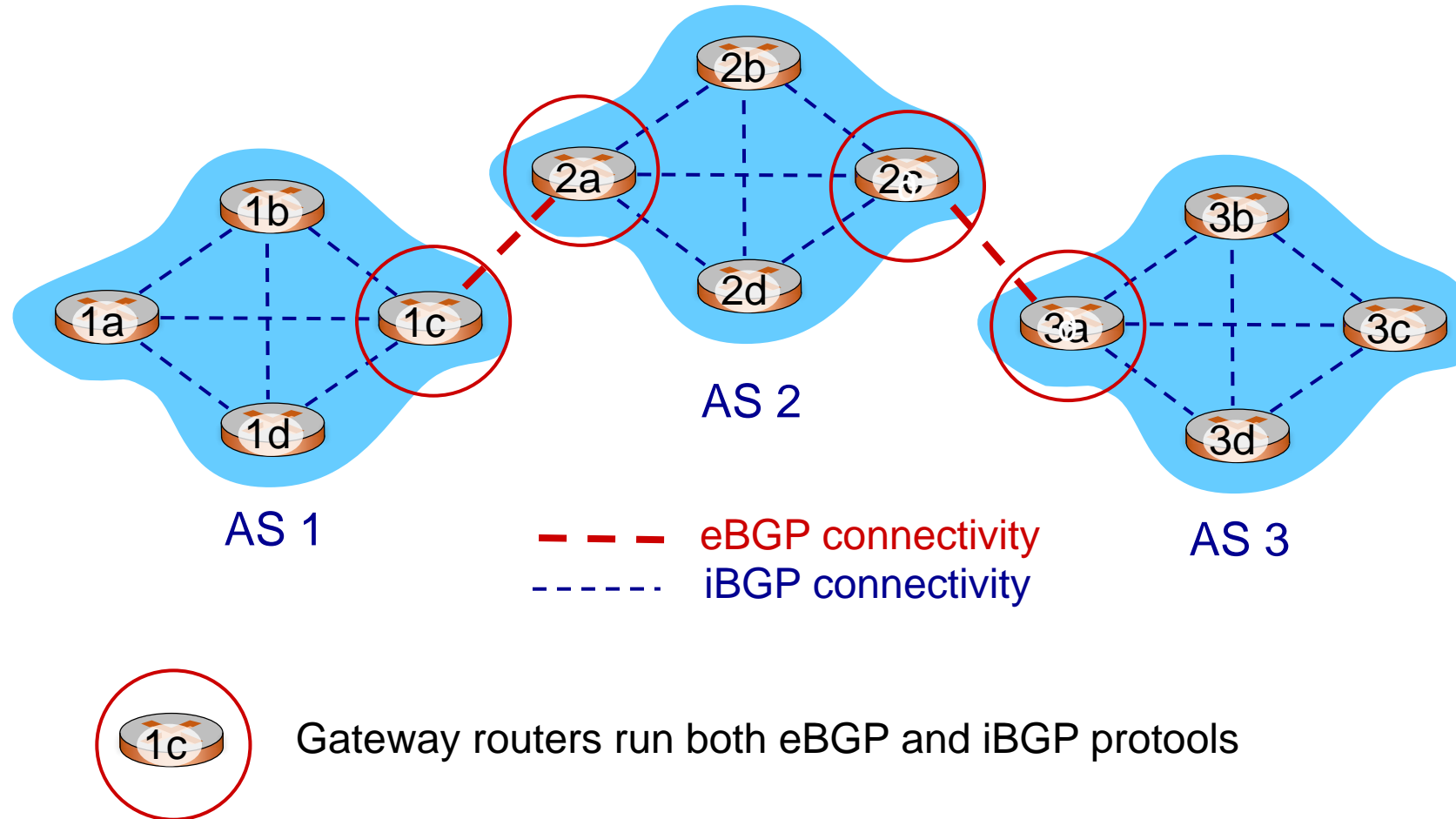
How does entry get in forwarding table?



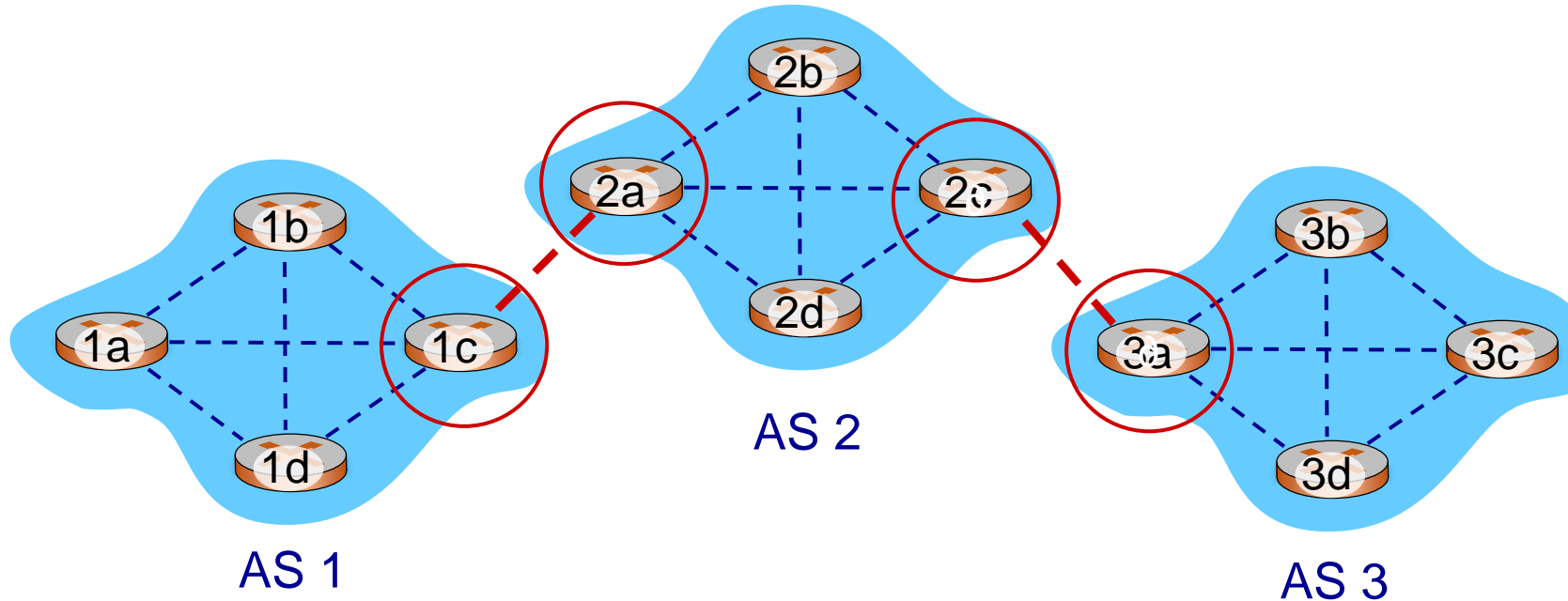
Internet inter-AS routing: BGP

- **BGP (Border Gateway Protocol):** *the* de facto inter-domain routing protocol
 - “glue that holds the Internet together”
- BGP provides each AS a means to:
 - **eBGP:** obtain subnet reachability information from neighboring ASes
 - **iBGP:** propagate reachability information to all AS-internal routers.
 - determine “good” routes to other networks based on reachability information and *policy*
- Allows subnet to advertise its existence to rest of Internet: “*I am here*”

eBGP, iBGP connections

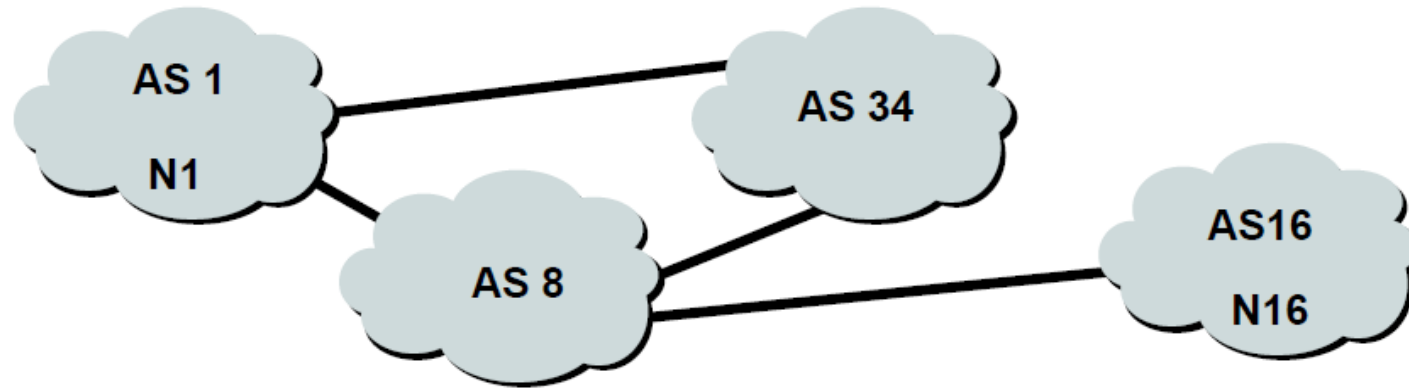


Route establishment in BGP



- For networks in AS1 and AS2 to communicate:
 - AS1 must announce a route to AS2
 - AS2 must accept the route from AS1
 - AS2 must announce a route to AS1
 - AS1 must accept the route from AS2

Route establishment in BGP



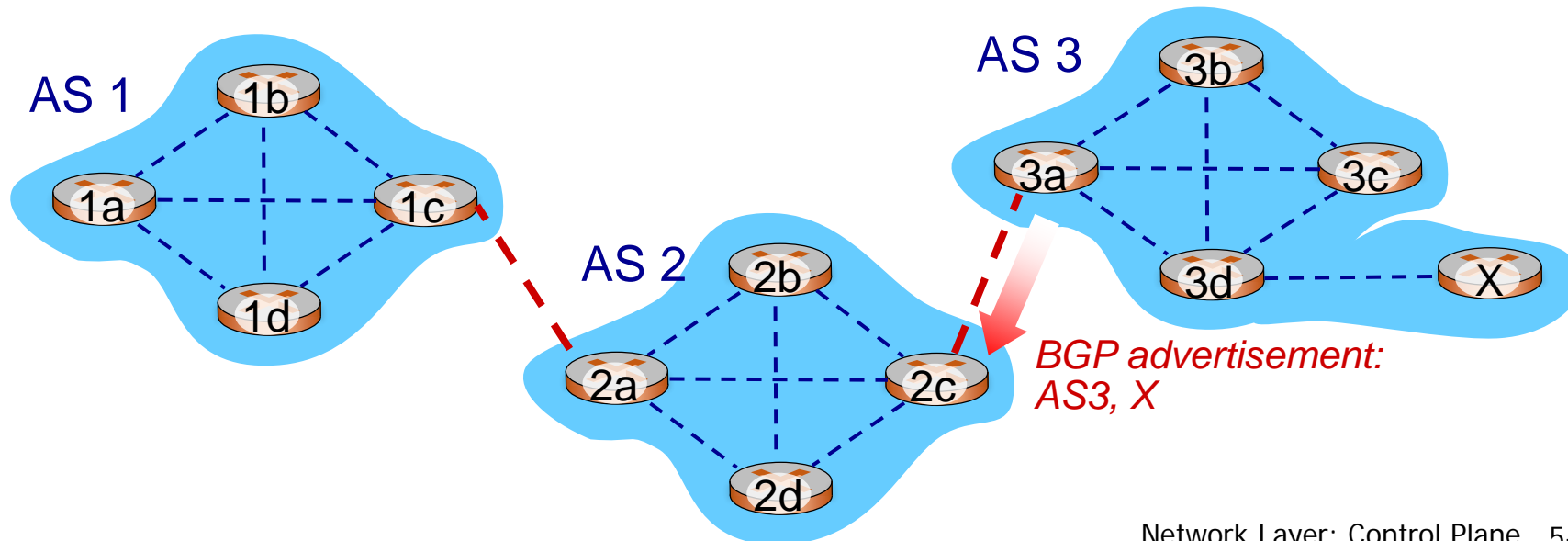
For net N1 in AS1 to send traffic to net N16 in AS16:

- AS16 must originate and announce N16 to AS8.
- AS8 must accept N16 from AS16.
- AS8 must announce N16 to AS1 or AS34.
- AS1 must accept N16 from AS8 or AS34.

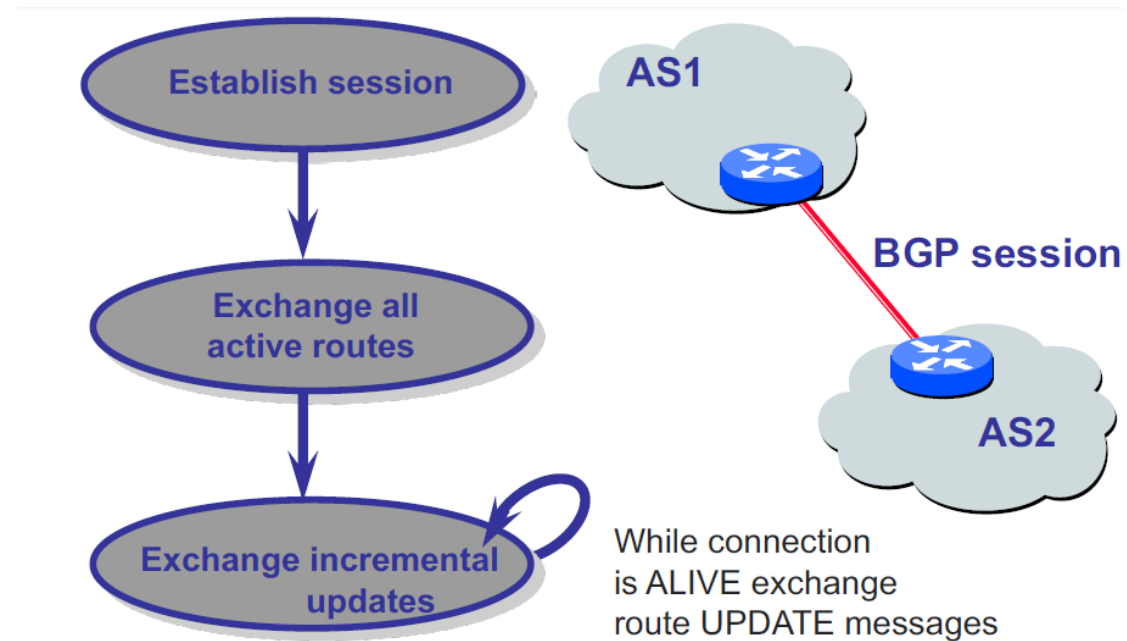
For two-way packet flow, similar policies must exist for N1.

BGP basics

- **BGP session:** two BGP routers (“peers”) exchange BGP messages over semi-permanent TCP connection:
 - advertising *paths* to different destination network prefixes (BGP is a “path vector” protocol)
- When AS3 gateway router 3a advertises path **AS3,X** to AS2 gateway router 2c:
 - AS3 *promises* to AS2 it will forward datagrams towards X



Route establishment and maintenance



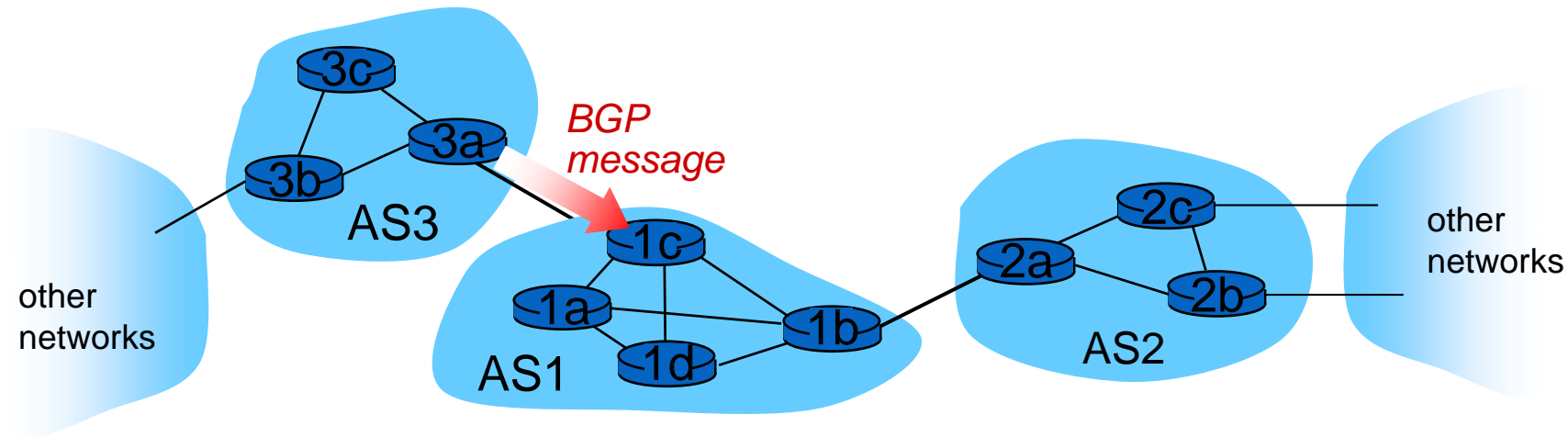
BGP messages

- BGP messages exchanged between peers over TCP connection
- BGP messages:
 - **OPEN**: opens TCP connection to remote BGP peer and authenticates sending BGP peer
 - **UPDATE**: advertises new path (or withdraws old)
 - **KEEPALIVE**: keeps connection alive in absence of UPDATES; also ACKs OPEN request
 - **NOTIFICATION**: reports errors in previous msg; also used to close connection

Path attributes and BGP routes

- Advertised prefix includes BGP attributes
 - prefix + attributes = “route”
- Two important attributes:
 - **AS-PATH**: list of ASes through which prefix advertisement has passed
 - **NEXT-HOP**: indicates specific internal-AS router to next-hop AS

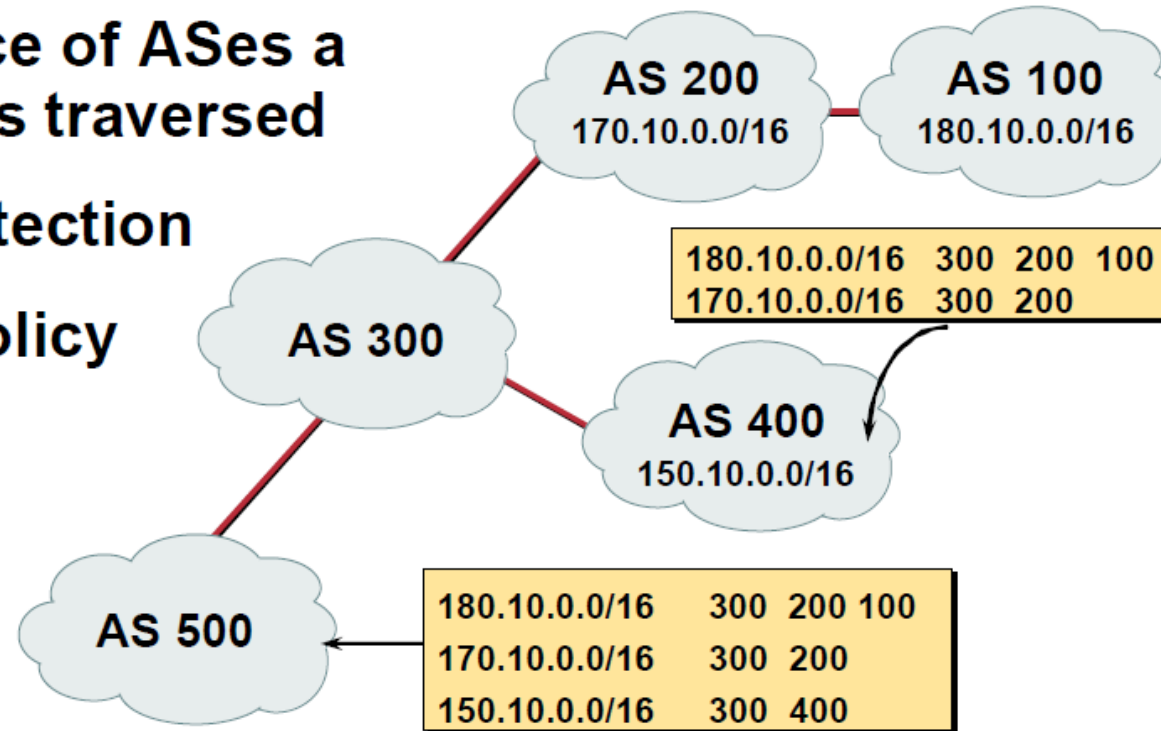
BGP route advertisement



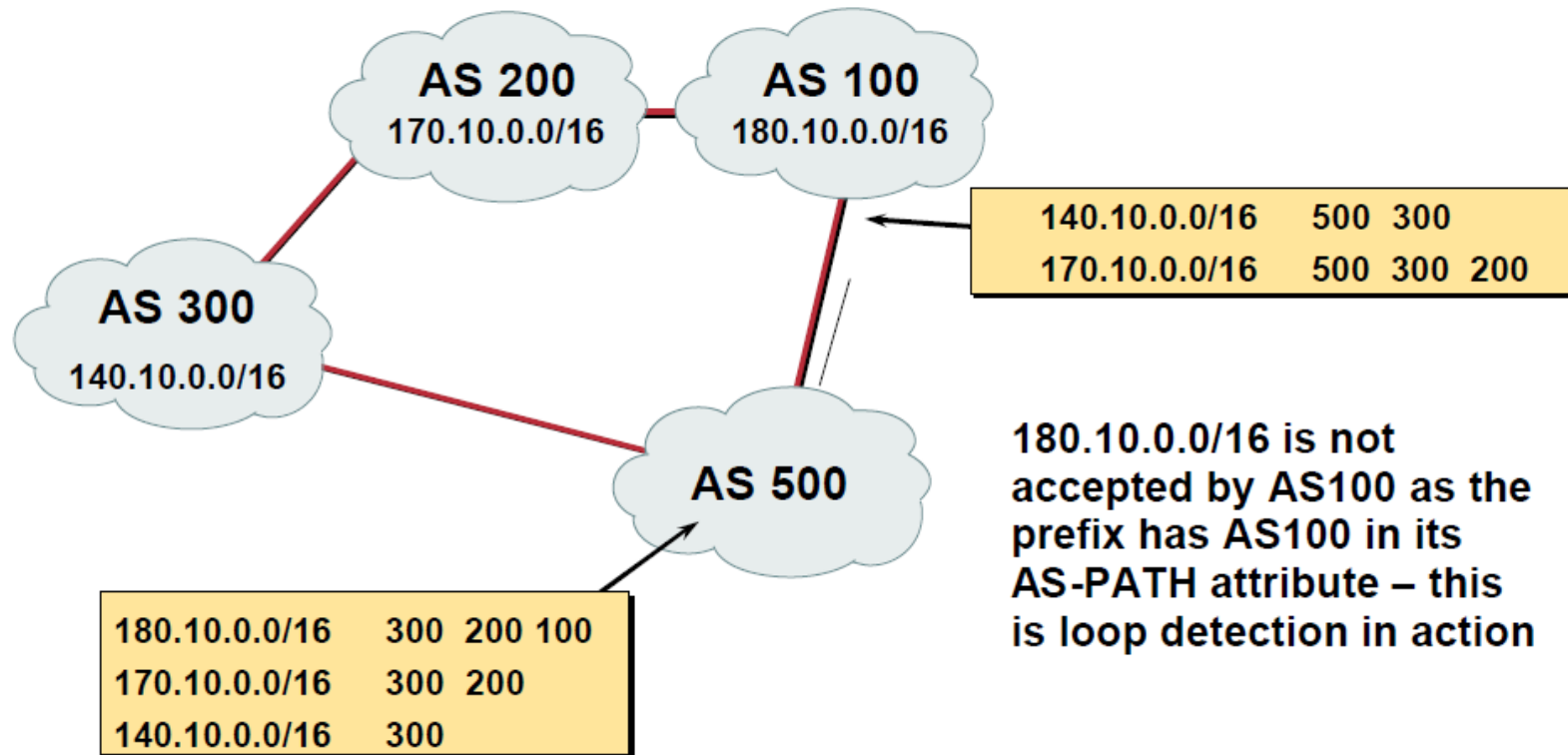
- ❖ BGP message contains “routes”
- ❖ “route” is a prefix and attributes: AS-PATH, NEXT-HOP,...
- ❖ Example: route:
 - ❖ Prefix: 138.16.64/22 ; AS-PATH: AS3 AS131 ; NEXT-HOP: 201.44.13.125

AS Path

- Sequence of ASes a route has traversed
- Loop detection
- Apply policy



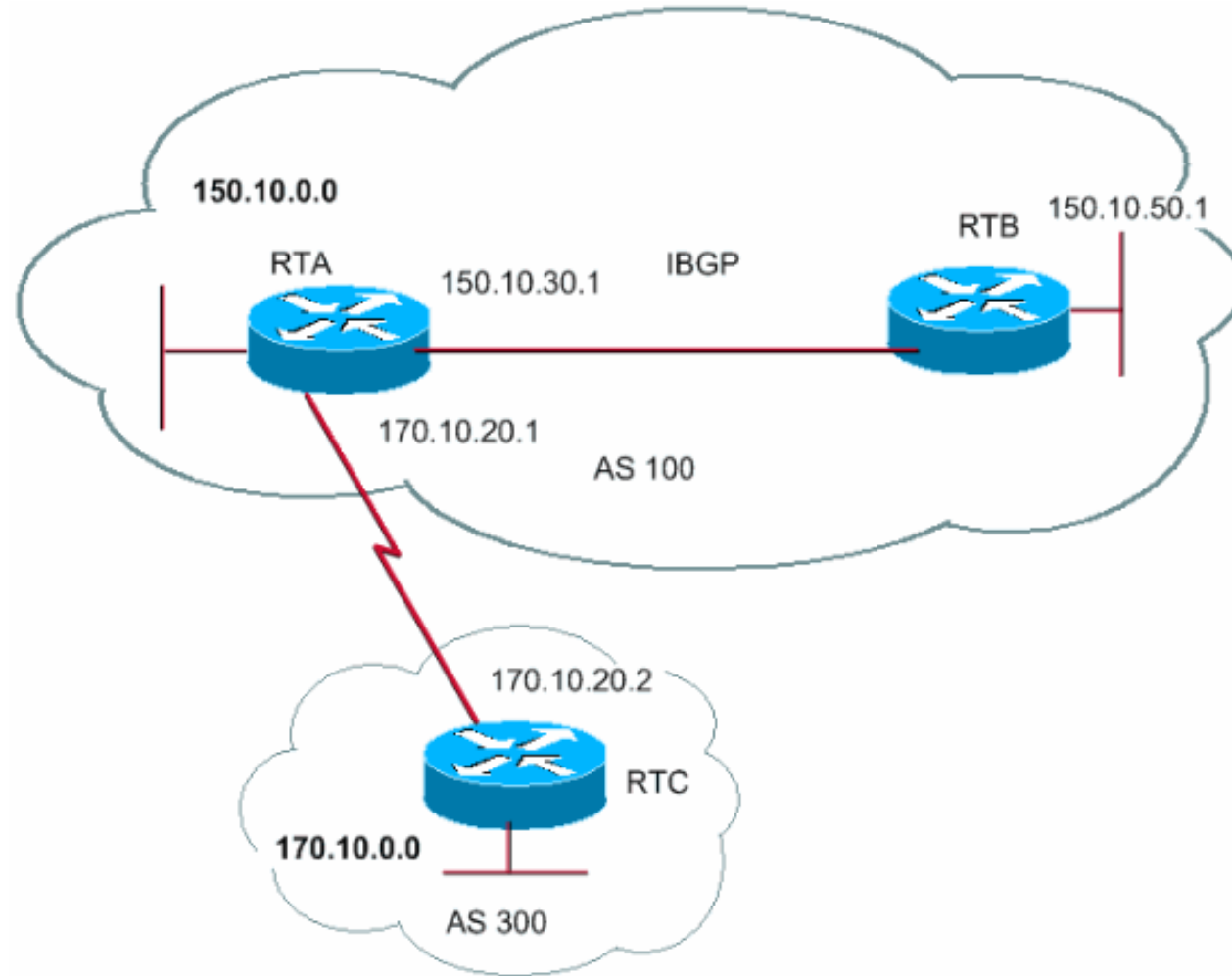
AS-Path loop detection



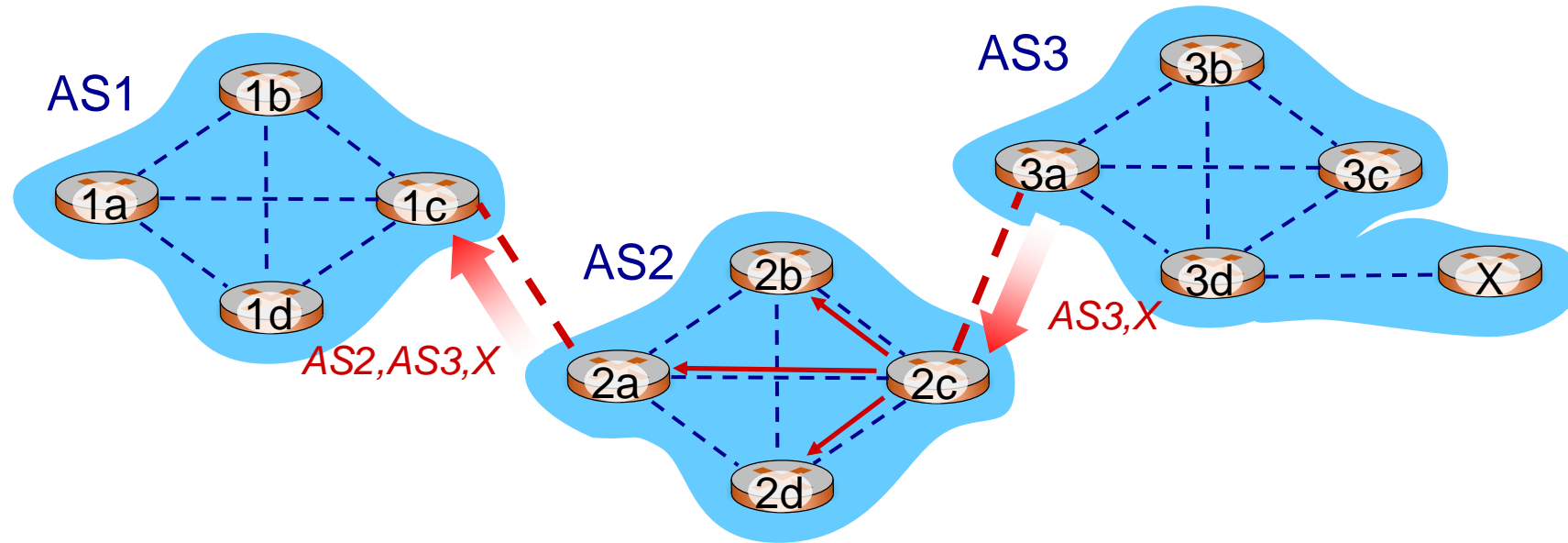
Next Hop

- **IGP should carry route to next hops**
- **Recursive route look-up**
- **Unlinks BGP from actual physical topology**
- **Allows IGP to make intelligent forwarding decision**

Next Hop

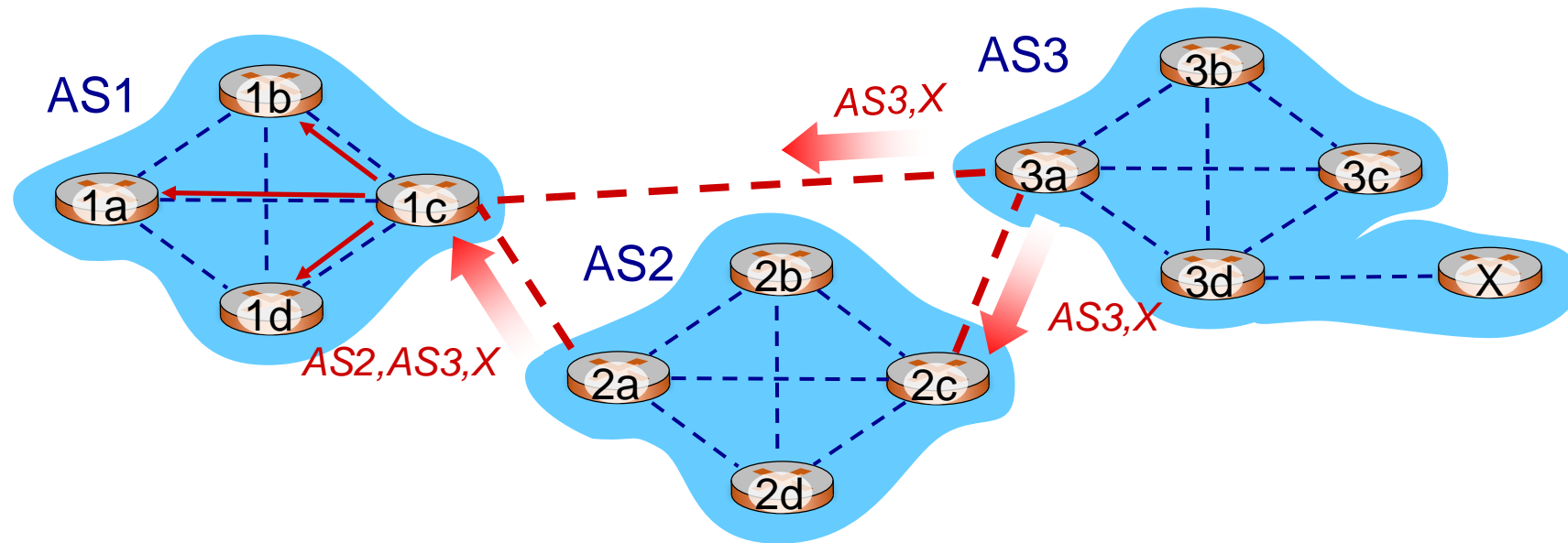


BGP path advertisement



- AS2 router 2c receives path advertisement **AS3,X** (via eBGP) from AS3 router 3a
- Based on AS2 policy, AS2 router 2c accepts path AS3,X, propagates (via iBGP) to all AS2 routers
- Based on AS2 policy, AS2 router 2a advertises (via eBGP) path **AS2, AS3, X** to AS1 router 1c

BGP path advertisement

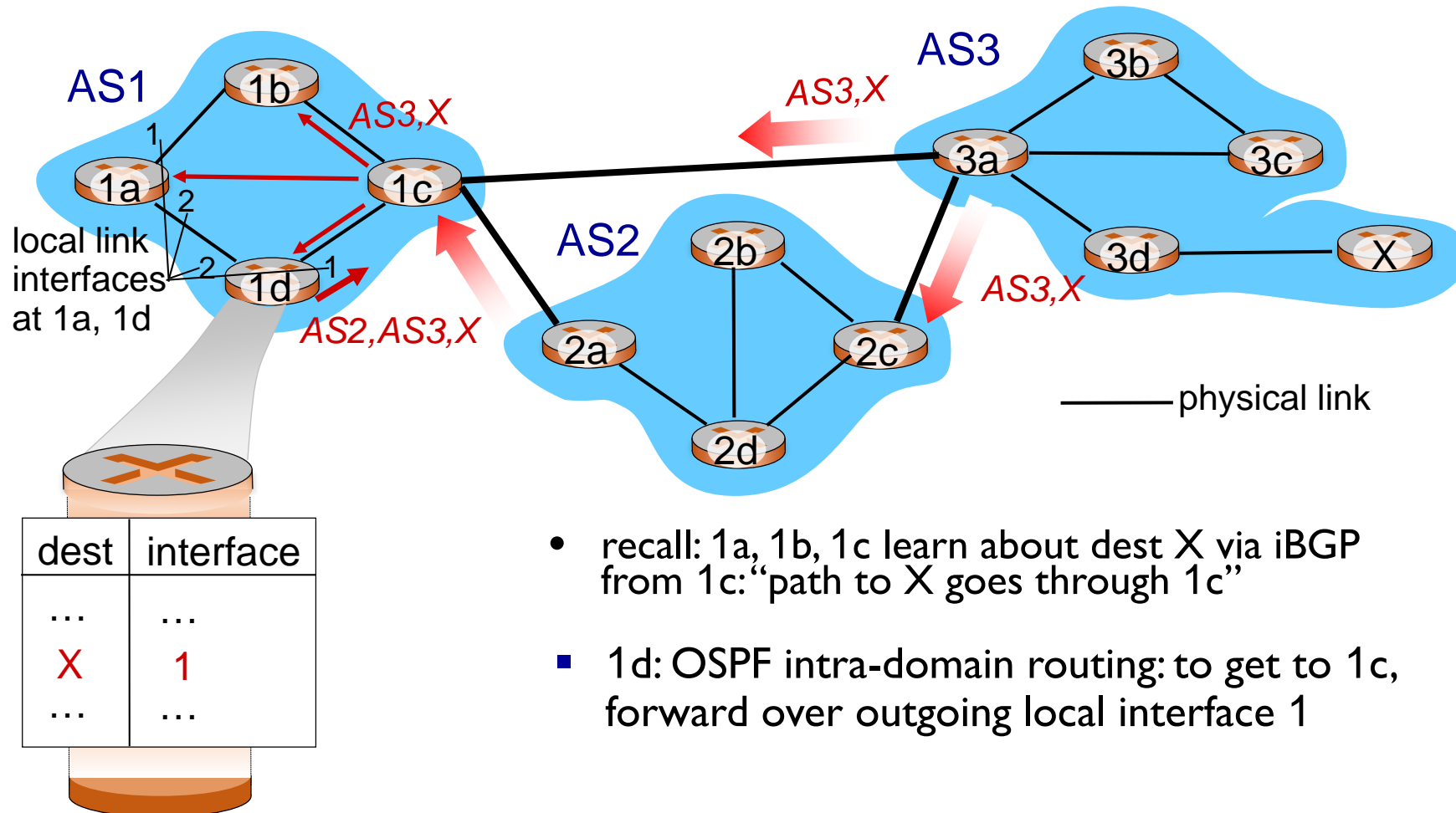


Gateway router may learn about **multiple** paths to destination:

- AS1 gateway router 1c learns path **AS2,AS3,X** from 2a
 - AS1 gateway router 1c learns path **AS3,X** from 3a
 - Based on policy, AS1 gateway router 1c chooses path **AS3,X**, and *advertises path within AS1 via iBGP*

BGP, OSPF, forwarding table entries

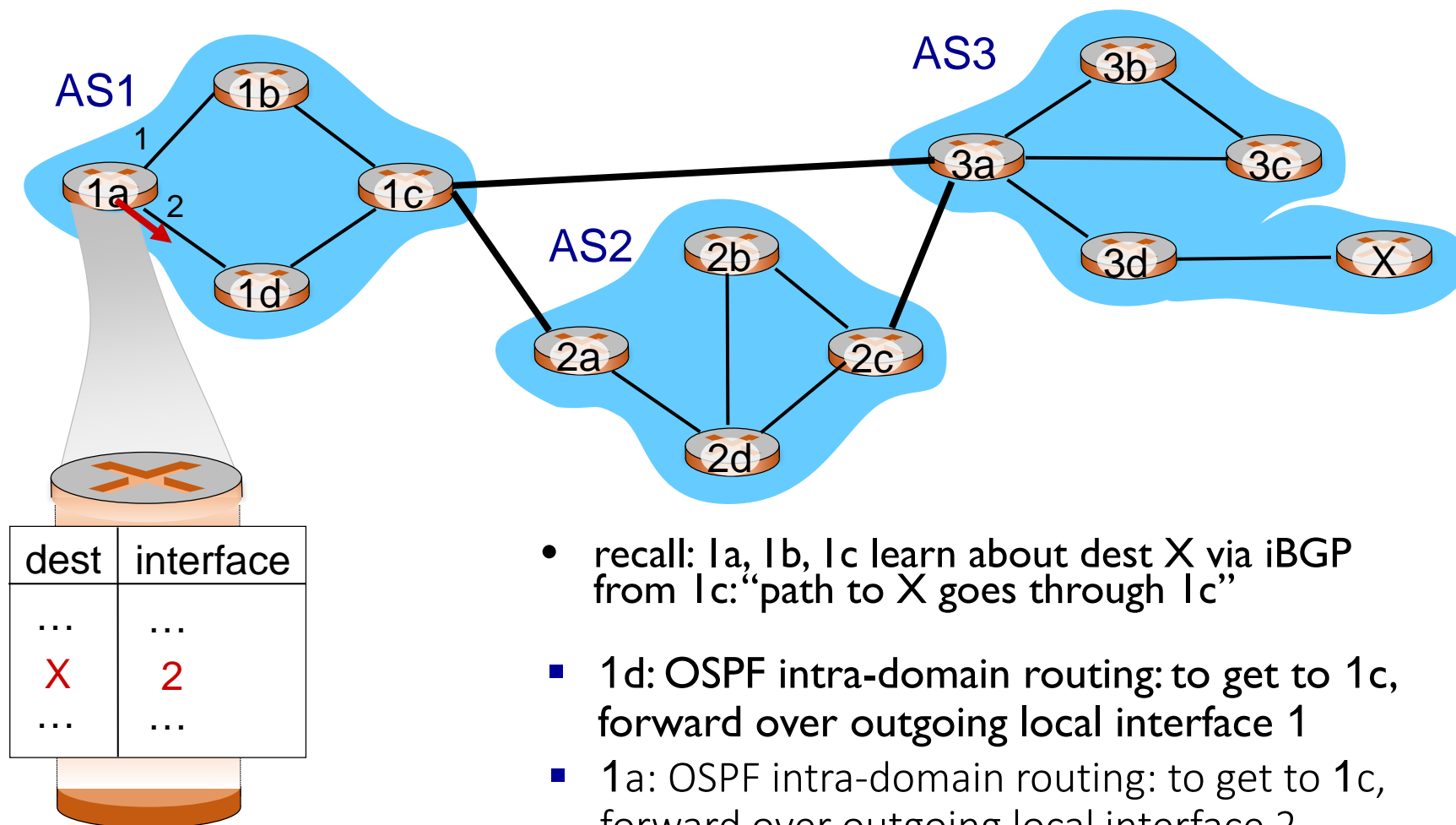
Q: how does router set forwarding table entry to distant prefix?



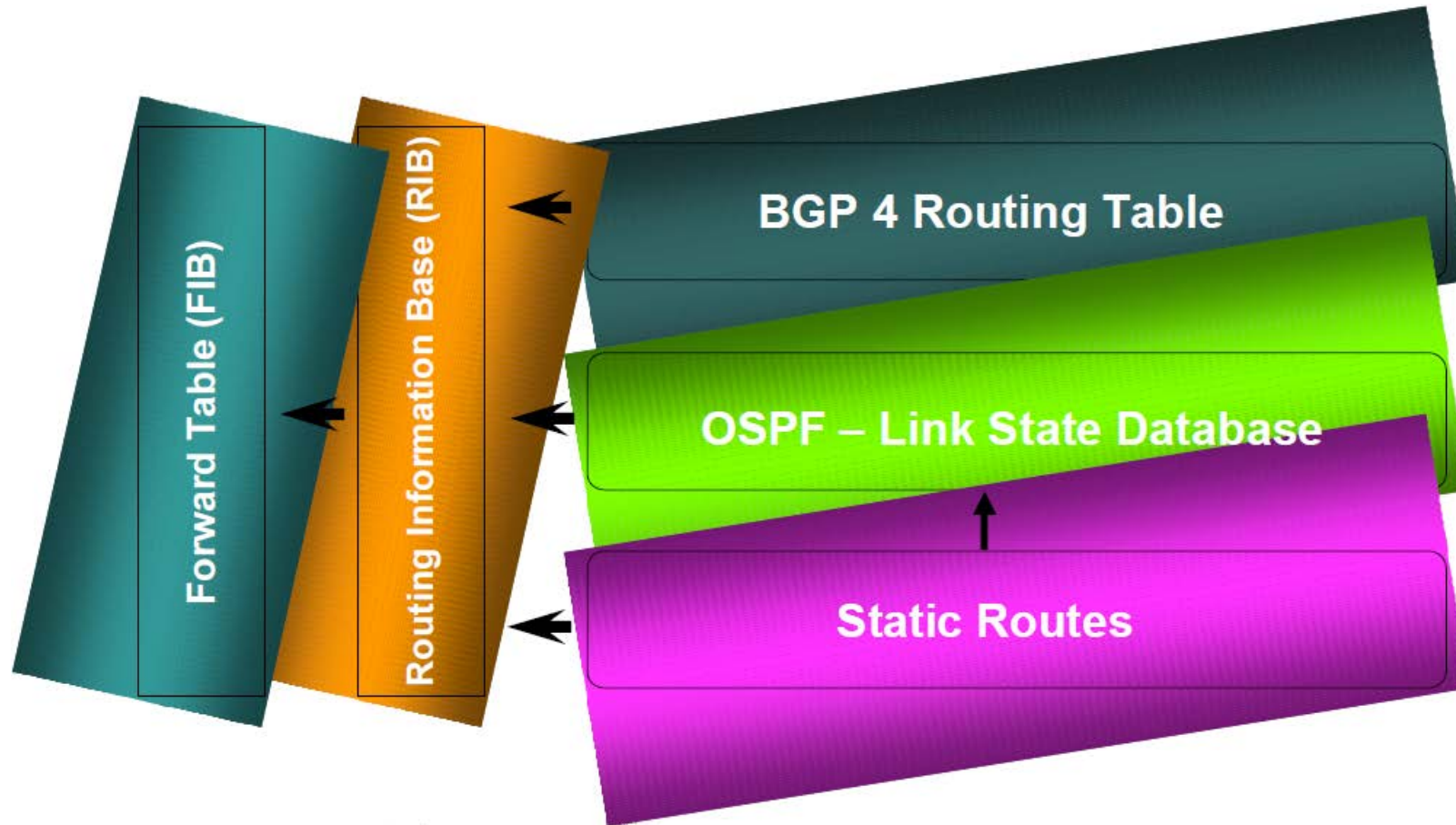
- recall: 1a, 1b, 1c learn about dest X via iBGP from 1c: “path to X goes through 1c”
- 1d: OSPF intra-domain routing: to get to 1c, forward over outgoing local interface 1

BGP, OSPF, forwarding table entries

Q: how does router set forwarding table entry to distant prefix?



Forwarding table entries



Continues....

- How the preferred route is selected?