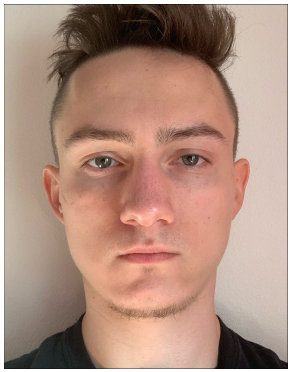
Enhanced Interior Gateway Routing Protocol

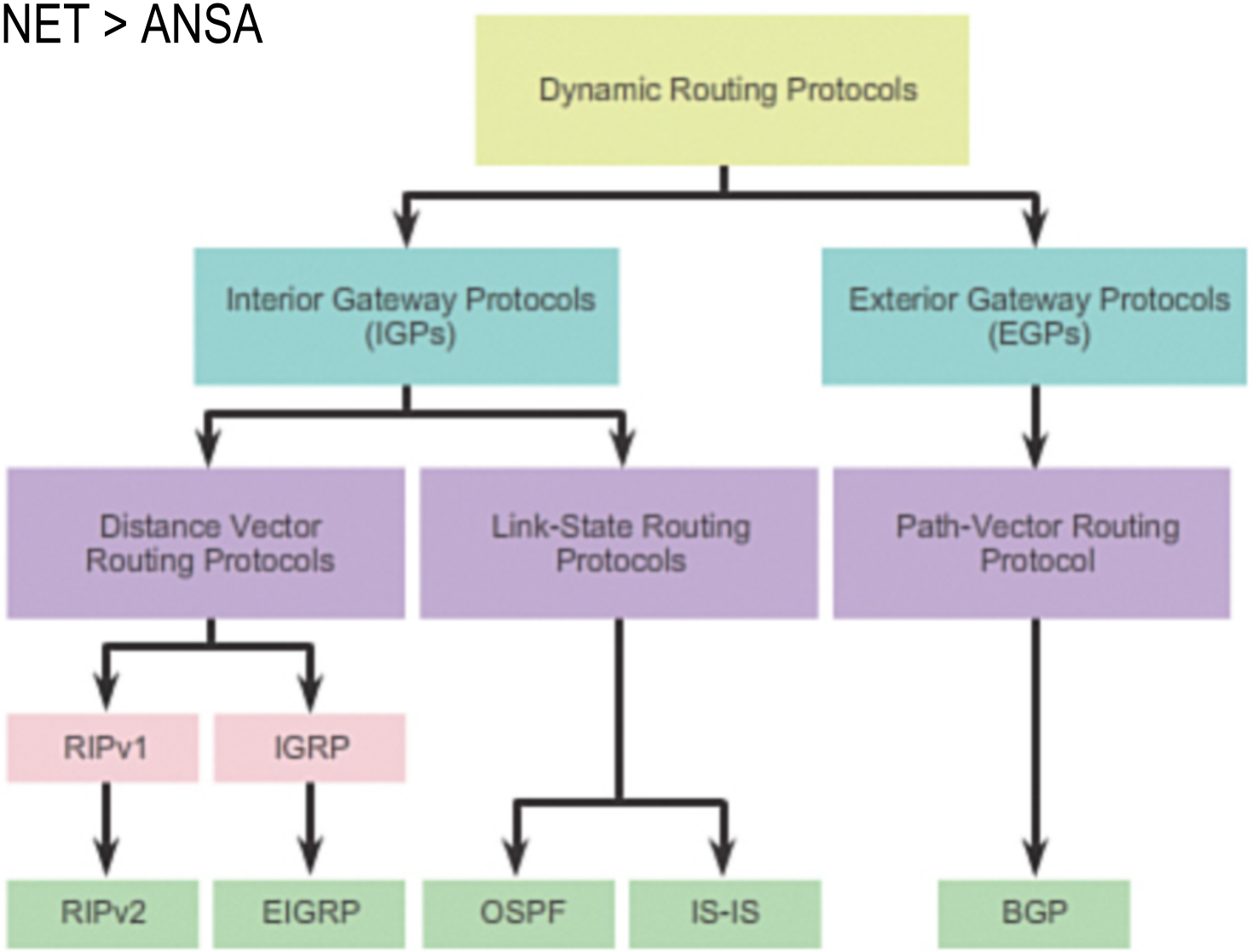


7th Virtual OMNeT++ Community Summit

5th October 2020, Zoom, Internet

MOTIVATION

- FIT is interested in routing&switching in enterprise networks
- INET > ANSA



EIGRP

- Hybrid DV

- Former cisco proprietary protocol invented with support of SRI International (prof. J.J. Garcia-Aceveda)
  - Document ID: 16406
  - RFC 7686
  - EIGRP – A fast routing protocol based on DV

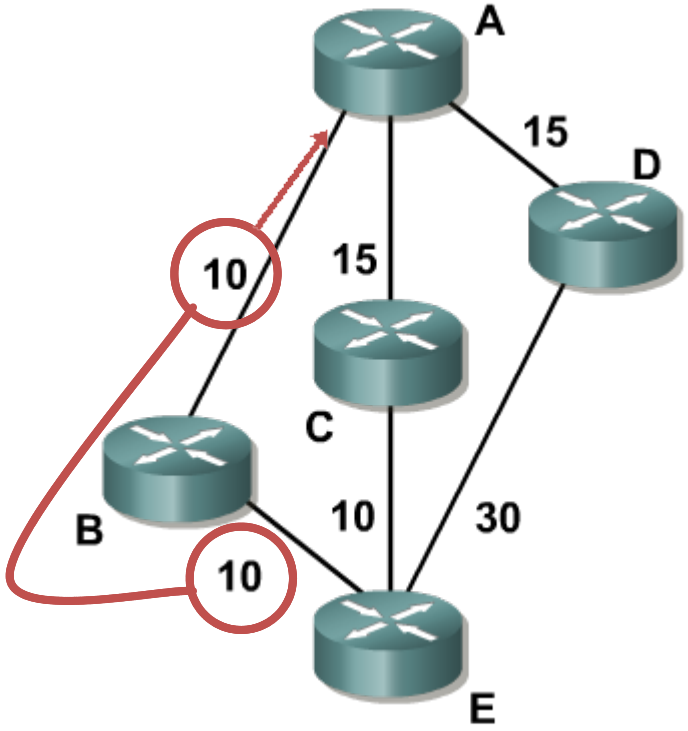
- Multi-protocol support (IP, IPX, AppleTalk)
- Multi-address family support (combine IPv4 and IPv6 routes in a single routing information update)

Main Features

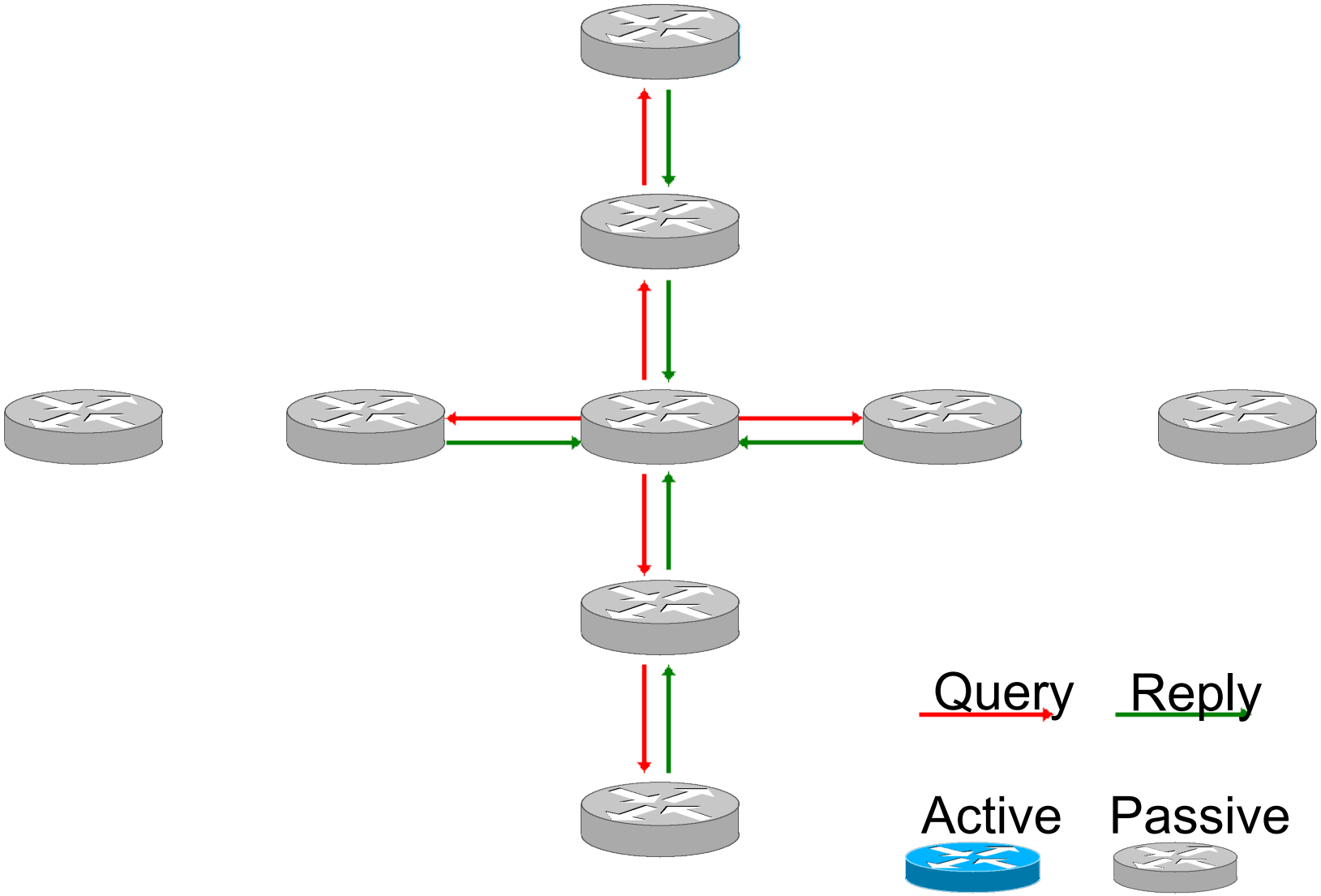
- **Protocol-dependent modules (PDMs)**
- **Neighbor Detection**
  - Every router has its own neighbor table where it stores information about directly connected neighbors
- **Reliable Transport Protocol (RTP)**
  - Transport protocol independent on L3 protocol – protocol number 88
  - Guarantees delivery of unicast and multicast communication
- **DUAL Finite-state Automata**
  - It directs whole best route selection mechanism
- **Loop-free Topology Protection**
  - Guarantees that each used next-hop doesn't cause routing loop in topology
  - Currently it is only routing protocol which guarantees (when configured appropriately) loop-free topology

TERMINOLOGY

- A **successor** represents the next-hop router where the route to the destination is the shortest.
- **Feasible successor** or so called backup next-hop
- **Reported distance** (RD) is distance from destination network advertised by a given EIGRP router neighbor
- **Feasible distance** (FD) is the best-known distance
- **Feasible condition** assumes that any route with $RD < FD$ is without any doubts loop-less

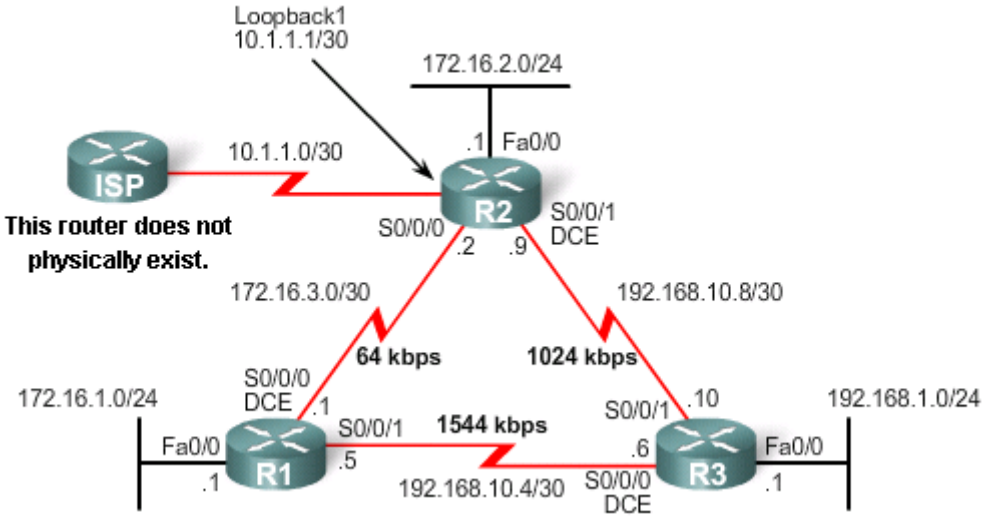


Diffuse Computation



METRIC

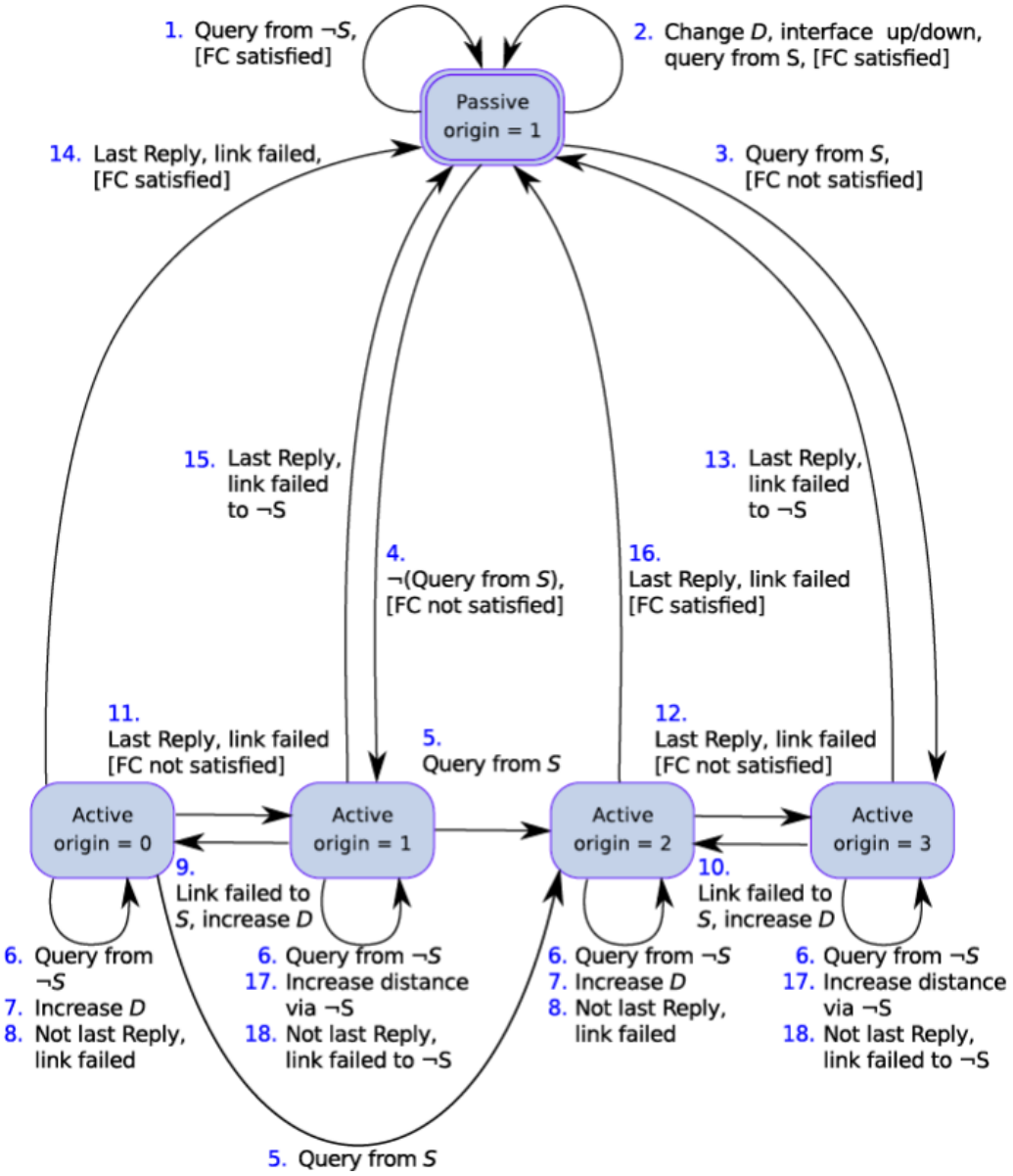
- **Composite metric**
  - Bandwidth
  - Delay
  - Reliability
  - Load
  - Jitter
  - Energy



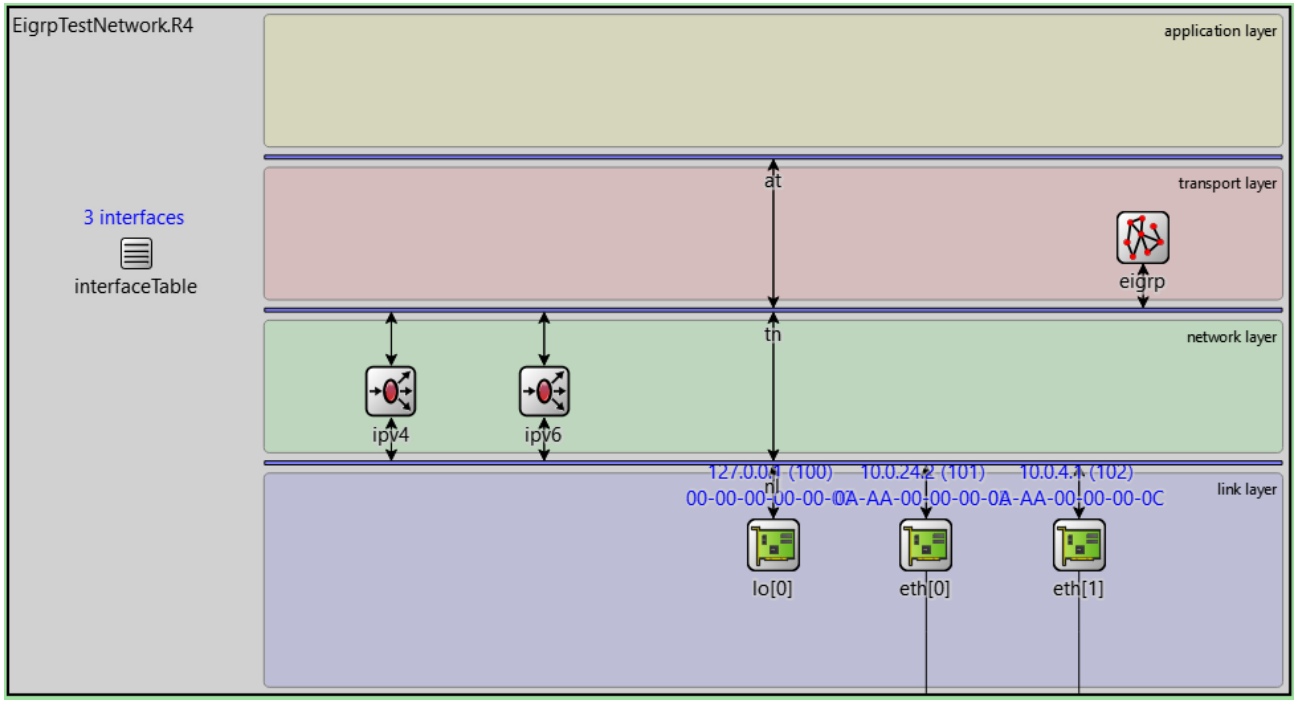

```
R2#show inter ser 0/0/1
Serial0/0/1 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 192.168.10.9/30
  MTU 1500 bytes, BW 1024 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
<remaining output omitted>
```

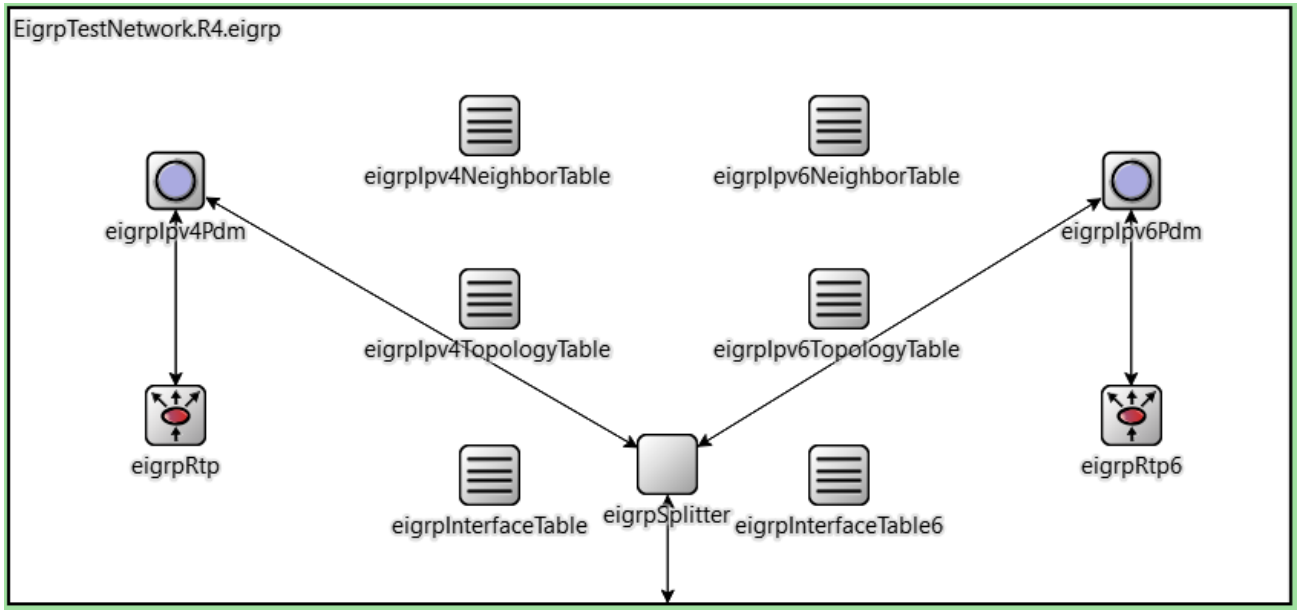
- Default formula $K_1 \cdot Bw + K_3 \cdot Dl$
- Complete formula $\left(K_1 \cdot Bw + \frac{K_2 \cdot Bw}{256 - Lo} + K_3 \cdot Dl\right) \cdot \frac{K_5}{Re + K_4}$
- Full-fledged $\left(K_1 \cdot Bw + \frac{K_2 \cdot Bw}{256 - Lo} + K_3 \cdot Dl + K_6 \cdot (En + Ji)\right) \cdot \frac{K_5}{Re + K_4}$

Finite-State Machine



IMPLEMENTATION





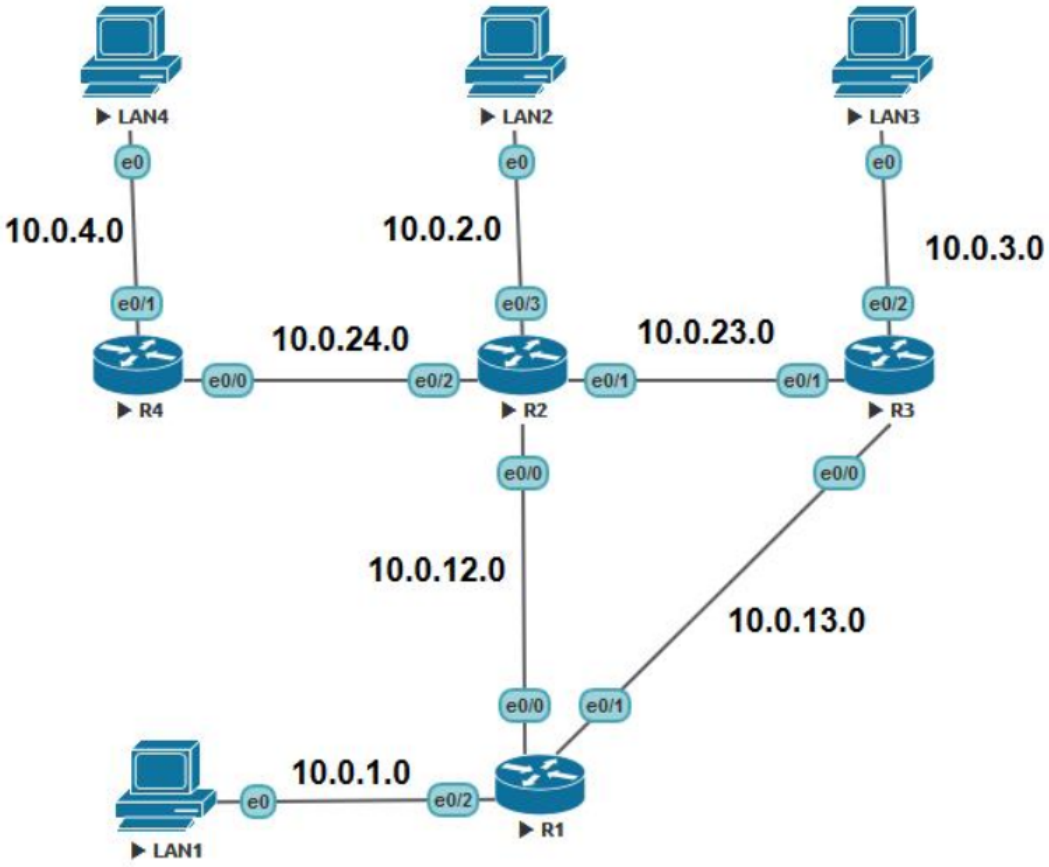
CONFIGURATION

```
<Devices>
        <!-- R1 -->
        <Router id="2001:db8:a::1">
        <Interfaces>
            <Interface name="eth2">
                <IPv6Address>2001:db8:a::1/64</IPv6Address>
                <EIGRP-IPv6 asNumber='1' />
            </Interface>
            <Interface name="eth0">
                                <IPv6Address>fe80:12::1/10</IPv6Address>
                <EIGRP-IPv6 asNumber='1' />
            </Interface>
            <Interface name="eth1">
                                <IPv6Address>fe80:13::1/10</IPv6Address>
                <EIGRP-IPv6 asNumber='1' />
            </Interface>
        </Interfaces>
        <Routing>
                <EIGRP>
                        <ProcessIPv4 asNumber="1">
                                <Networks>
                                        <Network>
                                                <IPAddress>10.0.1.0</IPAddress>
                                                        <Wildcard>0.0.0.255</Wildcard>
                                                </Network>
                                                <Network>
                                                <IPAddress>10.0.12.0</IPAddress>
                                                        <Wildcard>0.0.0.3</Wildcard>
                                                </Network>
                                                <Network>
                                                <IPAddress>10.0.13.0</IPAddress>
                                                        <Wildcard>0.0.0.3</Wildcard>
                                                </Network>
                                        </Networks>
                                <PassiveInterface>eth2</PassiveInterface>
                        </ProcessIPv4>
                </EIGRP>
        </Routing>

        <Routing6>
                <EIGRP>
                        <ProcessIPv6 asNumber="1" routerId="10.0.1.0">
                                <PassiveInterface>eth2</PassiveInterface>
                        </ProcessIPv6>
                </EIGRP>
        </Routing6>
    </Router>
```

TESTING

- Validation against real-network Cisco implementation



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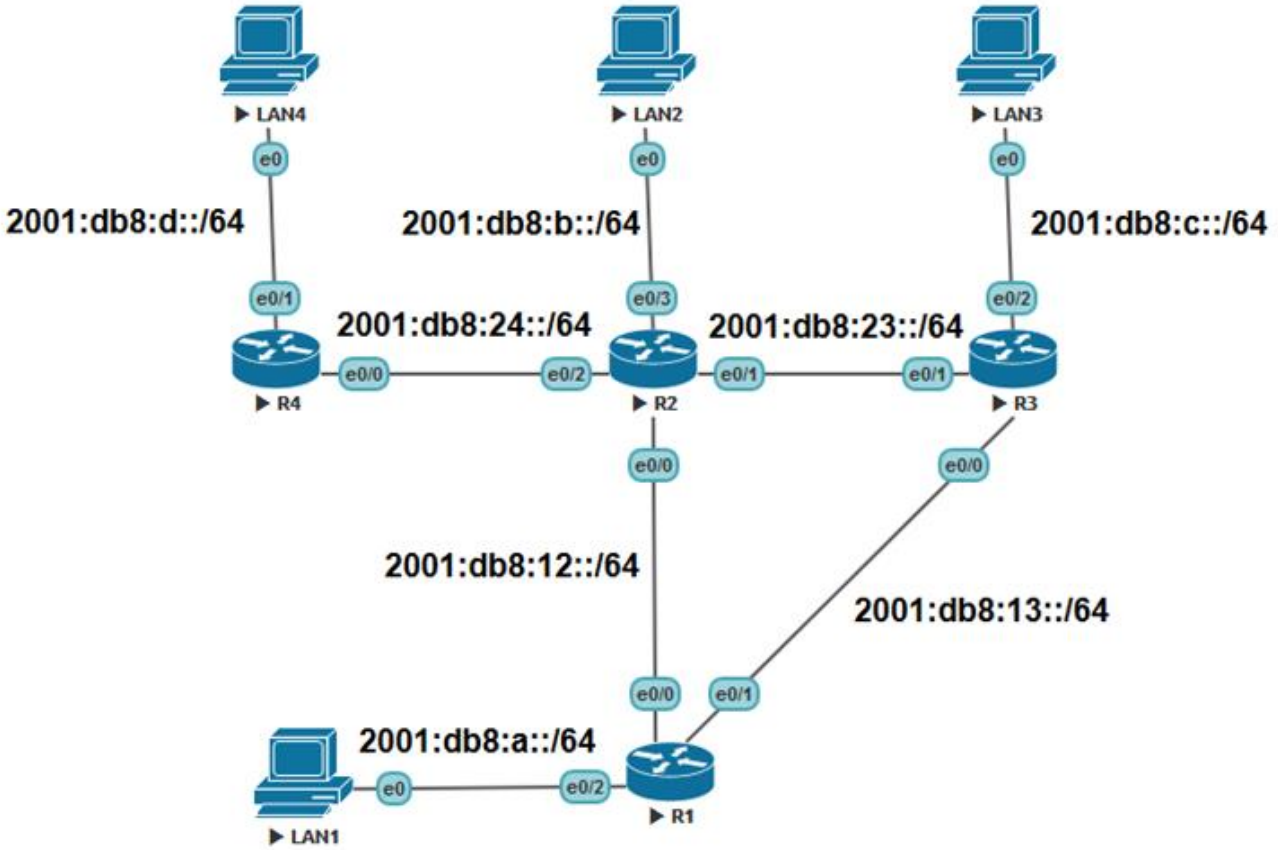

COMPARING OUTCOMES


```
P 2001:DB8:A::/64, 1 successors, FD is 281600
        via Connected, Ethernet0/2
P 2001:DB8:23::/64, 2 successors, FD is 307200
        via FE80:12::2 (307200/281600), Ethernet0/0
        via FE80:13::3 (307200/281600), Ethernet0/1
P 2001:DB8:B::/64, 1 successors, FD is 307200
        via FE80:12::2 (307200/281600), Ethernet0/0
P 2001:DB8:24::/64, 1 successors, FD is 307200
        via FE80:12::2 (307200/281600), Ethernet0/0
P 2001:DB8:D::/64, 1 successors, FD is 332800
        via FE80:12::2 (332800/307200), Ethernet0/0
P 2001:DB8:12::/64, 1 successors, FD is 281600
        via Connected, Ethernet0/0
P 2001:DB8:C::/64, 1 successors, FD is 307200
        via FE80:13::3 (307200/281600), Ethernet0/1
P 2001:DB8:13::/64, 1 successors, FD is 281600
        via Connected, Ethernet0/1
```

[0] P 2001:db8:a::/64 is successor FD:28160 via Connected (28160/0), IF:eth2(103)
[1] P 2001:db8:d::/64 is successor FD:33280 via fe80:12::2 (33280/30720), IF:eth0(101)
[2] P 2001:db8:d::/64 FD:33280 via fe80:13::3 (35840/33280), IF:eth1(102)
[3] P 2001:db8:c::/64 is successor FD:30720 via fe80:13::3 (30720/28160), IF:eth1(102)
[4] P 2001:db8:c::/64 FD:30720 via fe80:12::2 (33280/30720), IF:eth0(101)
[5] P 2001:db8:24::/64 is successor FD:30720 via fe80:12::2 (30720/28160), IF:eth0(101)
[6] P 2001:db8:24::/64 FD:30720 via fe80:13::3 (33280/30720), IF:eth1(102)
[7] P 2001:db8:23::/64 is successor FD:30720 via fe80:12::2 (30720/28160), IF:eth0(101)
[8] P 2001:db8:23::/64 is successor FD:30720 via fe80:13::3 (30720/28160), IF:eth1(102)
[9] P 2001:db8:b::/64 is successor FD:30720 via fe80:12::2 (30720/28160), IF:eth0(101)
[10] P 2001:db8:b::/64 FD:30720 via fe80:13::3 (33280/30720), IF:eth1(102)
[11] P 2001:db8:13::/64 is successor FD:28160 via Connected (28160/0), IF:eth1(102)
[12] P 2001:db8:12::/64 is successor FD:28160 via Connected (28160/0), IF:eth0(101)

COMPARING OUTCOMES

```
P 10.0.3.0/24, 1 successors, FD is 307200, serno 5
        via 10.0.13.2 (307200/281600), Ethernet0/1
        via 10.0.12.2 (332800/307200), Ethernet0/0
P 10.0.1.0/24, 1 successors, FD is 281600, serno 3
        via Connected, Ethernet0/2
P 10.0.2.0/24, 1 successors, FD is 307200, serno 8
        via 10.0.12.2 (307200/281600), Ethernet0/0
        via 10.0.13.2 (332800/307200), Ethernet0/1
P 10.0.13.0/24, 1 successors, FD is 281600, serno 2
        via Connected, Ethernet0/1
P 10.0.4.0/24, 1 successors, FD is 332800, serno 9
        via 10.0.12.2 (332800/307200), Ethernet0/0
        via 10.0.13.2 (358400/332800), Ethernet0/1
P 10.0.23.0/24, 2 successors, FD is 307200, serno 6
        via 10.0.12.2 (307200/281600), Ethernet0/0
        via 10.0.13.2 (307200/281600), Ethernet0/1
P 10.0.12.0/24, 1 successors, FD is 281600, serno 1
        via Connected, Ethernet0/0
P 10.0.24.0/24, 1 successors, FD is 307200, serno 7
        via 10.0.12.2 (307200/281600), Ethernet0/0
        via 10.0.13.2 (332800/307200), Ethernet0/1
```

[0] P 10.0.12.0/30 is successor FD:28160 via Connected (28160/0), IF:eth0(101)

[1] P 10.0.3.0/24 is successor FD:30720 via 10.0.13.2 (30720/28160), IF:eth1(102)

[2] P 10.0.3.0/24 FD:30720 via 10.0.12.2 (33280/30720), IF:eth0(101)

[3] P 10.0.4.0/24 is successor FD:33280 via 10.0.12.2 (33280/30720), IF:eth0(101)

[4] P 10.0.4.0/24 FD:33280 via 10.0.13.2 (35840/33280), IF:eth1(102)

[5] P 10.0.2.0/24 is successor FD:30720 via 10.0.12.2 (30720/28160), IF:eth0(101)

[6] P 10.0.2.0/24 FD:30720 via 10.0.13.2 (33280/30720), IF:eth1(102)

[7] P 10.0.24.0/30 is successor FD:30720 via 10.0.12.2 (30720/28160), IF:eth0(101)

[8] P 10.0.24.0/30 FD:30720 via 10.0.13.2 (33280/30720), IF:eth1(102)

[9] P 10.0.23.0/30 is successor FD:30720 via 10.0.12.2 (30720/28160), IF:eth0(101)

[10] P 10.0.23.0/30 is successor FD:30720 via 10.0.13.2 (30720/28160), IF:eth1(102)

[11] P 10.0.1.0/24 is successor FD:28160 via Connected (28160/0), IF:eth2(103)

[12] P 10.0.13.0/30 is successor FD:28160 via Connected (28160/0), IF:eth1(102)

COMPARING OUTCOMES

```
C        10.0.1.0/24 is directly connected, Ethernet0/2
L        10.0.1.1/32 is directly connected, Ethernet0/2
D        10.0.2.0/24 [90/307200] via 10.0.12.2, 00:02:59, Ethernet0/0
D        10.0.3.0/24 [90/307200] via 10.0.13.2, 00:02:57, Ethernet0/1
D        10.0.4.0/24 [90/332800] via 10.0.12.2, 00:02:59, Ethernet0/0
C        10.0.12.0/24 is directly connected, Ethernet0/0
L        10.0.12.1/32 is directly connected, Ethernet0/0
C        10.0.13.0/24 is directly connected, Ethernet0/1
L        10.0.13.1/32 is directly connected, Ethernet0/1
D        10.0.23.0/24 [90/307200] via 10.0.13.2, 00:03:02, Ethernet0/1
                      [90/307200] via 10.0.12.2, 00:03:02, Ethernet0/0
D        10.0.24.0/24 [90/307200] via 10.0.12.2, 00:02:59, Ethernet0/0
```

[0] C 10.0.12.0/30 gw:* metric:20 if:eth0

[1] C 10.0.13.0/30 gw:* metric:20 if:eth1

[2] D 10.0.23.0/30 gw:10.0.12.2 metric:30720 if:eth0

[3] D 10.0.23.0/30 gw:10.0.13.2 metric:30720 if:eth1

[4] D 10.0.24.0/30 gw:10.0.12.2 metric:30720 if:eth0

[5] C 10.0.1.0/24 gw:* metric:20 if:eth2

[6] D 10.0.2.0/24 gw:10.0.12.2 metric:30720 if:eth0

[7] D 10.0.3.0/24 gw:10.0.13.2 metric:30720 if:eth1

[8] D 10.0.4.0/24 gw:10.0.12.2 metric:33280 if:eth0

CONTRIBUTION

- We have extended INET 4.2 with EIGRP simulation modules

- We are going to prepare EIGRP tutorials (and also RIP and BGP ones)
  - https://inet.omnetpp.org/docs/tutorials/

ANSA.OMNETPP.ORG