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Open Shortest Path First (OSPF)

The OSPF protocol

- OSPF is an intra-AS routing protocol (IGP).

- OSPF is a link-state routing protocol: each network router knows the <u>network topology</u>.

- The OSPF packets are directly encapsulated into IP packets, with protocol field equal to 89.

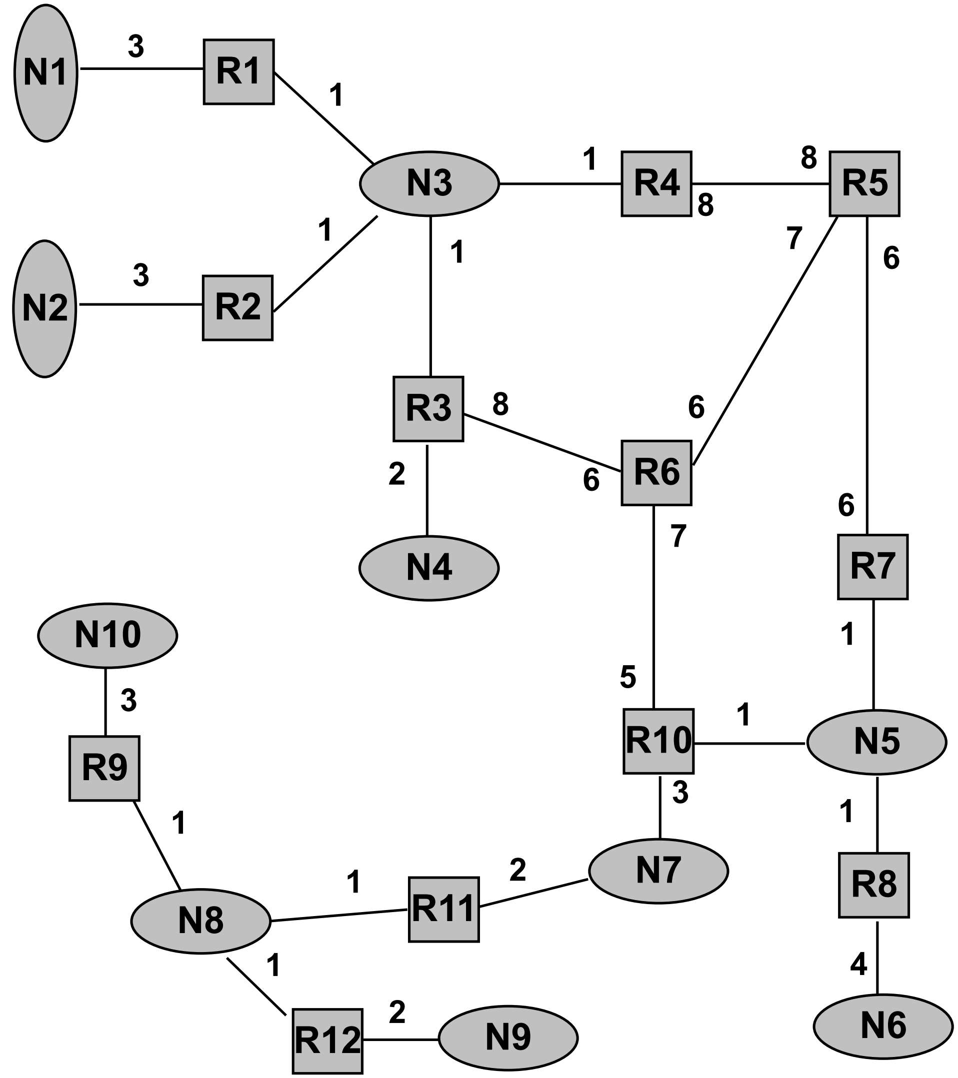
- The OSPF administrative distance is equal to 110.

Functioning principles

- Each router periodically send (default: 10 s) *Hello packets*, to notify its links status to the neighbors
- Each router describes its topology generating a Link State Advertisement (LSA) packet.
- The LSA is sent to all network routers using the flooding technique.
- Each router has a global network view (LSA database) and it is able to compute the set of shortest paths (Shortest Path Tree: SPT) executing the Dijkstra algorithm.

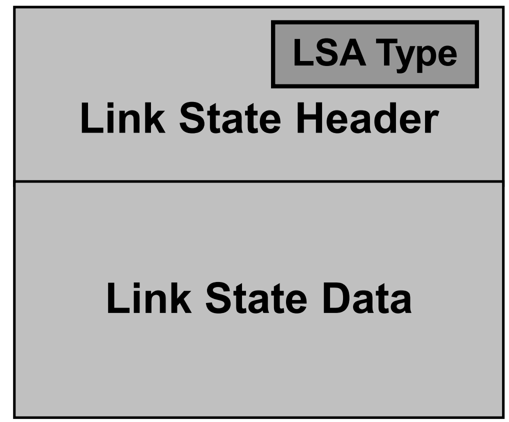
Routers and networks

- The elements of an AS are:
  - Routers
  - Networks: classified in Transit Networks (more than one router) and Stub Networks (connected to a single router)



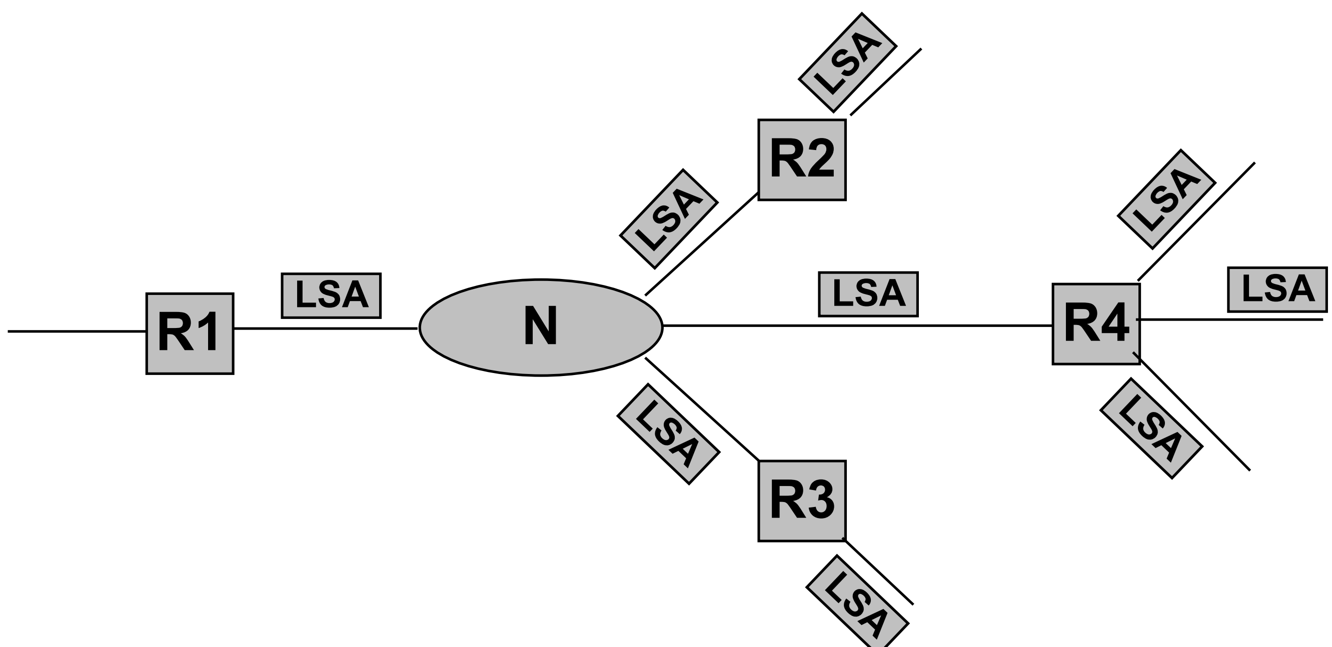
Link State Advertisment (LSA)

- An LSA is composed of a Link State Header and a Link State Data
- The Type field identifies the different LSAs:
    - ✓ Router_Lsa (type 1)
    - ✓ Network_Lsa (type 2)
    - ✓ ……………………………………



Flooding

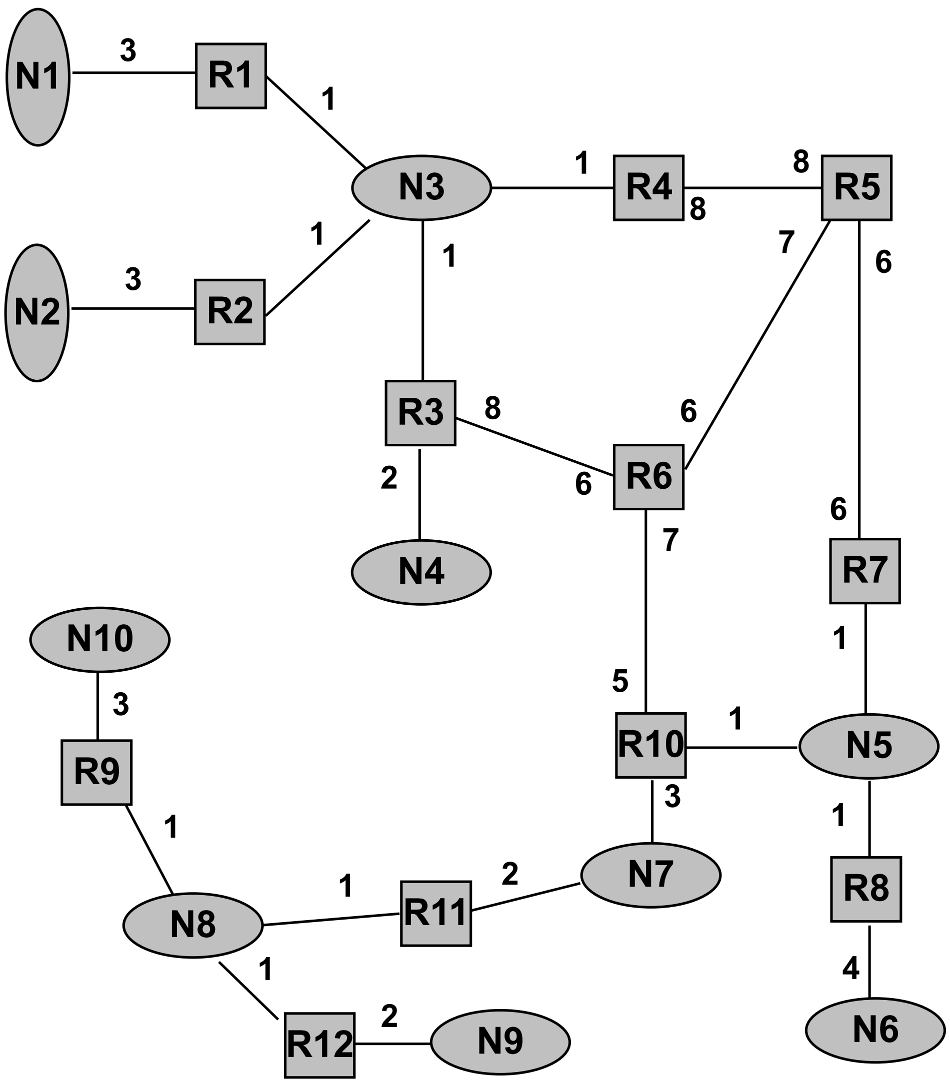
- The *flooding* technique:
  - an LSA received on an incoming interface is forward to all the remaining interfaces
  - each LSA has a sequence number
    - ✓ To avoid the forwarding of "old" LSAs (already forwarded);
    - ✓ To update the LSA database only if needed.

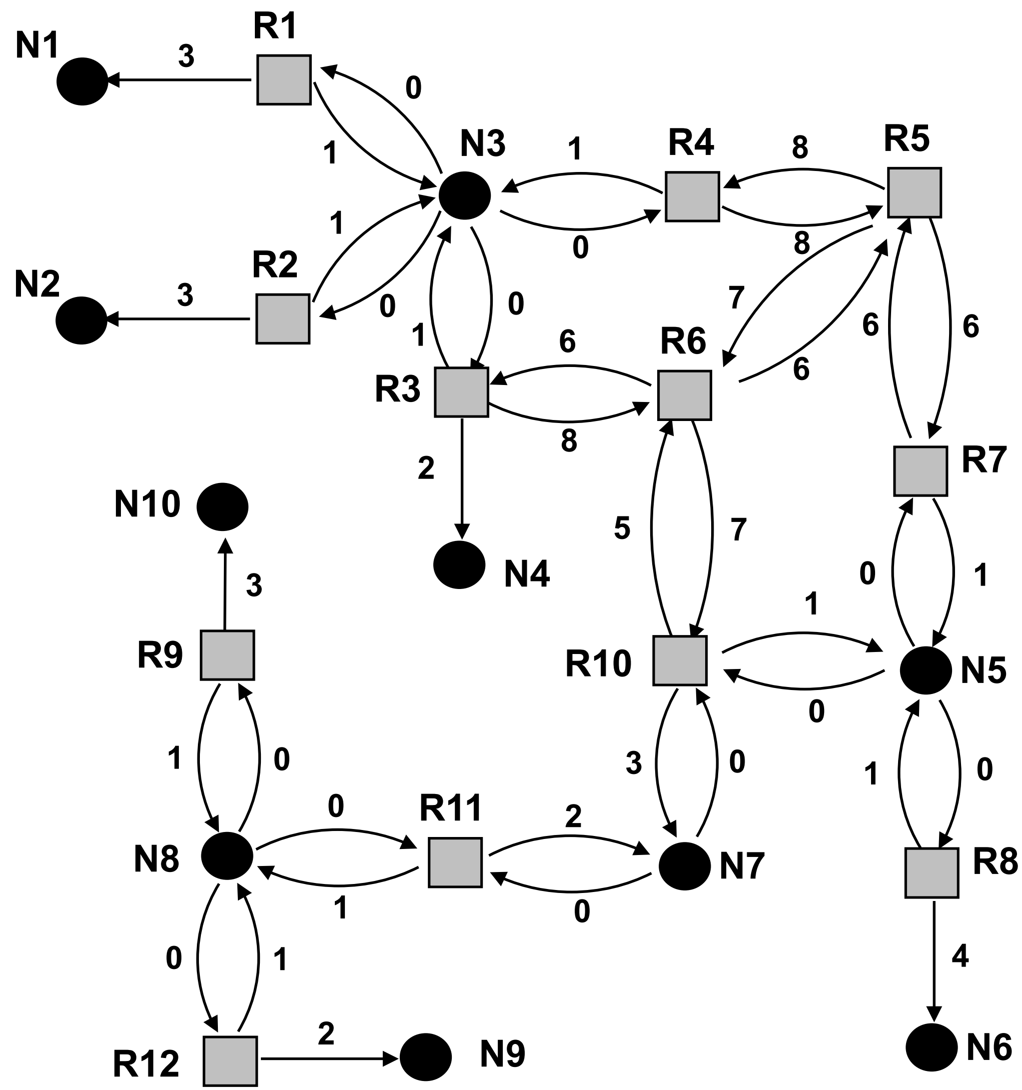


Shortest Path Tree computation

- A router maintains a database with the latest data on network topology.
- The network topology is a weighted graph where:
  - Nodes are routers and networks
  - Links are
    - Point-to-point links among routers;
    - Links among a router and a network.
- Each router computes the Shortest Path Tree (Dijkstra algorithm) and it is able to update its routing table.

OSPF: Example (1/2)

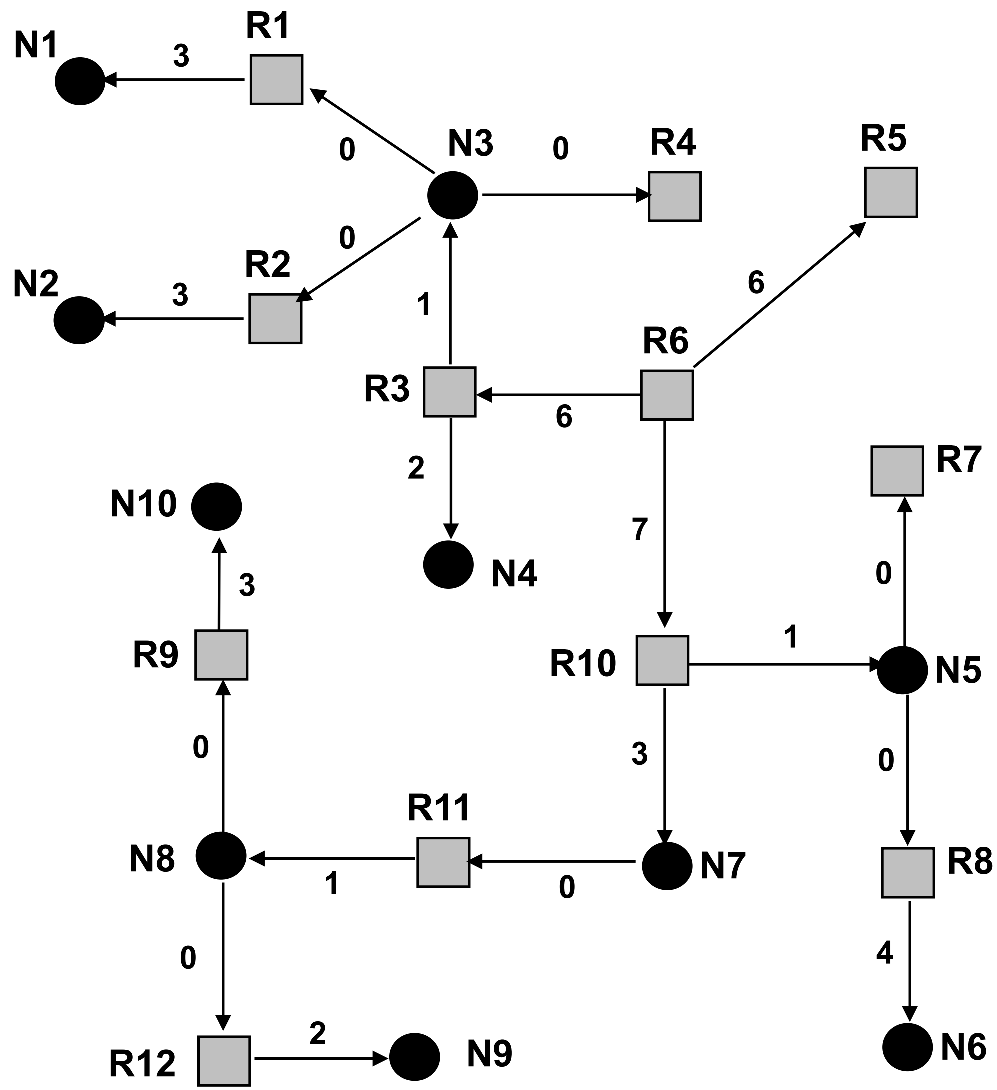




OSPF: Example (2/2)

- Shortest Path Tree e Routing Table for router R6

Destin.	N.H.	Cost
N1	R3	10
N2	R3	10
N3	R3	7
N4	R3	8
N5	R10	8
N6	R10	12
N7	R10	10
N8	R10	11
N9	R10	13
N10	R10	14



OSPF configuration

- The command to access to OSPF configuration is:

R(config)# router ospf *id*

- The *id* value is a number in interval [1 - 65535] and it has a local validity.

- Interfaces (and so networks) on which enable OSPF:

R(config-router)# network *network-address wildcard-mask* **area** *area-number*

  - The wildcard mask is obtained from netmask inverting 0s and 1s
  - Area: an AS can be divided into areas to solve scalability issues; area 0 is always present.

OSPF link cost

- The OSPF link cost it he metric value used to perform path computation.
- Can be changed into the interface configuration section:

  R(config)# interface FastEthernet X/Y

  R(config-if)# ip ospf cost *cost*

- By default it depends on the bandwidth:

Interface Type	10^8/ bps = Cost
Fast Ethernet and faster	10^8/ 100,000,000 bps = 1
Ethernet	10^8/ 10,000,000 bps = 10
E1	10^8/2,048,000 bps = 48
T1	10^8/ 1,544,000 bps = 64
128 kbps	10^8/ 128,000 bps = 781
64 kbps	10^8/64,000 bps = 1562
56 kbps	10^8/56,000 bps = 1785

- It can be used to implement simple Traffic Engineering

Verifica configurazione OSPF

R# show ip ospf neighbor

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.3          1   FULL/  -        00:00:30    192.168.10.6    Serial0/0/1
10.2.2.2          1   FULL/  -        00:00:33    192.168.10.2    Serial0/0/0
```

R# show ip protocols

```
R1#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 10.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.16 0.0.0.15 area 0
    192.168.10.0 0.0.0.3 area 0
    192.168.10.4 0.0.0.3 area 0
 Reference bandwidth unit is 100 mbps
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.2.2.2             110      11:29:29
    10.3.3.3             110      11:29:29
  Distance: (default is 110)
```

R# show ip ospf database

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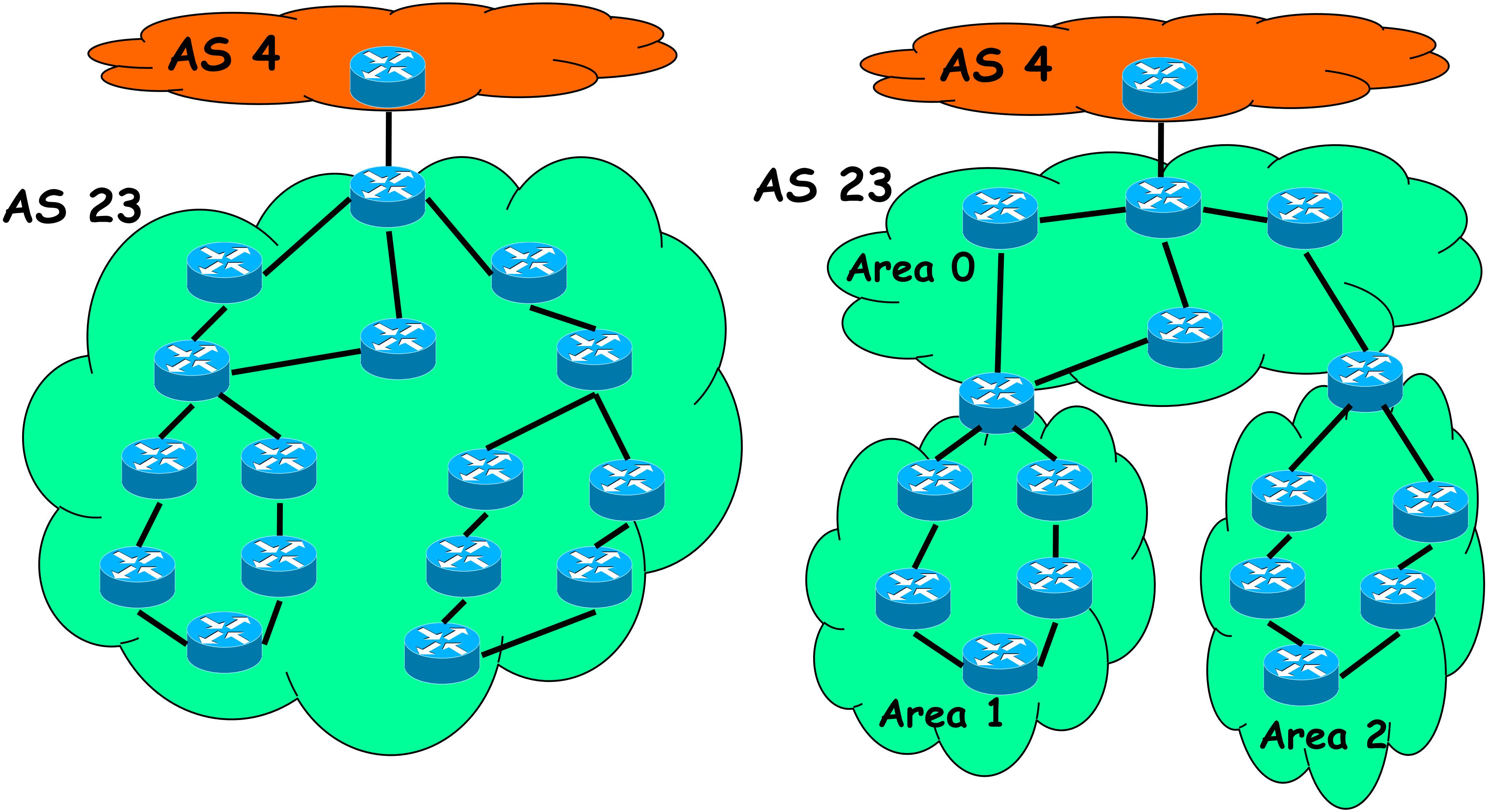
Multi-area OSPF

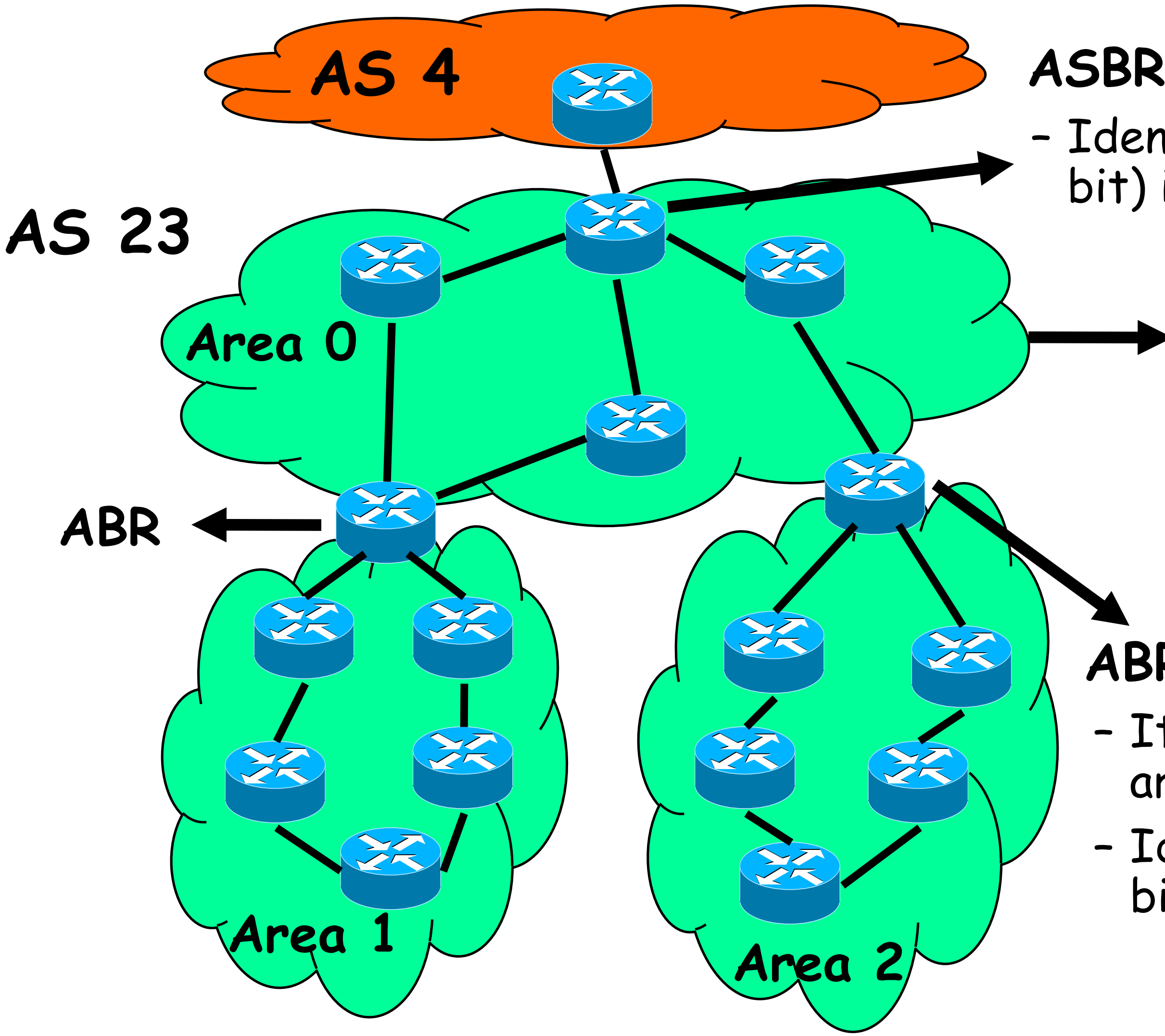
OSPF scalability issues

- The OSPF protocol can have scalability issues:
  - Each router maintains a database with the whole set of LSAs
  - The LSAs of routers and transit networks are sent inside the AS
  - The Shortest Path Tree computation (Dijkstra algorithm) time depends on the number of routers and transit networks → O(NlogN)
- The AS is divided into areas
- In each area, the “internal” routers exchange LSAs:
  - Different Databases in different areas
  - Flooding is restricted to the area

Multi-area OSPF (1/2)



Multi-area OSPF (2/2)



ASBR (AS Border Router)

- Identified by a proper bit (*e* bit) in the router LSA

Backbone area

- All areas must be connected to it
- ALWAYS present

ABR (Area Border Router)

- It has the databases of the areas it belongs to
- Identified by a proper bit (*b* bit) in the router LSA