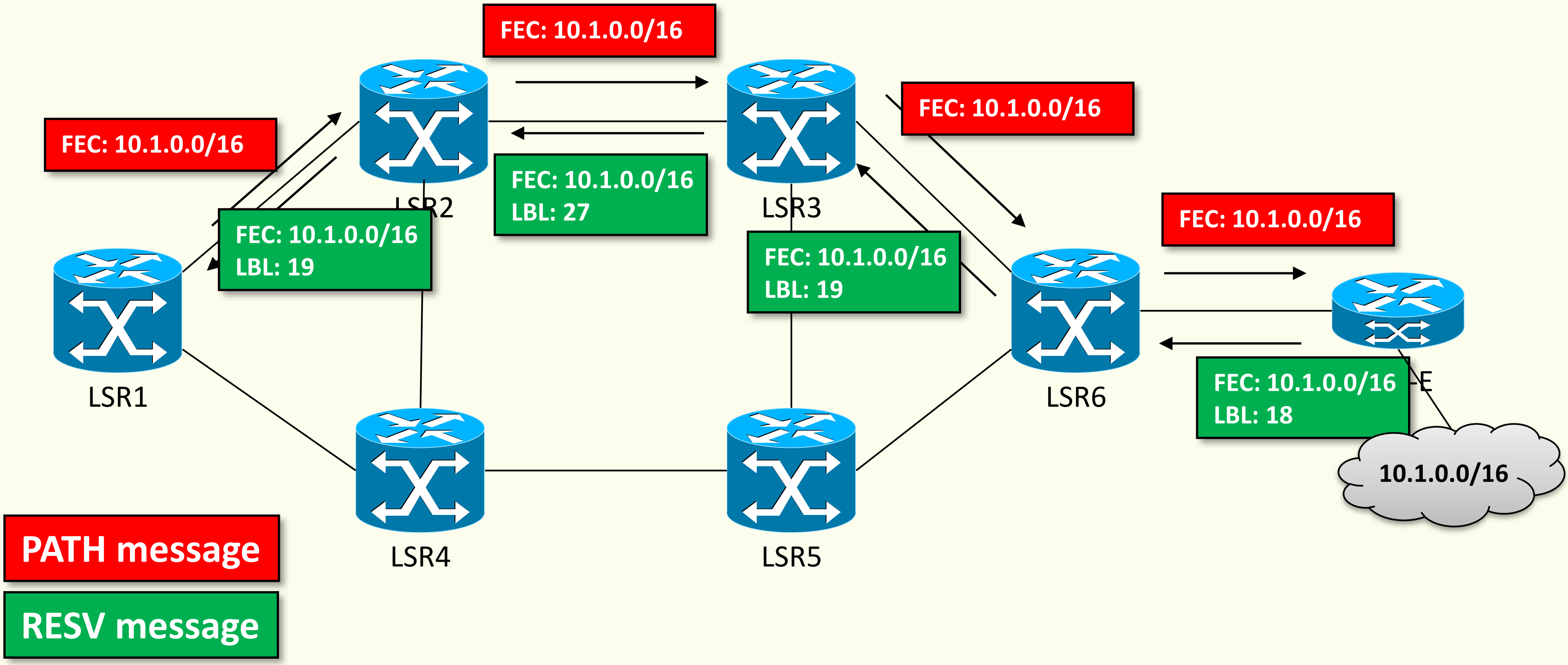
RSVP for label distribution

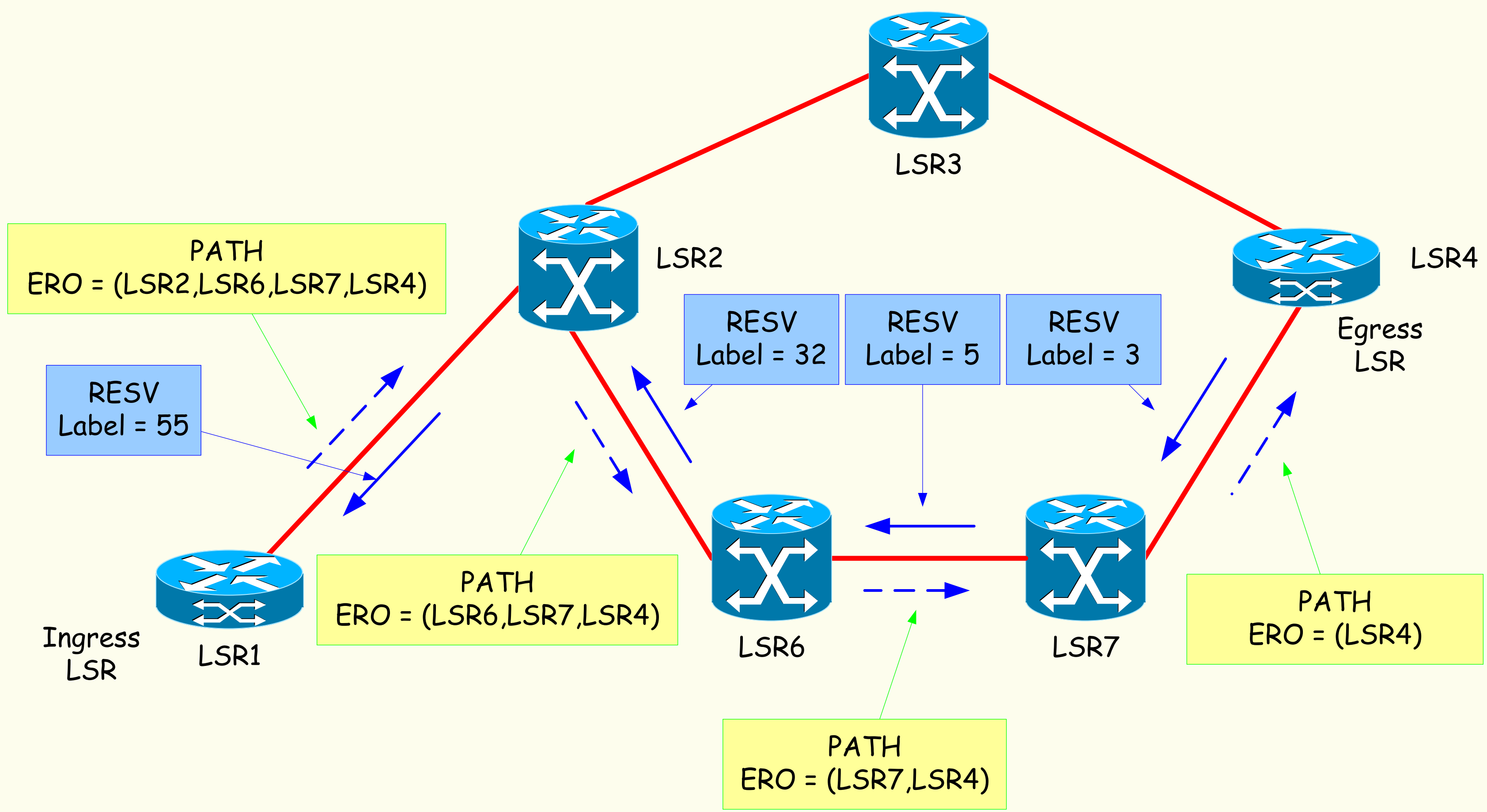
- Ordered control with downstream on-demand



RSVP-TE

- RSVP is extended to support LSP setup after CSPF computation
  - The LSP ***head-end*** has full (ordered) control of the setup
- Realized by the definition of new Objects carried by Path and Resv messages
  - *Path* objects: **Label Request Object**, **Explicit Route Object** (ERO), **Sender TSpec** (revisited)
  - *Resv* objects: **Label Object**
  - Common to both: **Record Route Object** (RRO)

RSVP-TE

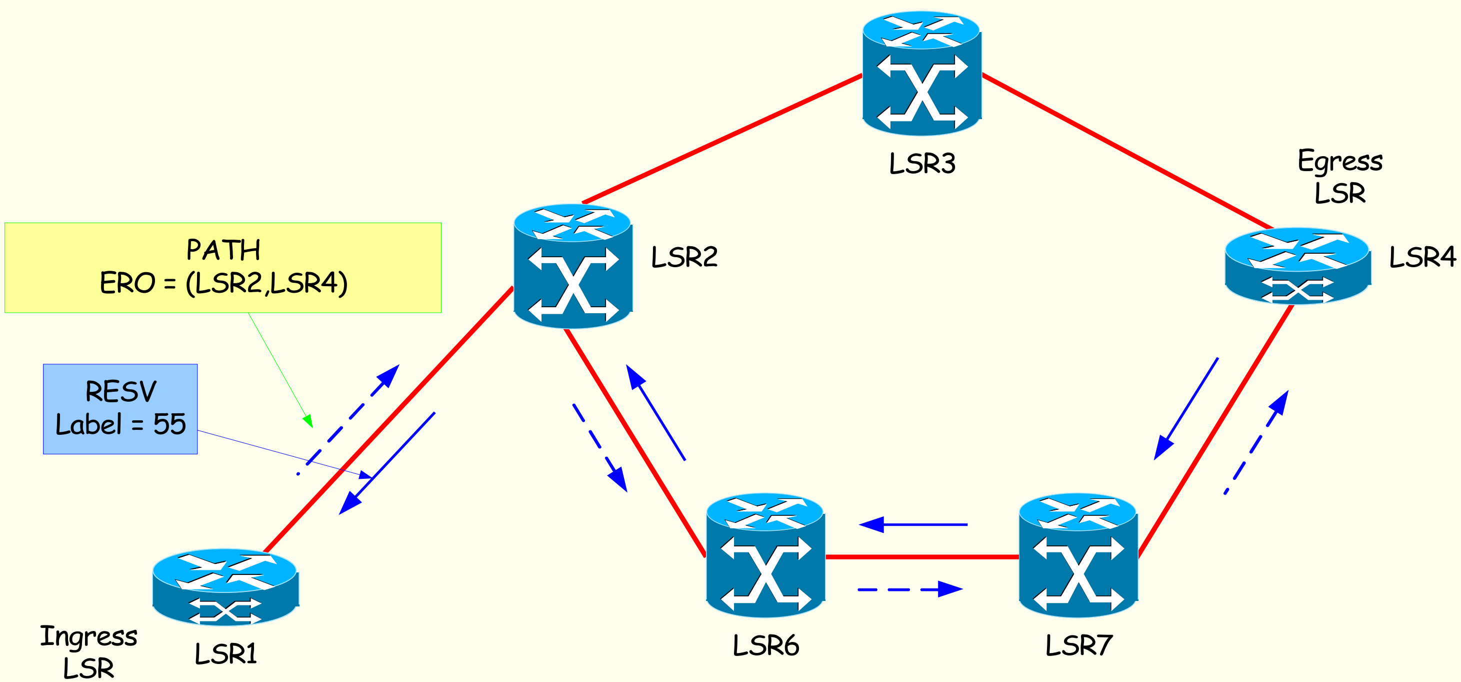

LSR3
LSR2
LSR4
PATH
ERO = (LSR2,LSR6,LSR7,LSR4)
RESV
Label = 32
RESV
Label = 5
RESV
Label = 3
Egress
LSR
RESV
Label = 55
PATH
ERO = (LSR6,LSR7,LSR4)
Ingress
LSR
LSR1
LSR6
LSR7
PATH
ERO = (LSR4)
PATH
ERO = (LSR7,LSR4)

RSVP-TE

- Explicit Route Object
  - consists of a sequence of sub-objects, each representing an **abstract node**, i.e., **a group** of one or more routers
  - **Strict** vs. **loose** hops

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|L|    Type     |     Length    | IPv4 address (4 bytes)        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| IPv4 address (continued)      | Prefix Length |      Resvd    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

RSVP-TE



LSR3
Egress
LSR
LSR4
LSR2
PATH
ERO = (LSR2,LSR4)
RESV
Label = 55
Ingress
LSR
LSR1
LSR6
LSR7

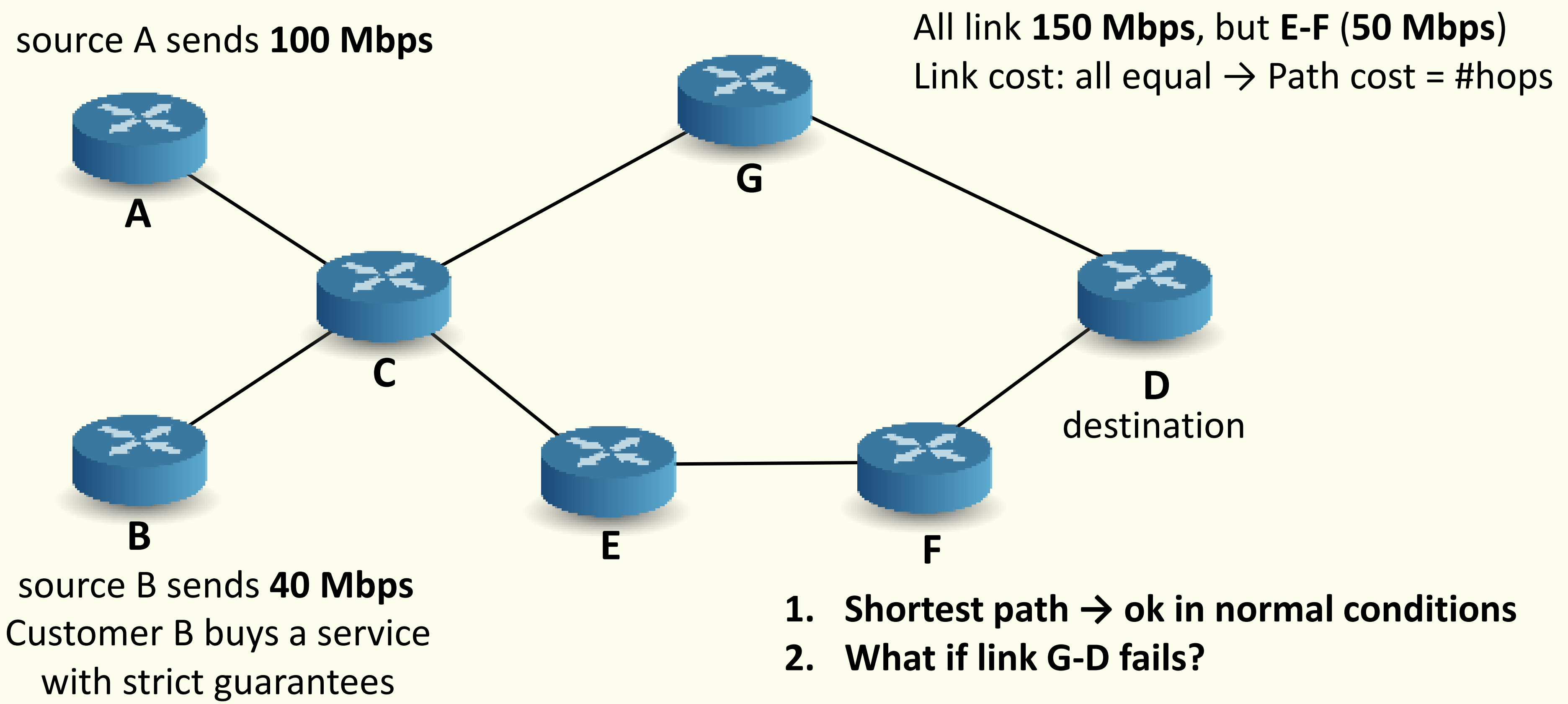
RSVP-TE

- Admission control is **required** and performed at each hop
  - CSPF computation is not mandatory
  - Unreserved bandwidth on a link has changed after CSPF computation
  - The TED at the head-end is not accurate
- If LSP setup is successful, reservation updates are fed back to OSPF-TE
- **Bandwidth reservations are in the control plane only!**

LSP priorities

- LSP have **priorities**, used to solve for resource contention
  - An important LSP is always established along the most optimal (shortest) path that fits the constraints, **regardless of existing reservations**
  - When LSPs need to reroute (e.g. after a link failure), important LSPs have a **better chance of finding an alternate path**
  - In the **absence of important LSPs**, resources can be reserved by less important LSPs

Application scenario [3]



1. **Shortest path → ok in normal conditions**
2. **What if link G-D fails?**

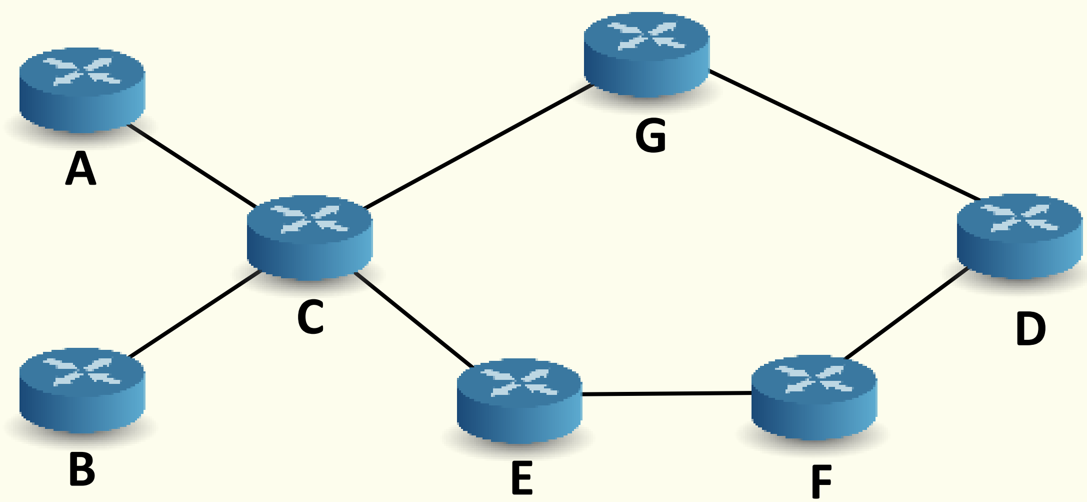
find paths between source/destination pairs that **comply with bandwidth constraints**, enforce the **priority of the path** sourced at B over that sourced at A

LSP priorities

- Eight priority levels, **two** priorities per LSP
  - **Setup** priority (0 highest – 7 lowest): controls access to the resources when the LSP is established
  - **Hold** priority (0 highest – 7 lowest): controls access to the resources for an LSP that is already established
- When an LSP is set up, if not enough resources are available, the setup priority of the new LSP is compared to the hold priority of the LSPs using the resources in order to determine whether the new LSP **can preempt** any of the existing LSPs and take over their resources

LSP priorities

- Why distinct priorities?
  - Case 1: All LSPs have Hold Pri 0 & Setup Pri 7
  - Case 2: All LSPs have Hold Pri 7 & Setup Pri 0



1. a new LSP can never preempt an existing LSP and in turn can never be preempted

2. constant churn if two LSPs compete for the same resource

Reoptimization

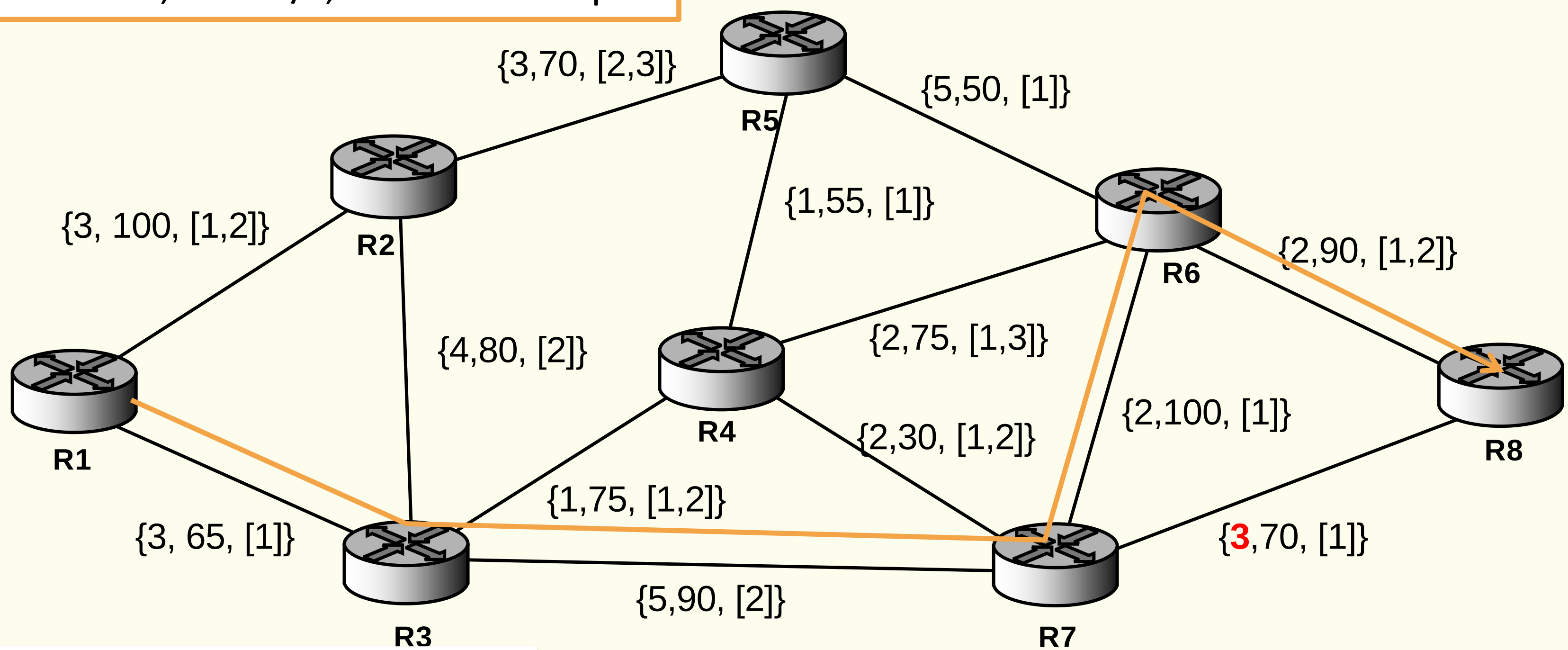
- Due to dynamic changes, also the optimal solution for an LSP may change over time
- **Reoptimization** is the process of recomputing CSPF on each update
  – Trade-off between stability and optimization

- Without a full knowledge of **present** and **future** LSP requirements, **any algorithm is sub-optimal**

Reoptimization

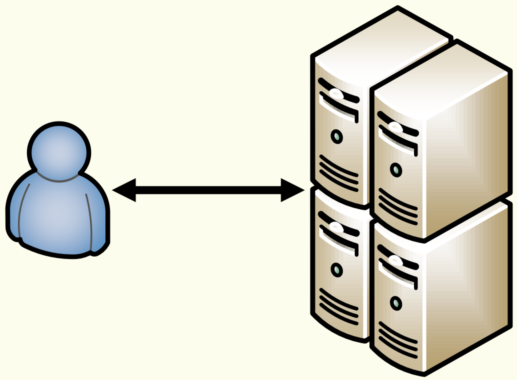
- Re-routing an LSP without any traffic loss: ***make-before-break*** approach

LSP: R1→R8, 60Mb/s, exclude Group 3

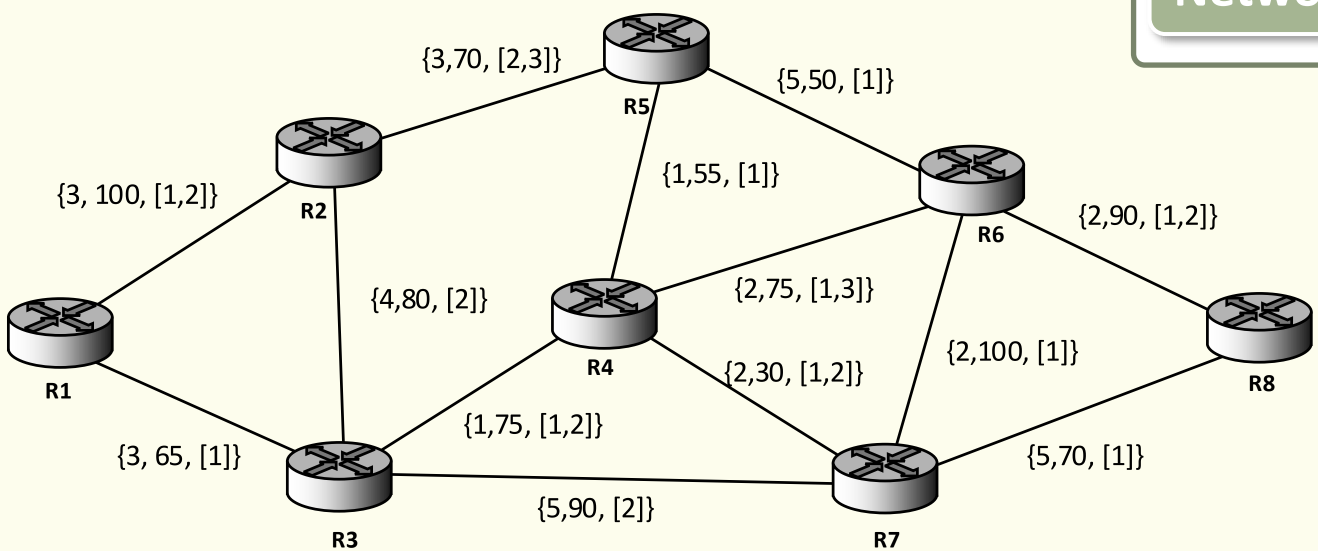


Shared Explicit (SE) reservation

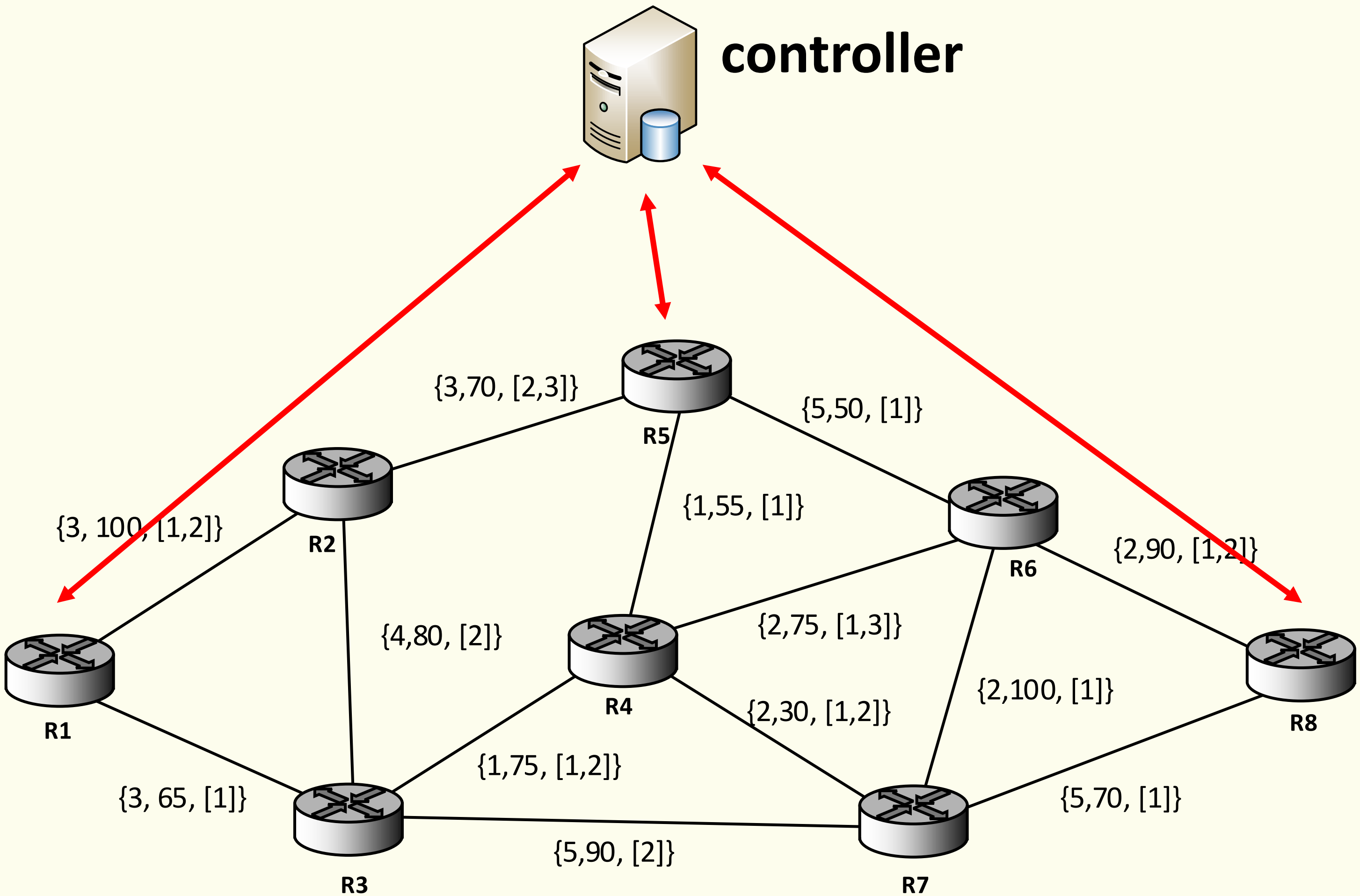
Centralized (offline) TE



- Traffic demand estimation
- Topology and network state discovery
- Route computation
- Network configuration



Centralized (online) TE

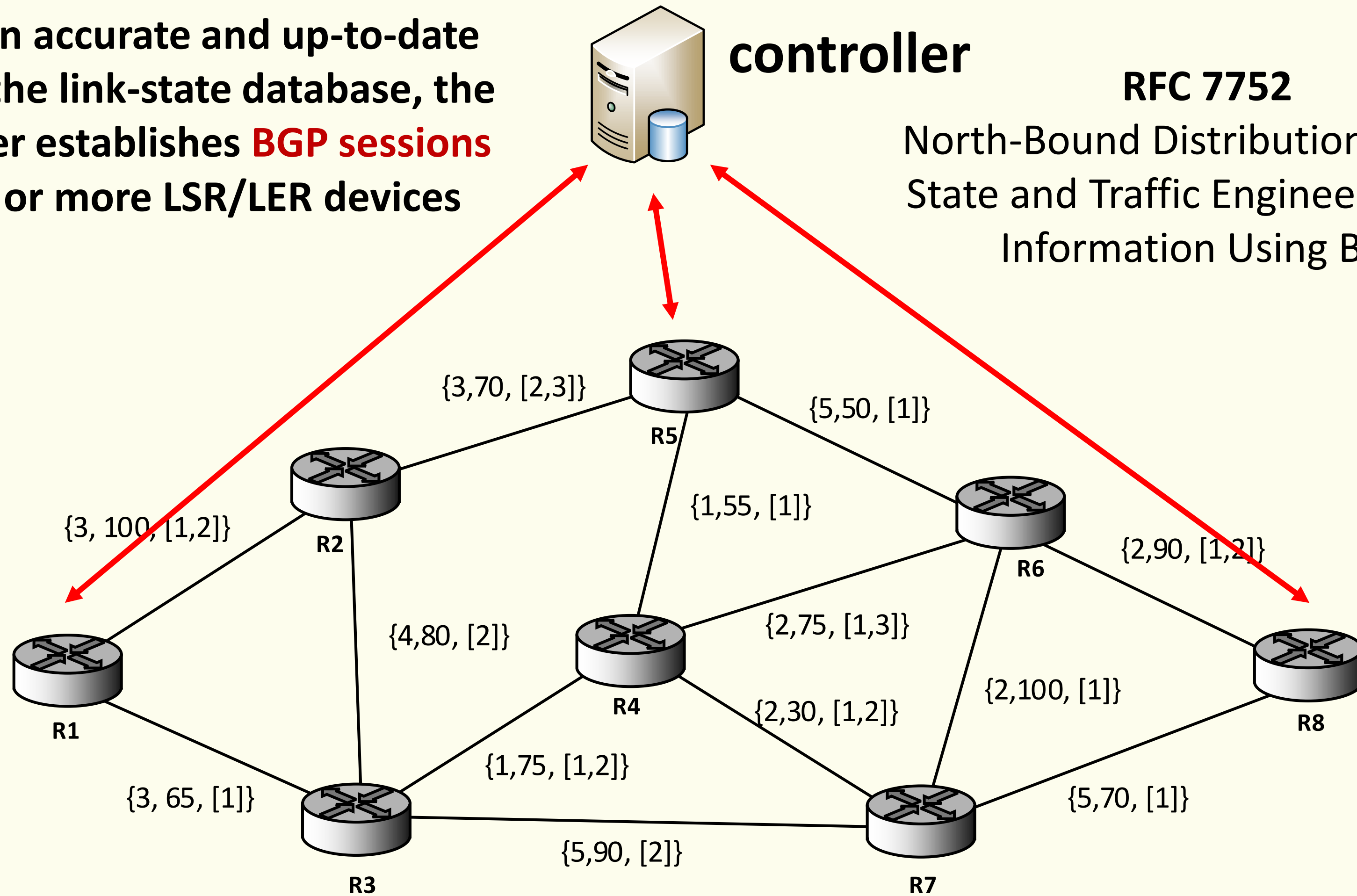


Centralized (online) TE

To get an accurate and up-to-date view of the link-state database, the controller establishes **BGP sessions** to one or more LSR/LER devices

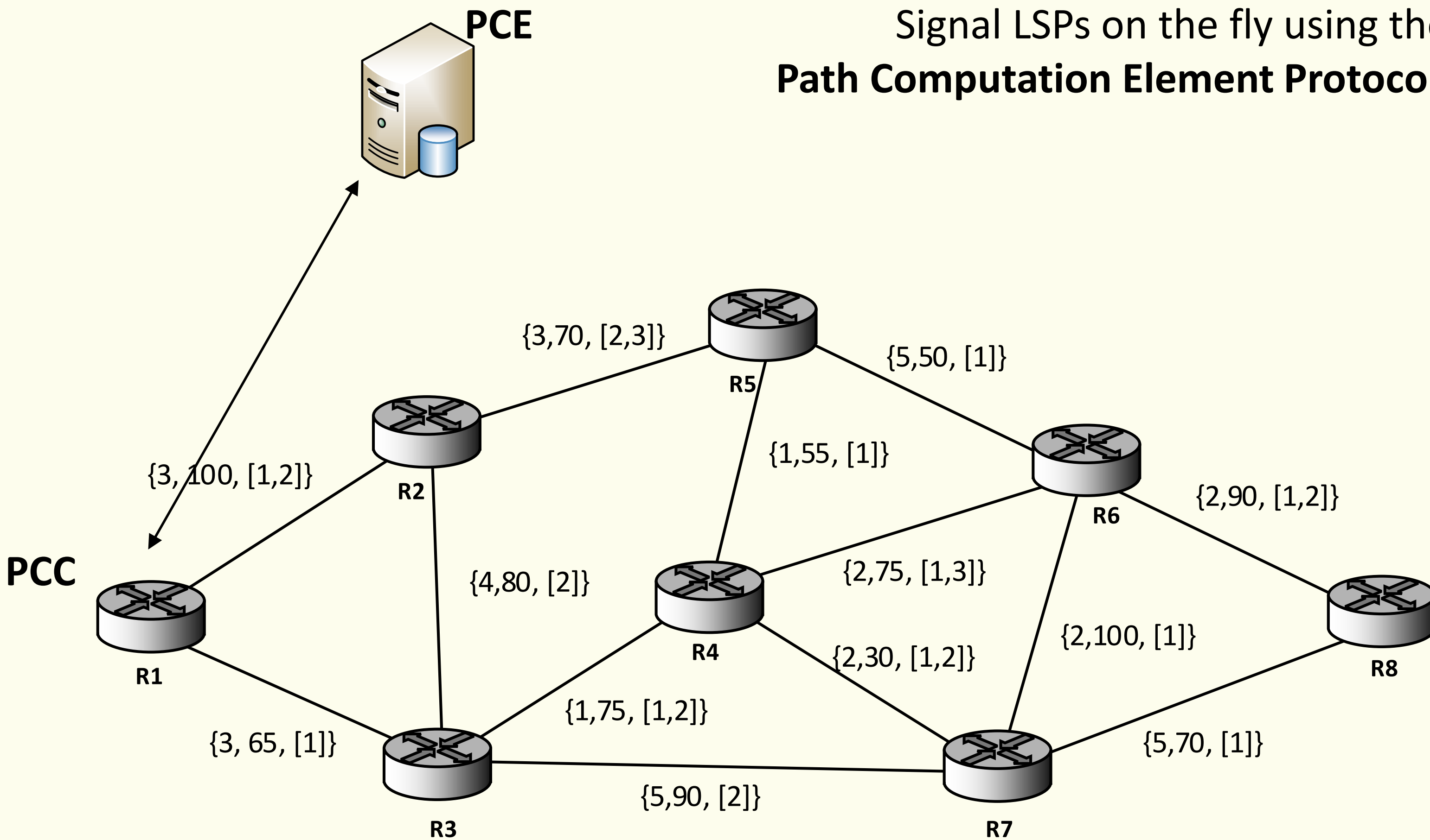
RFC 7752

North-Bound Distribution of Link-State and Traffic Engineering (TE) Information Using BGP



Path Computation Element

Signal LSPs on the fly using the
Path Computation Element Protocol (PCEP)

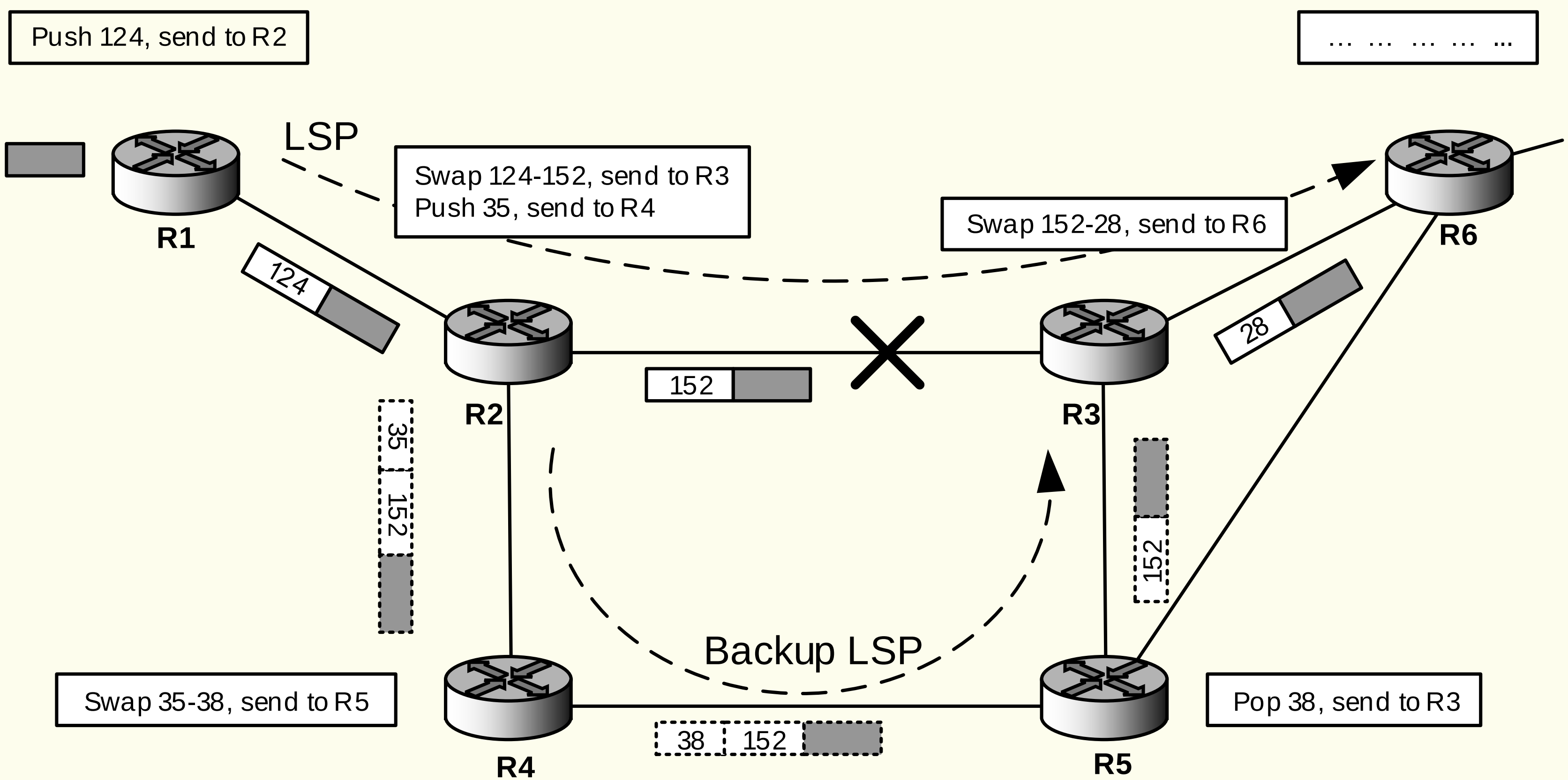


Protection and restoration

- Protection and restoration are mechanisms to handle failures
- It requires fast failure detection

1. Path protection (end-to-end)
   – LSP protection is achieved using two LSPs: the *primary*, used under normal operation, and the *secondary*, used if there is a failure on the primary
2. Local protection using **fast reroute**
   – Link vs. node protection
   – One vs. many LSP protected

Link protection, many LSPs



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