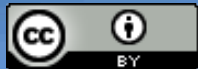




# Campus Networking Workshop

## Introduction to OSPF

Modified from originals by Philip Smith



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# Note: Routing and 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

# 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

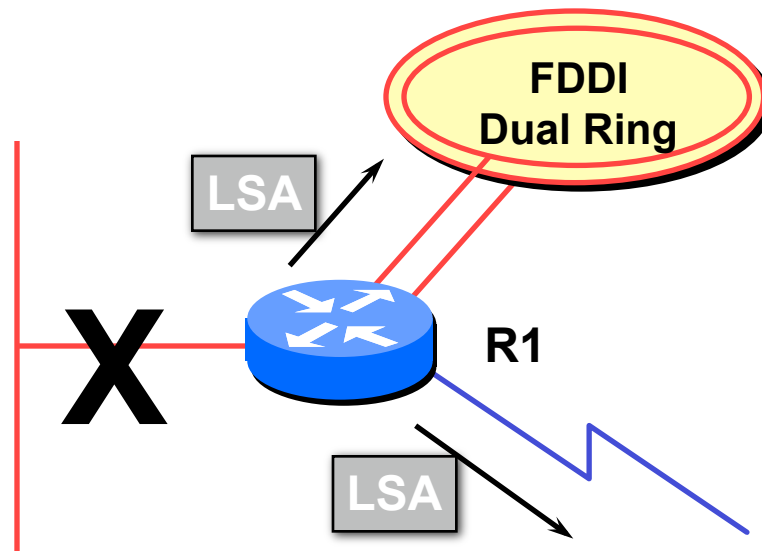
# Link State Algorithm

- 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

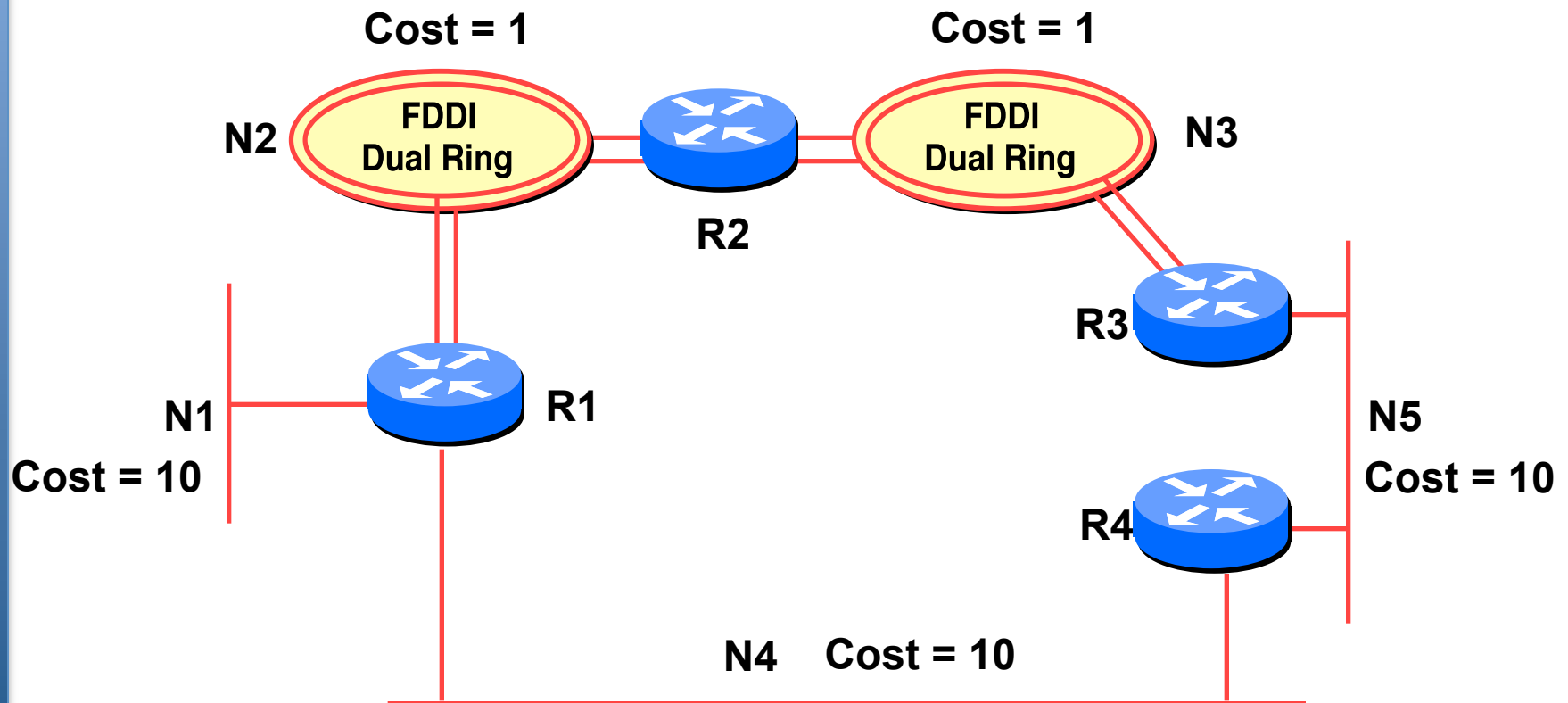
# Low Bandwidth Requirements



- 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”

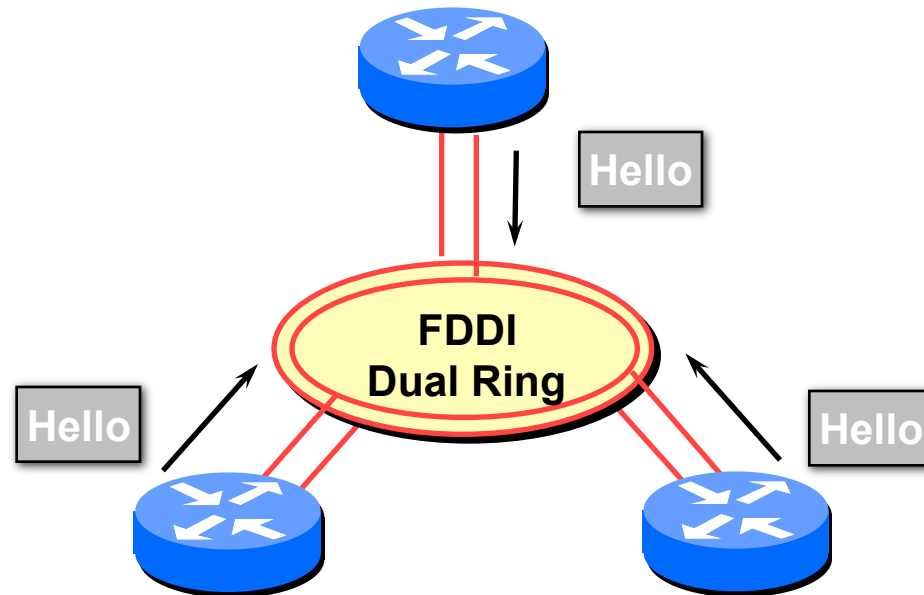
The optimal path is determined by the sum of the interface costs:  $\text{Cost} = 10^8 / \text{bandwidth}$



# 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

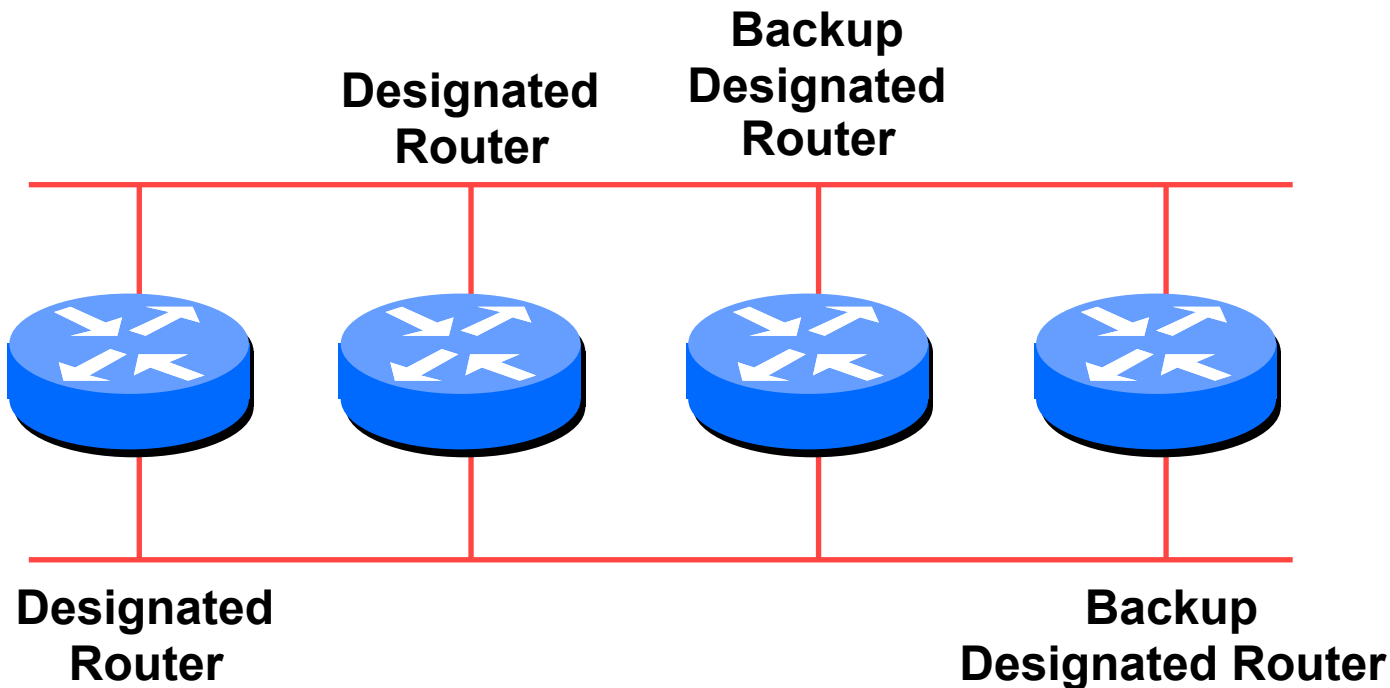
# Broadcast Networks

- 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

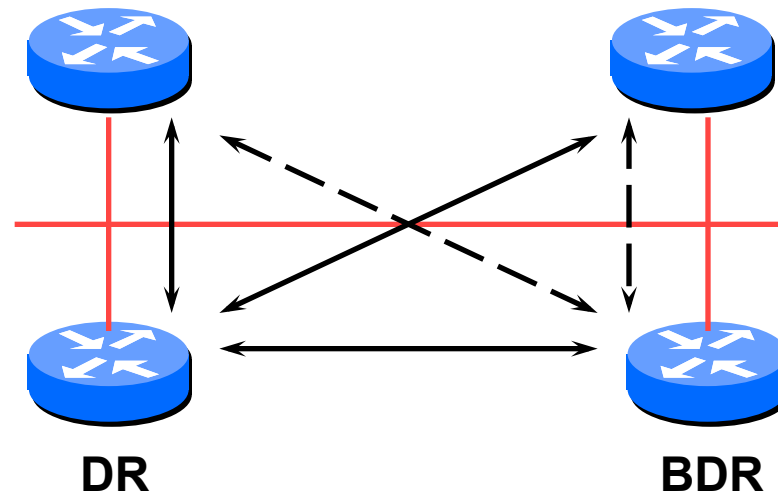
- Generates network link advertisements for the multi-access network
- Speeds database synchronisation



# 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.

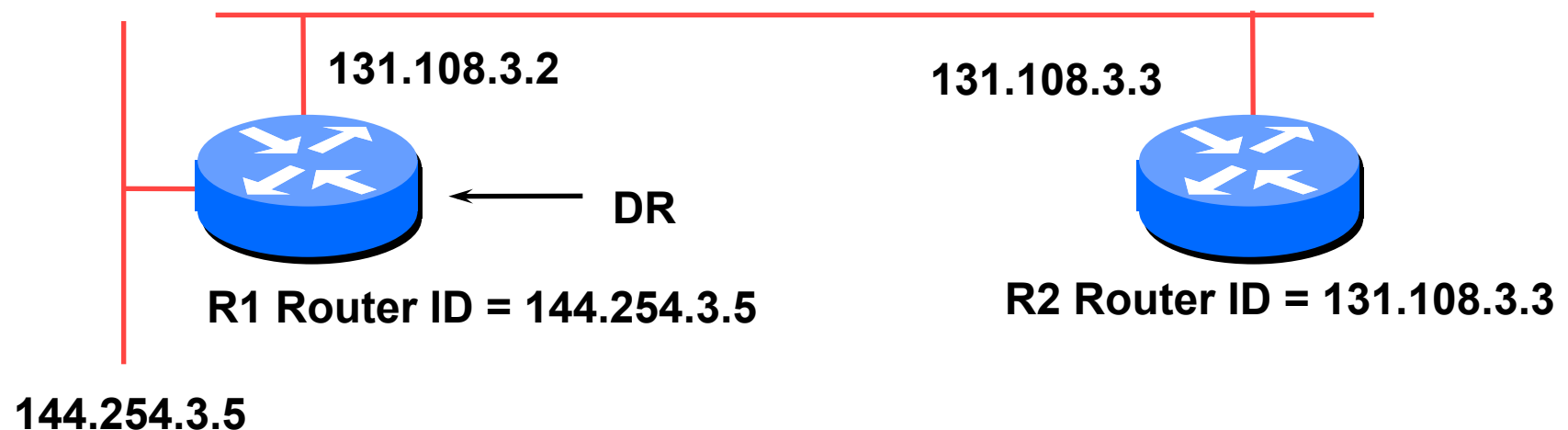
# Designated Router



- 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)





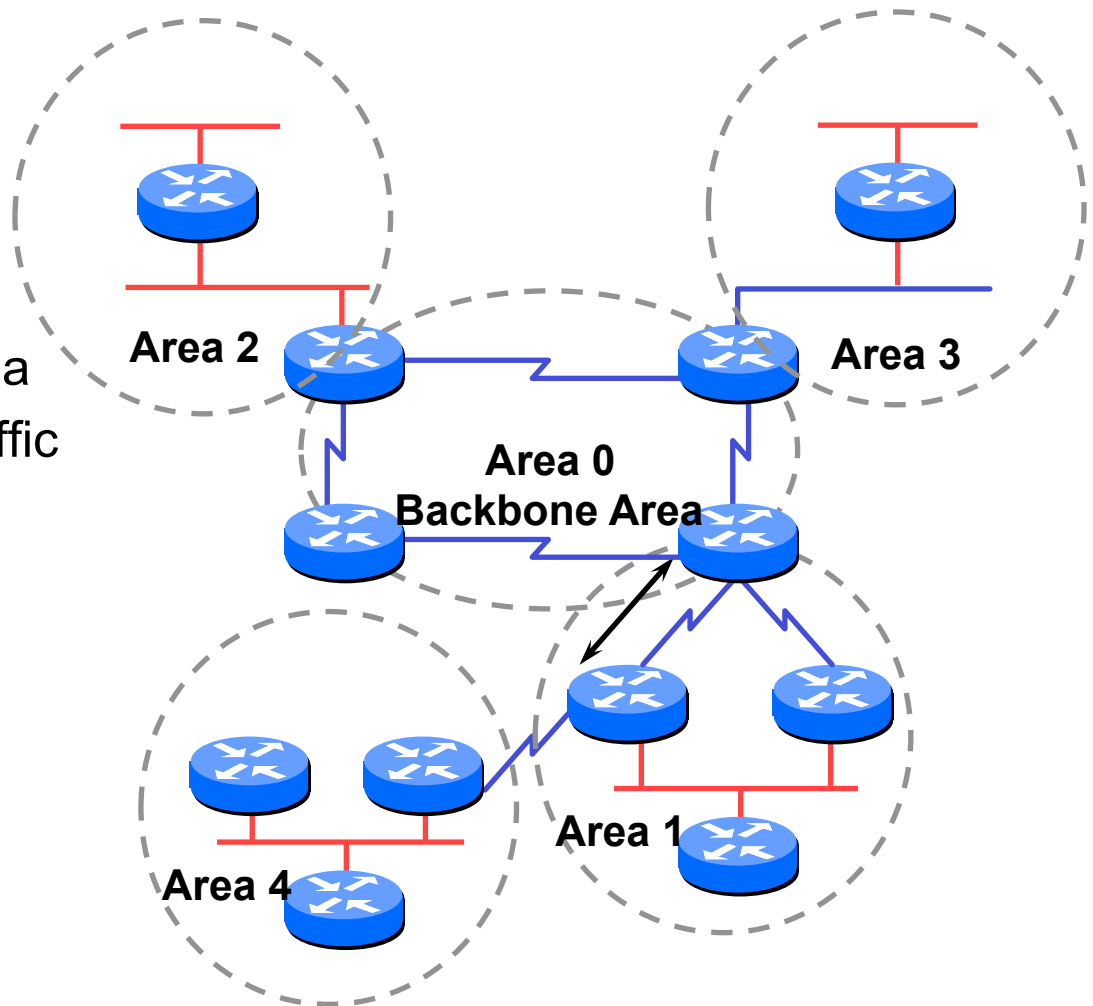


# More Advanced OSPF

- 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



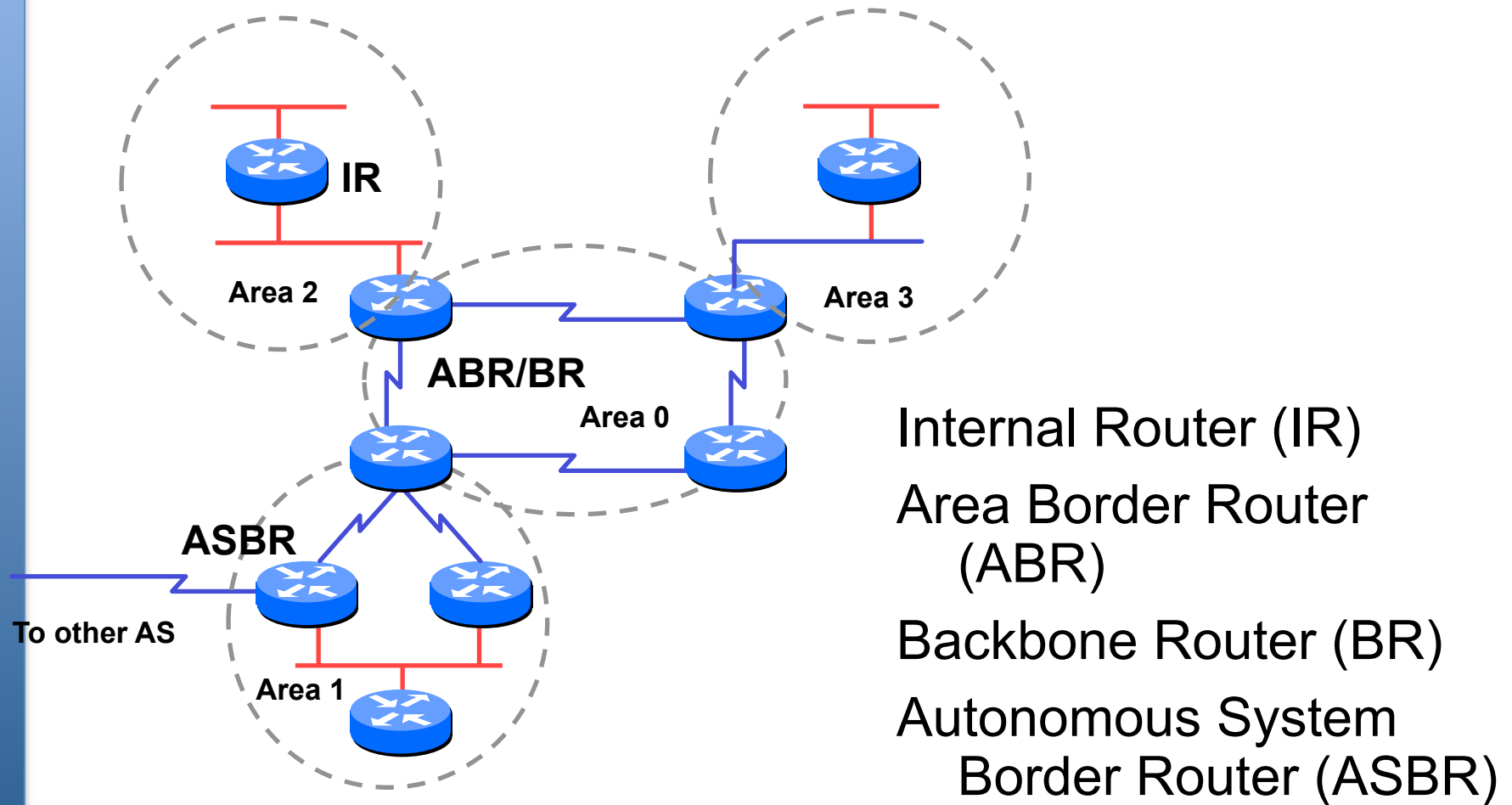
# OSPF Areas

- 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

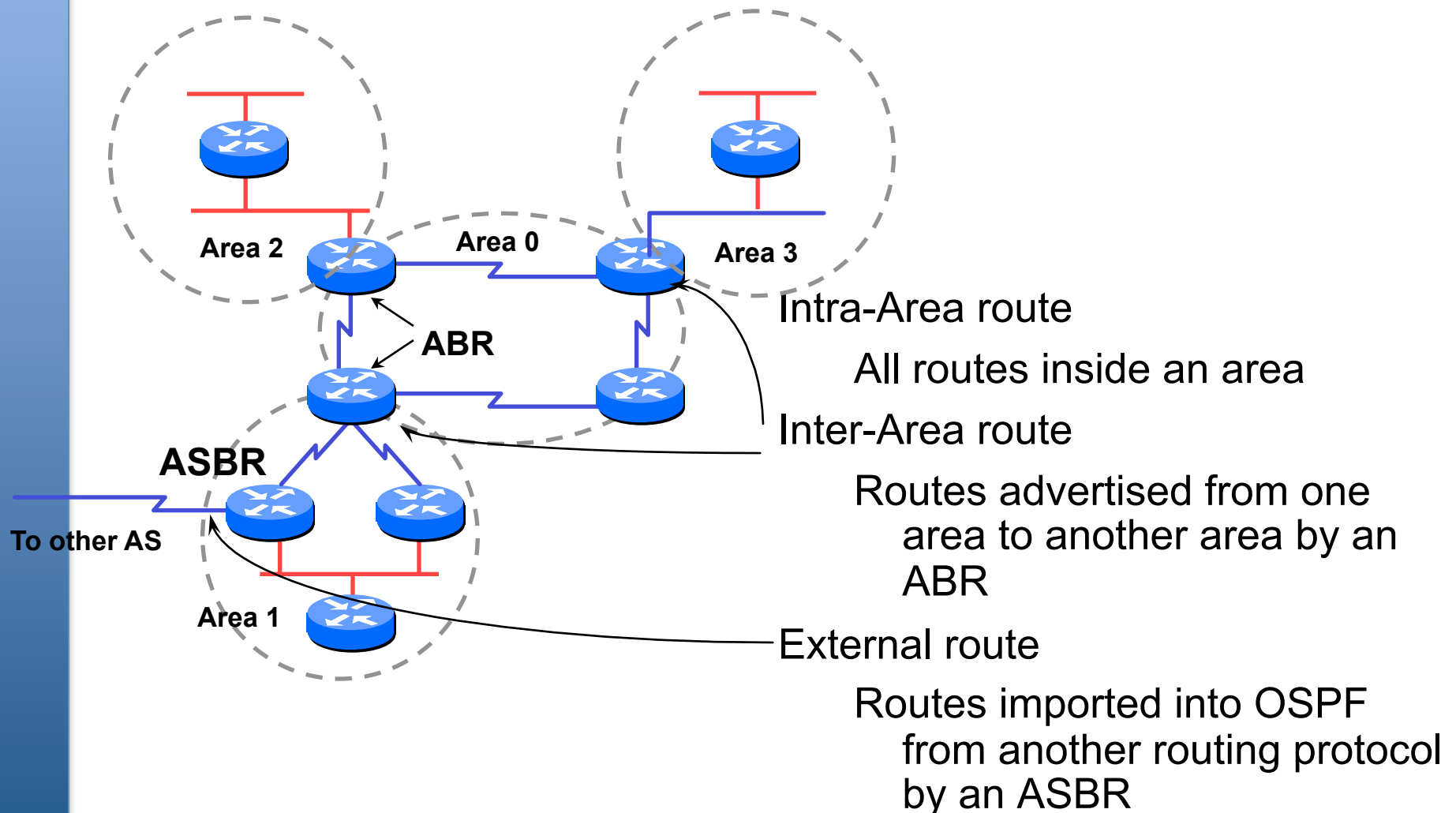
# Virtual Links

- OSPF requires that all areas **MUST** be connected to area 0
- If topology is such that an area cannot have a physical connection to a device in area 0, then a virtual link must be configured
- Otherwise the disconnected area will only be able to have connectivity to its immediately neighbouring area, and not the rest of the network

# Classification of Routers

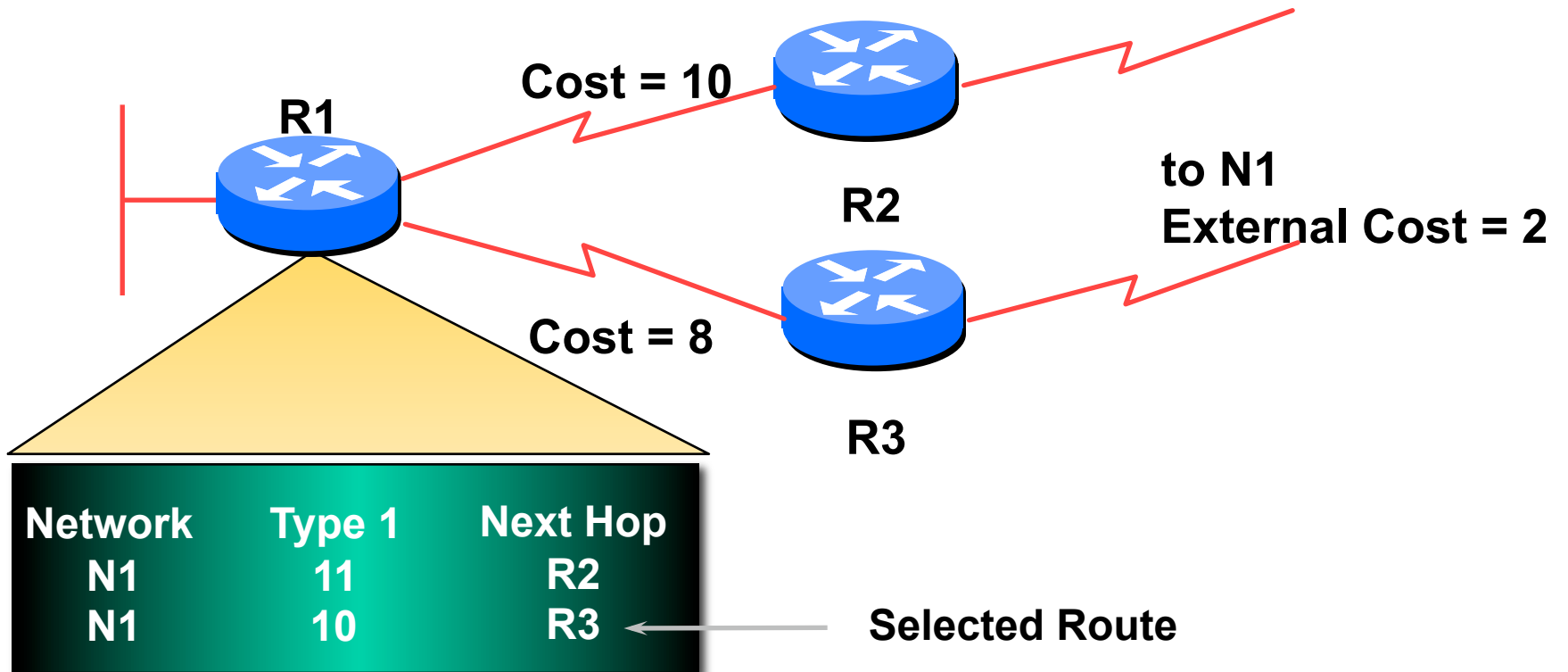


# OSPF Route Types



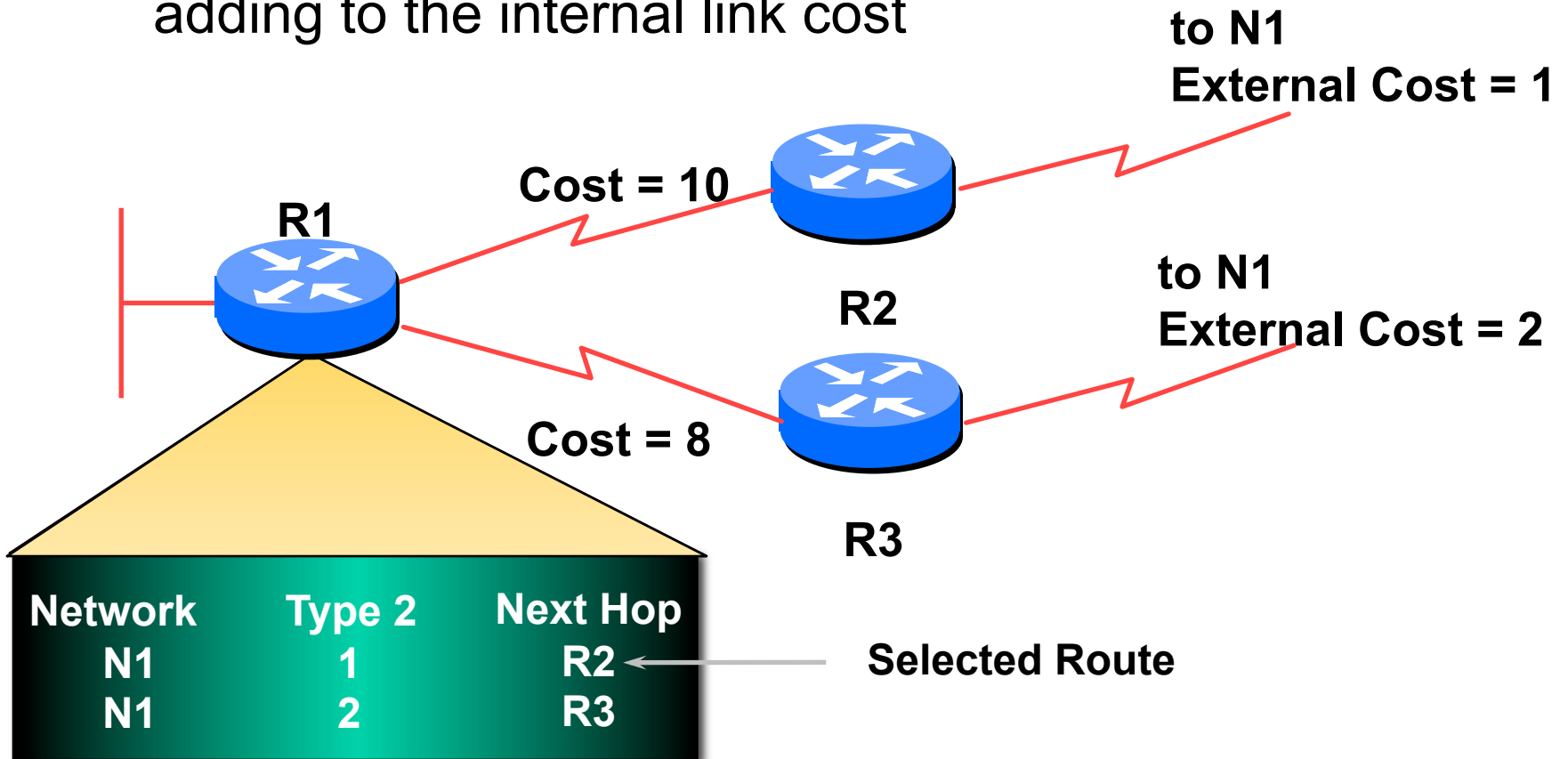
# External Routes

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

Now 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

Route authentication – Cisco example:

```
router ospf <pid>
  network 192.0.2.0 0.0.0.255 area 0
  area 0 authentication
interface ethernet 0/0
  ip ospf authentication-key <password>
```

# 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 multiplexors

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



# Summary

Link State Protocol

Shortest Path First

OSPF operation

Broadcast networks

Designated and Backup Designated Router

Advanced Topics

Areas, router classification, external networks,  
authentication, multipath

OSPFv3