Campus Networking Workshop

Introduction to OSPF

Modified from originals by Philip Smith

IPv4

- Internet Protocol version 4
  - Addresses are 32 bits long
  - An IPv4 address has a network portion and a host portion
  - “Subnet mask” used to mark the separation
    - Represents the number of network bits
    - The remaining bits are “host” bits
    - Written as
      - 12.34.56.78 255.255.255.0 or
      - 12.34.56.78/24

IPv6

- Internet Protocol version 6
  - Addresses are 128 bits long
  - An IPv6 address also has a network portion and a host portion
  - “Prefix Length” used to mark the separation
    - Represents the number of network bits
    - The remaining bits are “host” bits
    - Written as
      - 2001:db8::/32

What do routers do?

- An IP packet whose source address has different subnet bits than its destination address, has to be forwarded by a router
- A “route” is a pointer that says: “to reach this subnet, send the packet to this router”
  - 12.23.45.0/24 -> 11.22.33.44
- Routes can be “static” if they are configured manually, or dynamic if they are learned from other routers

Routing vs Forwarding

- Routing is not the same as Forwarding
- Routing is the building of maps
  - Each routing protocol usually has its own routing database
  - Routing protocols populate the forwarding table
- Forwarding is passing the packet to the next hop device
  - Forwarding table contains the best path to the next hop for each prefix
  - There is only ONE forwarding table

Routing Protocols

- Mechanisms that routers follow to exchange routes
  - Can be standard (RIP, OSPF, ISIS, BGP) or proprietary (EIGRP)
  - Categories: Interior (IGP), or exterior (EGP)
  - Categories: *Link state* or *Distance Vector*

OSPF Background

- Developed by IETF – RFC1247
  - Designed for Internet TCP/IP environment
- OSPF v2 described in RFC2328/STD54
- Link state/Shortest Path First Technology
- Dynamic Routing
- Fast Convergence
- Route authentication

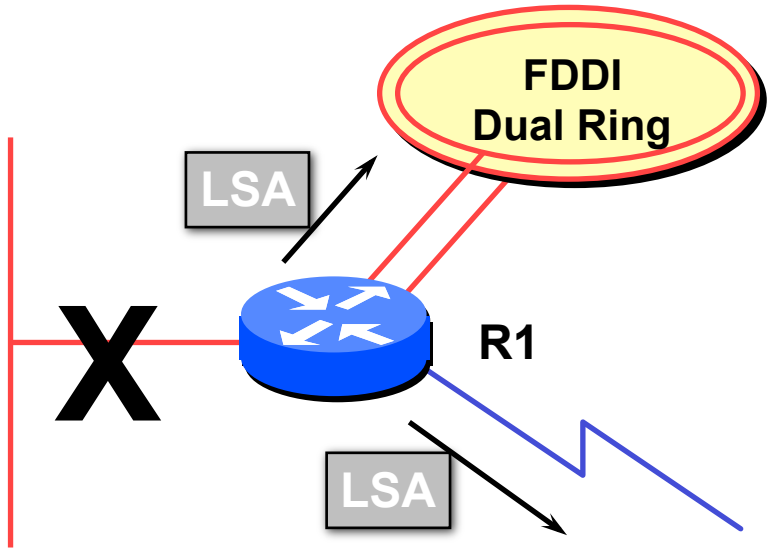
Link State Algorithm

- Each router contains a database containing a map of the whole topology
  - Links
  - Their state (including cost)
- All routers have the same information
- All routers calculate the best path to every destination
- Any link state changes are flooded across the network
  - “Global spread of local knowledge”

Link State Routing

- Automatic neighbour discovery
  - Neighbours are physically connected routers
- Each router constructs a Link State Packet (LSP)
  - Distributes the LSP to neighbours…
  - …using an LSA (Link State Advertisement)
- Each router computes its best path to every destination
- On network failure
  - New LSPs are flooded
  - All routers recompute shortest path tree

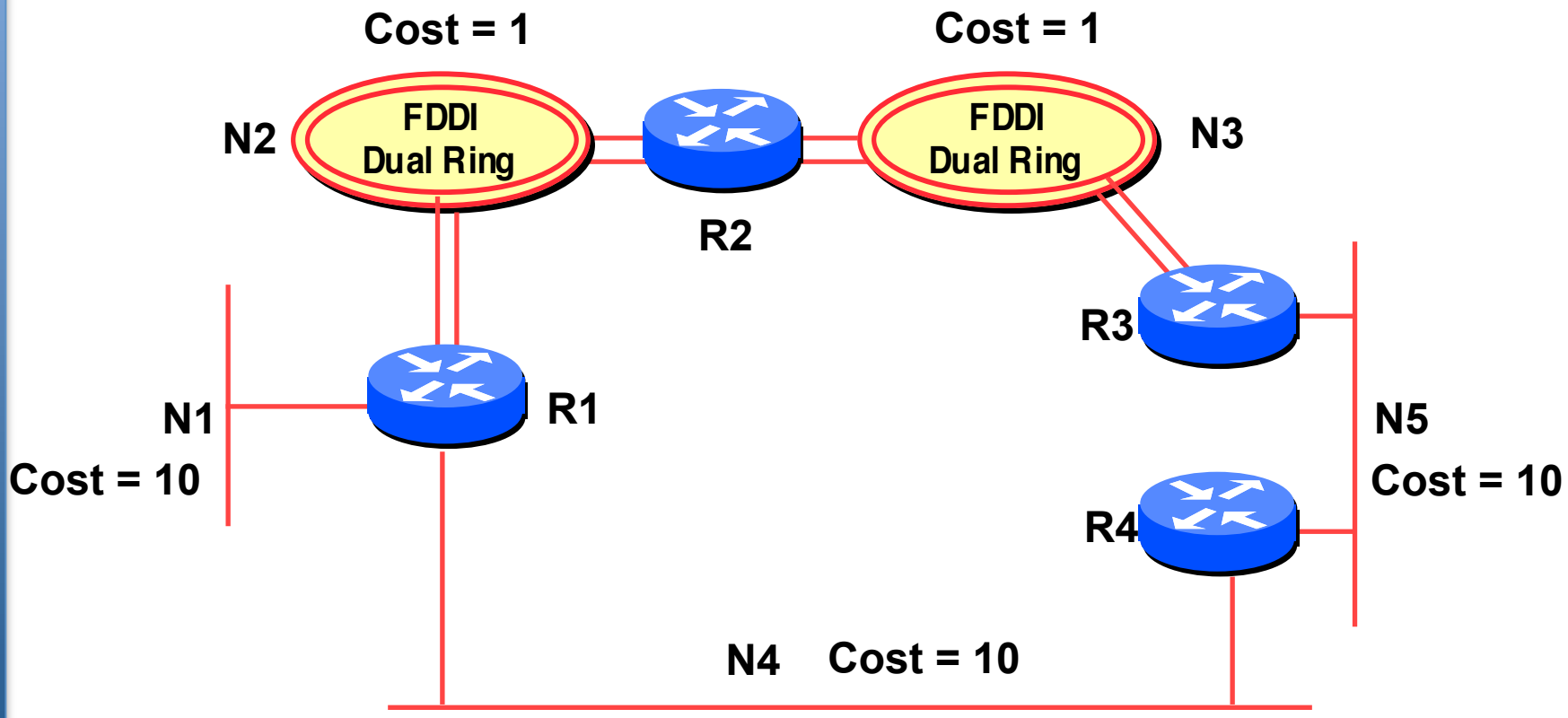
Low Bandwidth Requirements



- Only changes are propagated
- Multicast used on multi-access broadcast networks
  - 224.0.0.5 used for all OSPF speakers
  - 224.0.0.6 used for DR and BDR routers

“Shortest Path First”

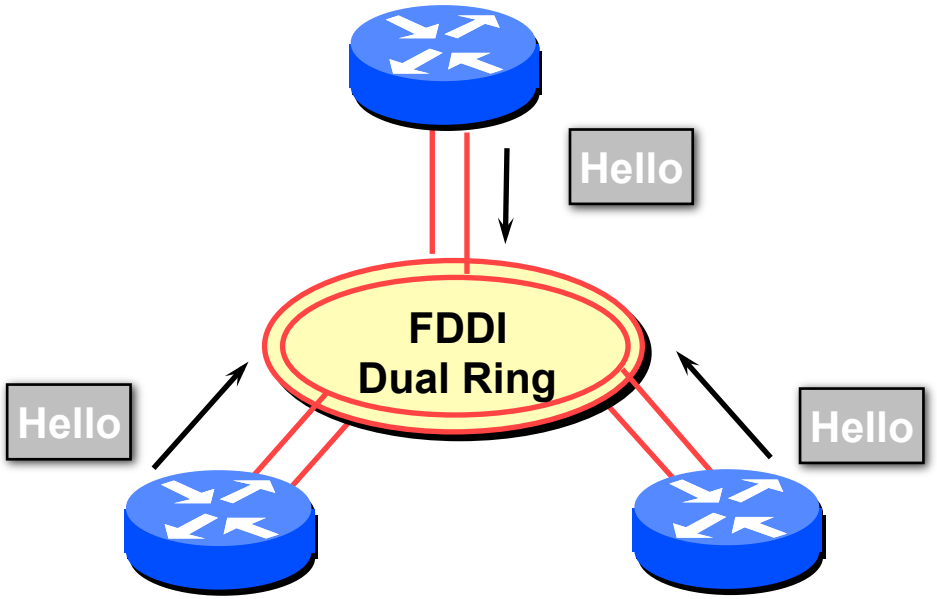
The optimal path is determined by the sum of the interface costs: Cost = 10^8/bandwidth



OSPF: How it works

Hello Protocol

- Responsible for establishing and maintaining neighbour relationships
- Elects Designated Router on broadcast networks



OSPF: How it works

- Hello Protocol
  - Hello Packets sent periodically on all OSPF enabled interfaces
  - Adjacencies formed between ***some*** neighbours
- Hello Packet
  - Contains information like Router Priority, Hello Interval, a list of known neighbours, Router Dead Interval, and the network mask

OSPF: How it works

- Trade Information using LSAs
  - LSAs are added to the OSPF database
  - LSAs are passed on to OSPF neighbours
- Each router builds an identical link state database
- SPF algorithm run on the database
- Forwarding table built from the SPF tree

OSPF: How it works

When change occurs:

- Announce the change to all OSPF neighbours
- All routers run the SPF algorithm on the revised database
- Install any change in the forwarding table

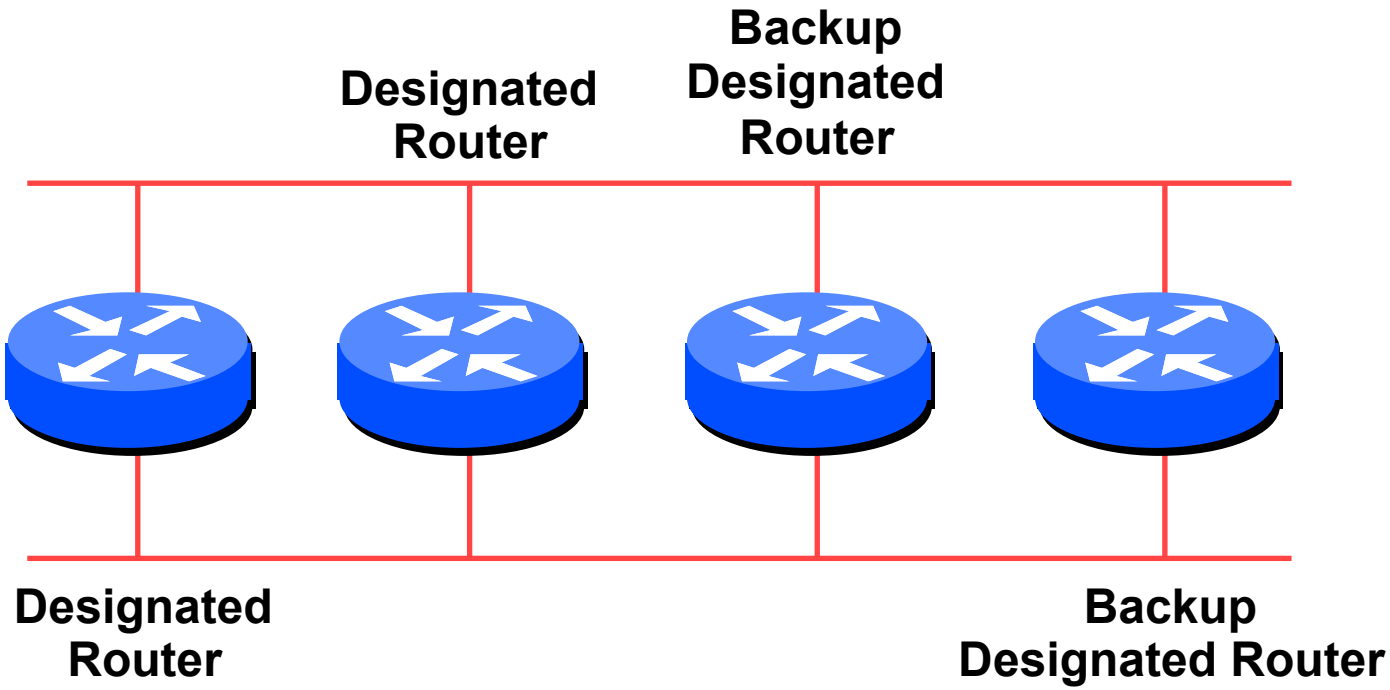
Broadcast Networks

- These are network technologies such as Ethernet
- Introduces Designated and Backup Designated routers (DR and BDR)
  - Only DR and BDR form full adjacencies with other routers
  - The remaining routers remain in a “2-way” state with each other
    - If they were adjacent, we’d have n-squared scaling problem
  - If DR or BDR “disappear”, re-election of missing router takes place

Designated Router

One per multi-access network

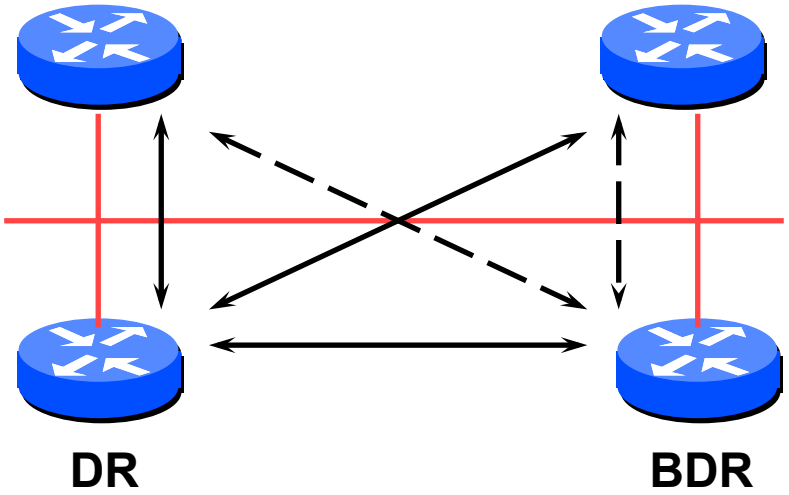
- Generates network link advertisements for the multi-access network
- Speeds database synchronisation



Designated Router

- All routers are adjacent to the DR
  - All routers are adjacent to the BDR also
- All routers exchange routing information with DR
  - BDR also stays synchronized with the DR
- DR updates the database of all its neighbours
  - BDR waits silently and only takes over if DR dies
- This scales!
  - *2n* problem rather than having an *n-squared* problem.

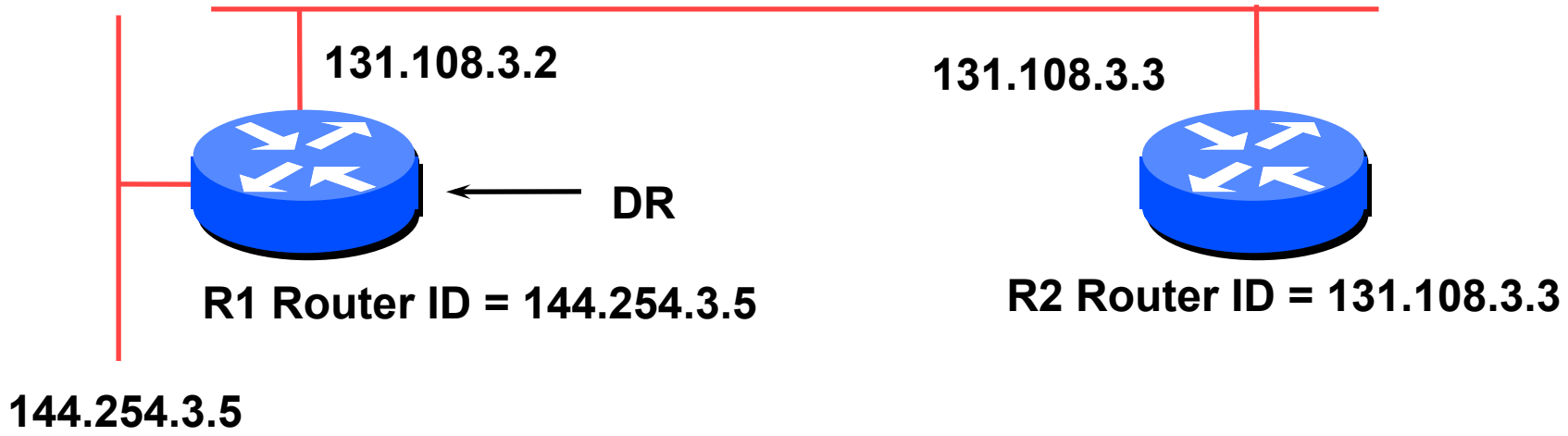
Designated Router



- Adjacencies only formed with DR and BDR
- LSAs propagate along the adjacencies

Designated Router Priority

- Determined by interface priority
- Otherwise by highest router ID
  - (For Cisco IOS, this is address of loopback interface, otherwise highest IP address on router)

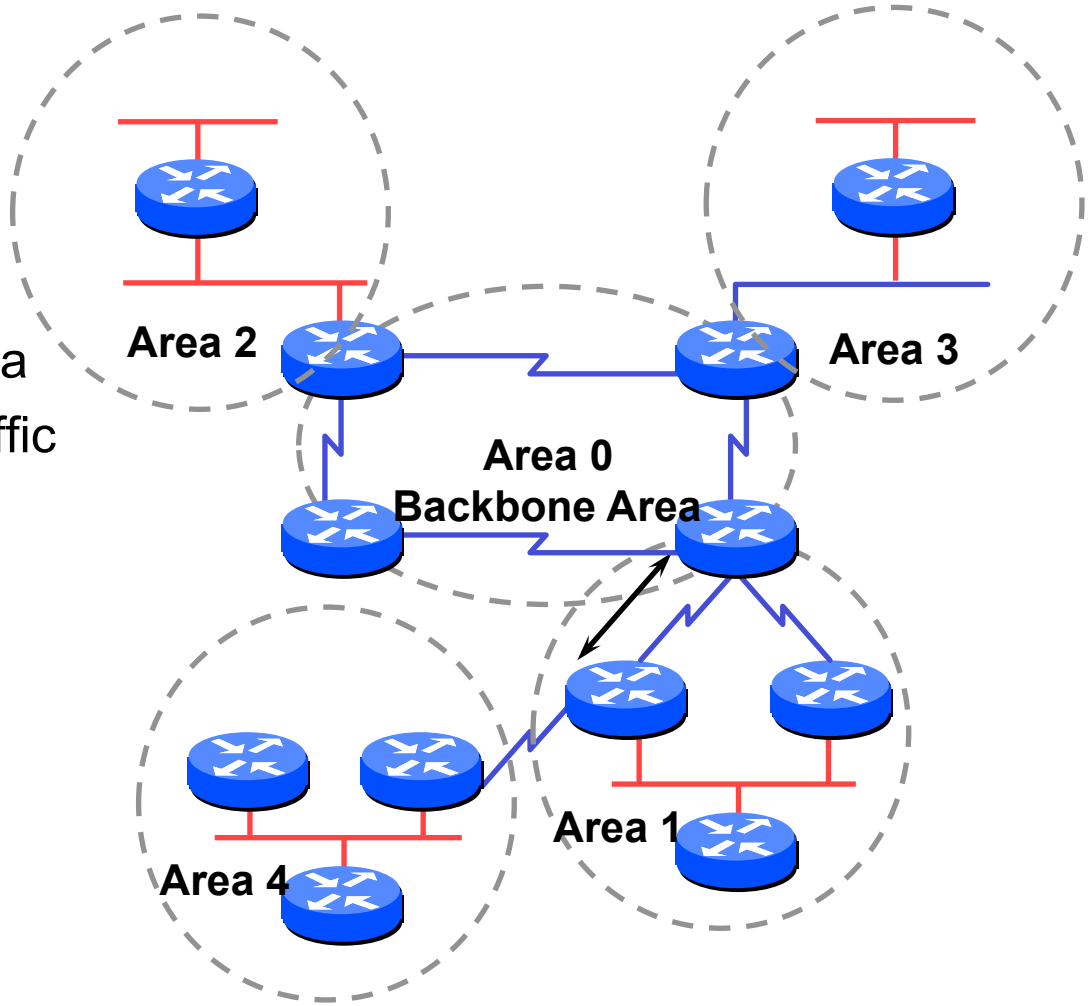


More Advanced OSPF

- OSPF Areas
- Virtual Links
- Router Classification
- OSPF route types
- External Routes
- Route authentication
- Equal cost multipath

OSPF Areas

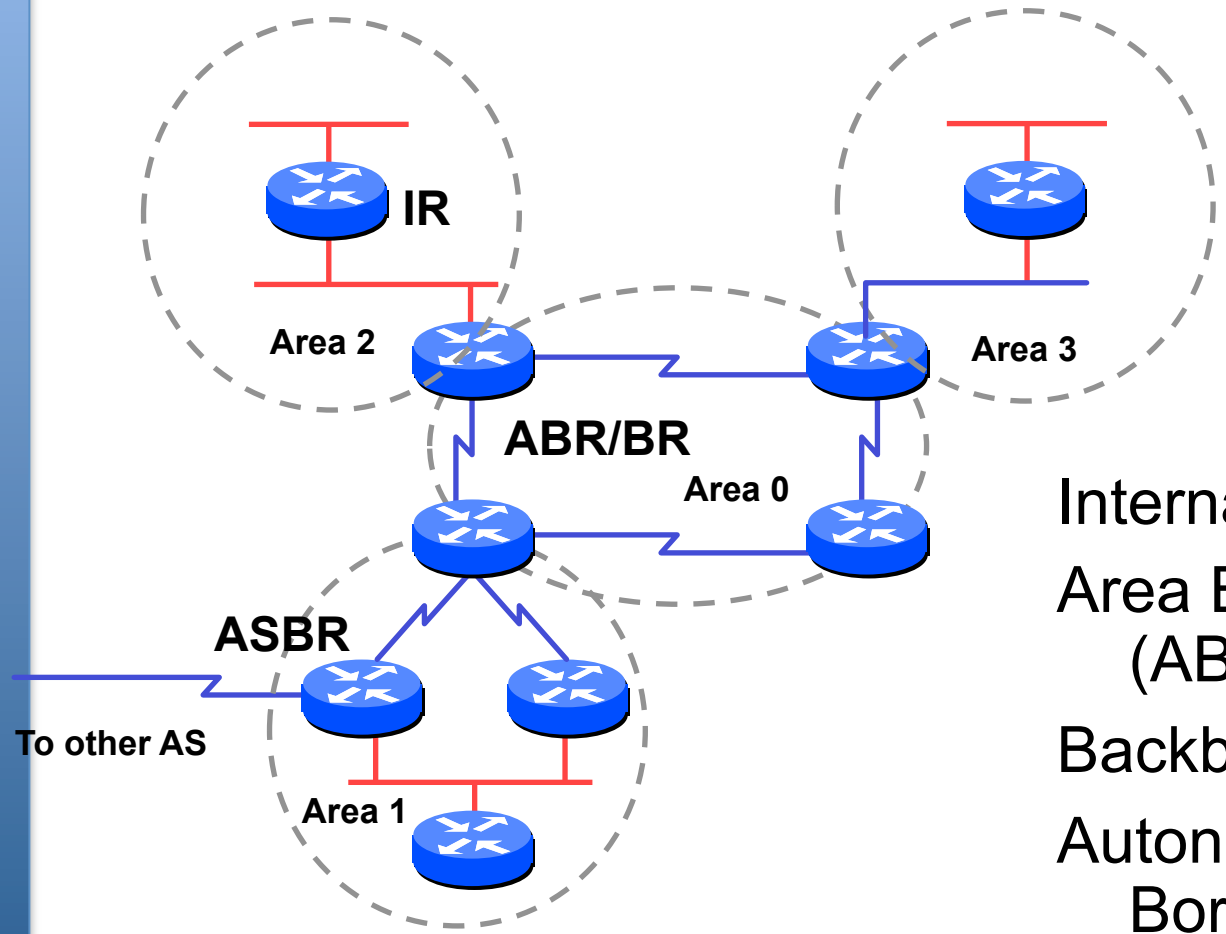
- Group of contiguous hosts and networks
- Per area topological database
  - Invisible outside the area
  - Reduction in routing traffic
- Backbone area contiguous
  - All other areas must be connected to the backbone
- Virtual Links



OSPF Areas

- Reduces routing traffic in area 0
- Consider subdividing network into areas
  - Once area 0 is more than 10 to 15 routers
  - Once area 0 topology starts getting complex
- Area design often mimics typical ISP core network design
- Virtual links are used for “awkward” connectivity topologies

Classification of Routers



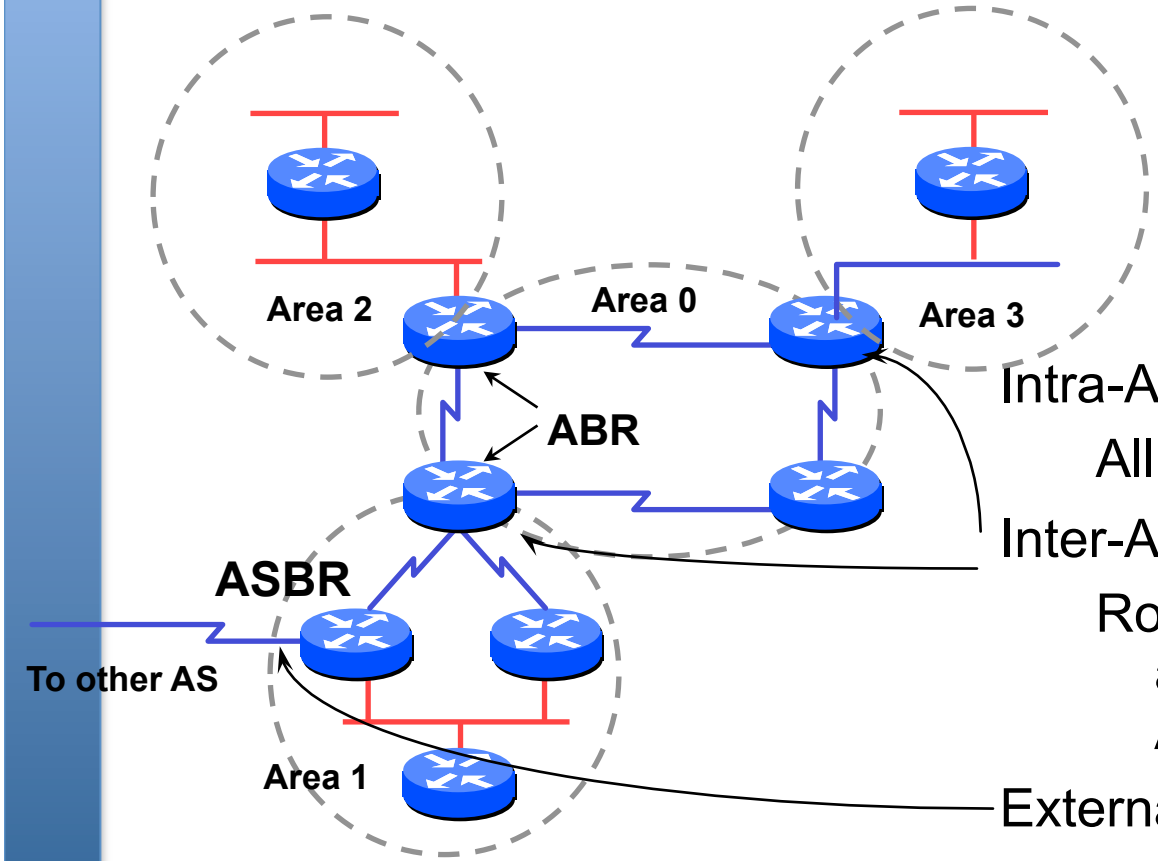
Internal Router (IR)

Area Border Router (ABR)

Backbone Router (BR)

Autonomous System Border Router (ASBR)

OSPF Route Types



Intra-Area route

All routes inside an area

Inter-Area route

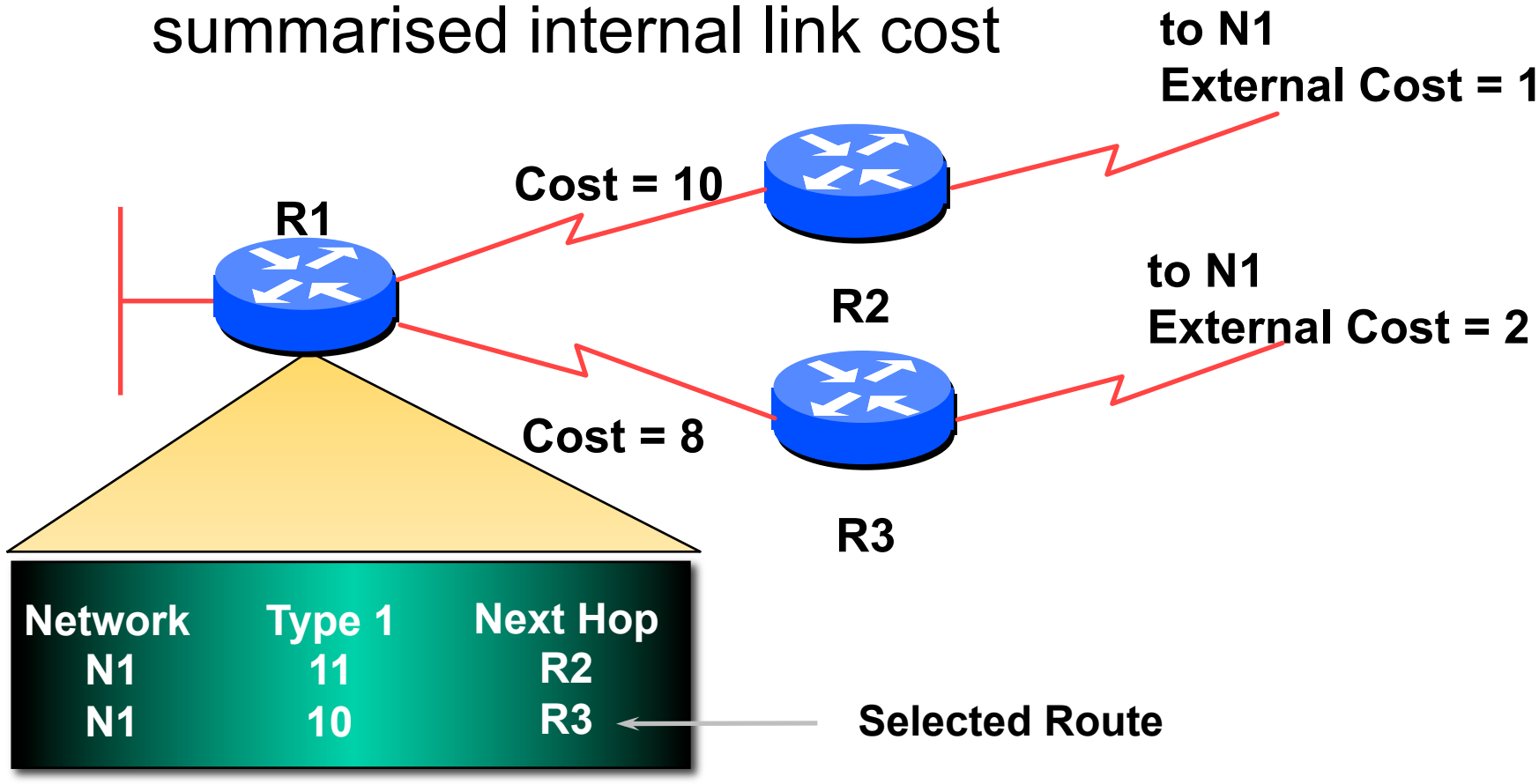
Routes advertised from one area to another area by an ABR

External route

Routes imported into OSPF from another routing protocol by an ASBR

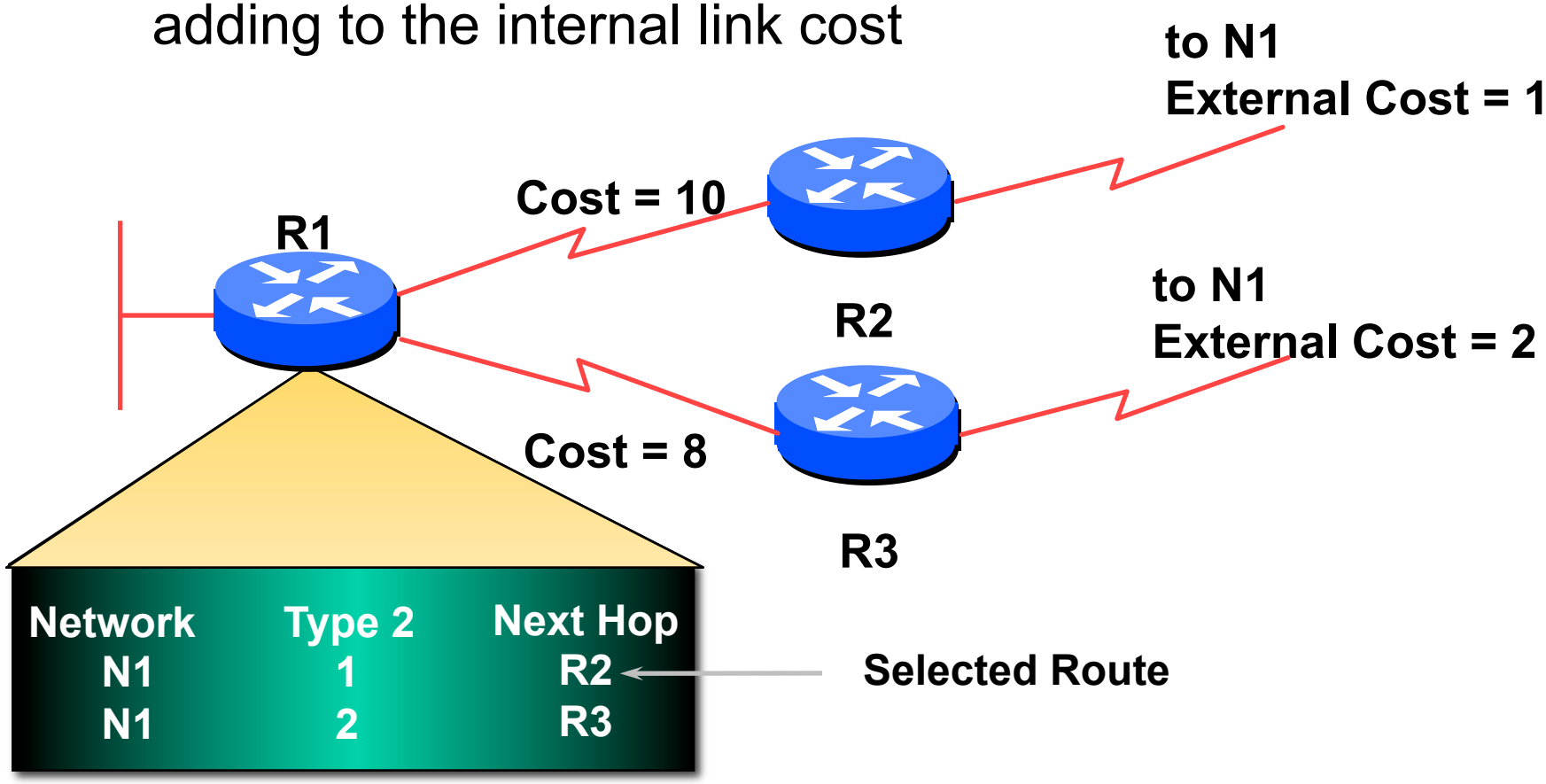
External Routes

Type 1 external metric: metrics are added to the summarised internal link cost



External Routes

Type 2 external metric: metrics are compared without adding to the internal link cost



Route Authentication

- It is recommended to use route authentication for OSPF
  - …and all other routing protocols
- Susceptible to denial of service attacks
  - OSPF runs on TCP/IP
  - Automatic neighbour discovery

Equal Cost Multipath

If *n* paths to same destination have equal cost, OSPF will install *n* entries in the forwarding table

- Loadsharing over the *n* paths
- Useful for expanding links across an ISP backbone
  - Don’t need to use hardware muliplexors
  - Don’t need to use static routing

OSPFv3

- OSPFv2 only supports IPv4
- OSPFv3 developed for IPv6 only
  - Dual stack networks need to run both protocols
  - They run independently of each other

OSPFv2 vs. OSPFv3

- Very similar, with a few differences
  - New LSA types to separate links from their prefixes
    - Avoids SPF recalculations when only the link prefix changes
  - Removes OSPF-specific authentication
    - Relies on underlying IPv6 security headers
  - Supports multiple instances

OSPF Configuration – Start

- Start the OSPF process

  `router ospf 100`

- “100” is the process ID
  - Process ID is unique to the router
    - You can run multiple OSPF processes on the same router
    - It is common to set the process ID to autonomous system (AS) number

OSPF Configuration
Advertising Networks Option 1

```
router OSPF 100
  redistribute connected subnets
```

- Includes all the subnets connected to the router, but announces them as external type-2 LSAs, which are not summarized
  - Not a good option when using multiple areas
- It also does not give you control over which networks you want to announce

OSPF Configuration
Advertising Networks Option 2

- **Per-link configuration (IOS 12.4 and later)**
  - **OSPF configured on each interface**
  - **Passive interfaces do not establish adjacencies**

```
router ospf 100
  passive-interface default
  no passive interface GigabitEthernet0
interface GigabitEthernet0
  ip address 10.10.0.1 255.255.255.0
  ip ospf 100 area 0
interface FastEthernet0
  ip address 192.168.10.1 255.255.255.0
  ip ospf 100 area 0
```

OSPF Configuration
Advertising Networks Option 3

- **Network statements**
  - **Annouce subnets included in given network blocks**
  - **Add one network statement per subnet, or use wildcard masks to include multiple subnets**

```
ospf router 100
  passive-interface default
  no passive-interface GigabitEthernet0
  network 10.10.0.0 0.0.0.255 area 0
  network 192.168.0.0 0.0.0.3 area 0
```

OSPF Configuration
Authenticating adjacencies

- **Very important to control which devices can establish adjacencies**
  - **A malicious user could inject routes and steal your traffic!**

```
router ospf 100
  area 0 authentication message-digest
interface GigabitEthernet0/0
  ip ospf authentication-key <key>
```

Questions?