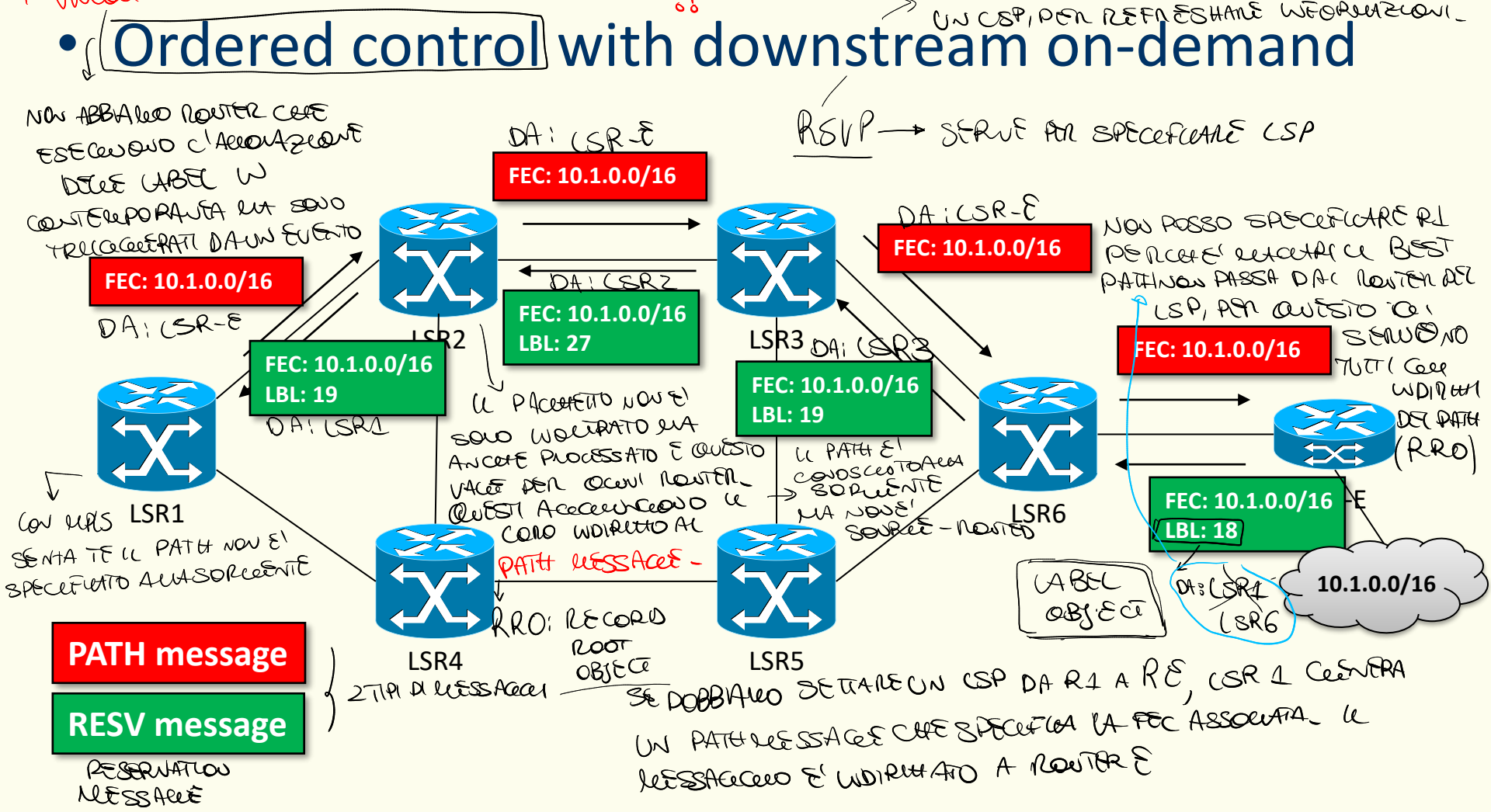
RSVP for label distribution

- Ordered control with downstream on-demand



PERCHÉ DOBBIAMO CONTROLLARE COMUNQUE AD OGNI ROUTER CHE IL LINK RISPETTI I VINCOLI?

IL LOCAL TRAFFIC-ENGINEERING DATABASE POTREBBE NON ESSERE AGGIORNATO.

↓

IL MOMENTO IN CUI È PIÙ ACCURATA L'INFORMAZIONE È PROPRIO UN ISTANTE PRIMA DELLA RESERVATION.

↳ UNRESERVED BANDWIDTH È UN VALORE DINAMICO E SOLO IL ROUTER DIRETTAMENTE COLLEGATO A QUEL LINK CONOSCE IL VALORE IN MODO ACCURATO.

SE L'ALLOCAZIONE NON VA A BUON FINE A CAUSA DELL'INACCURATEZZA DEL LOCAL-TE DB

(CALCOLO IL PATH IN R1 CON UN DB NON AGGIORNATO POI CONTROLLO IL VINCOLO ANCHE SUL ROUTER DIRETTAMENTE COLLEGATO AL LINK)

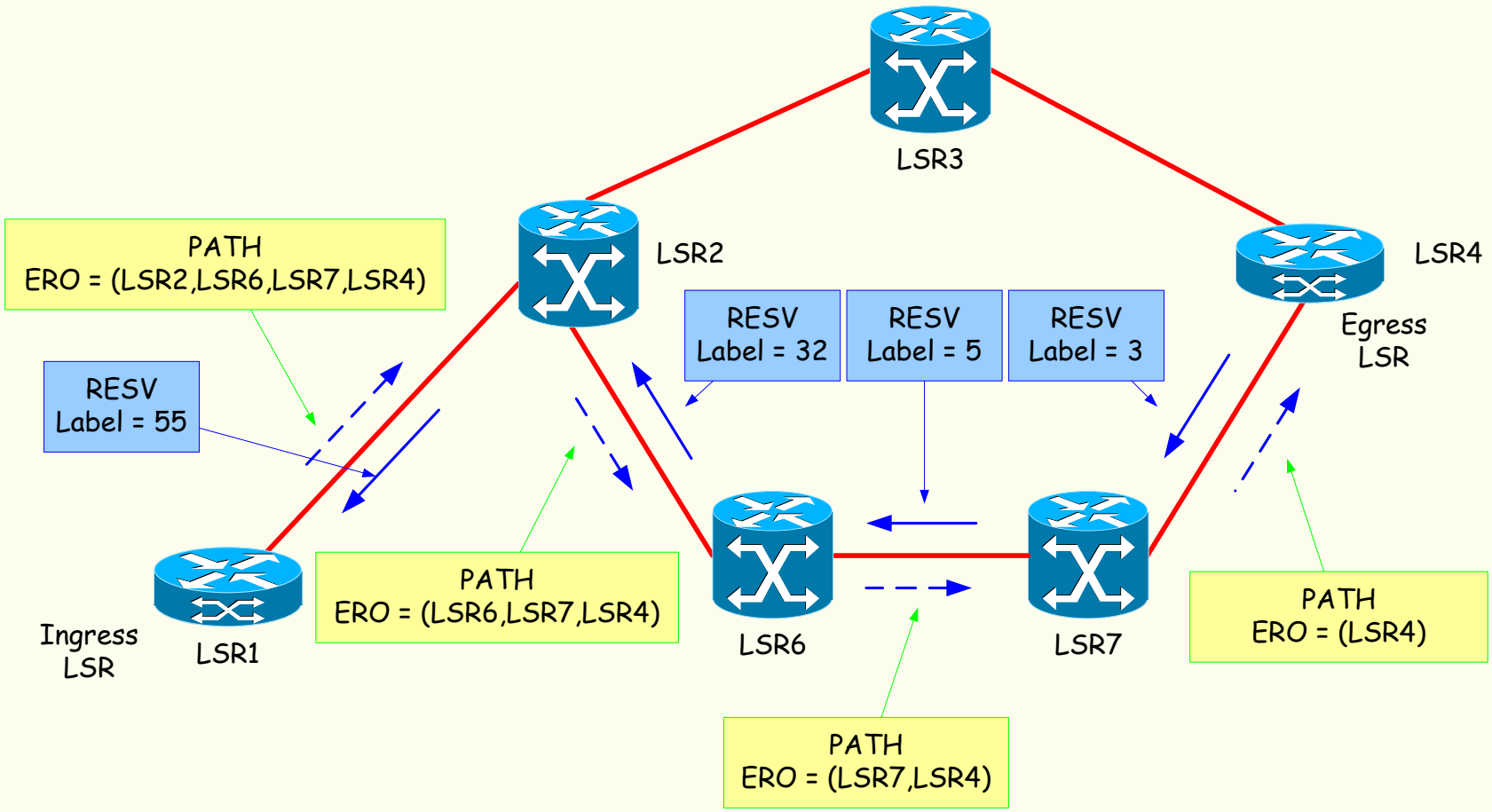
ALLORA ANZICHÉ RITORNARE LA LABEL, VIENE RITORNATO UN MESSAGGIO DI FAIL

APPROCCIO ANCORA MOLTO DISTRIBUITO.

RSVP-TE

- RSVP is extended to support LSP setup after CSPF computation
  - The LSP ***head-end*** has full (ordered) control of the setup (source)
- 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
Egress LSR
PATH
ERO = (LSR2,LSR6,LSR7,LSR4)
RESV
Label = 32
RESV
Label = 5
RESV
Label = 3
RESV
Label = 55
Ingress LSR
LSR1
PATH
ERO = (LSR6,LSR7,LSR4)
LSR6
LSR7
PATH
ERO = (LSR4)
PATH
ERO = (LSR7,LSR4)

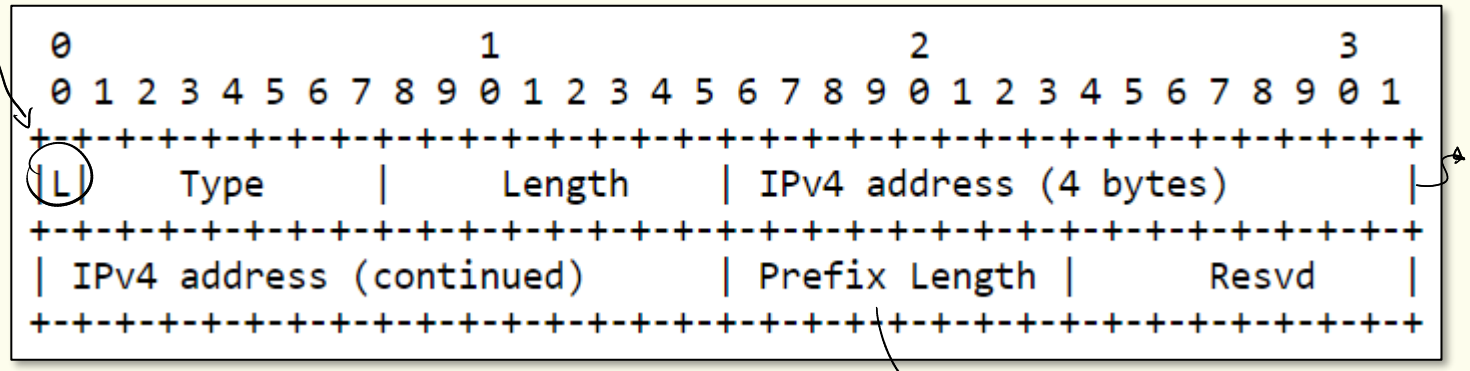
RSVP-TE

- 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

NEL CASO PIÙ CENTRALE ABBIAMO UNA SORGENTE IBRIDA ALCUNE COMPUTAZIONI SONO EFFETTUATE SUL ROUTER SORGENTE E ALTRE SONO DELEGATE AI ROUTER DEL PATH.

↳ ROUTER CHE PUÒ ESSERE UN SINGOLO ROUTER NON DIRETTAMENTE COLLEGATO O UN GRUPPO IDENTIFICATO DA UN PREFISSO DI RETE.

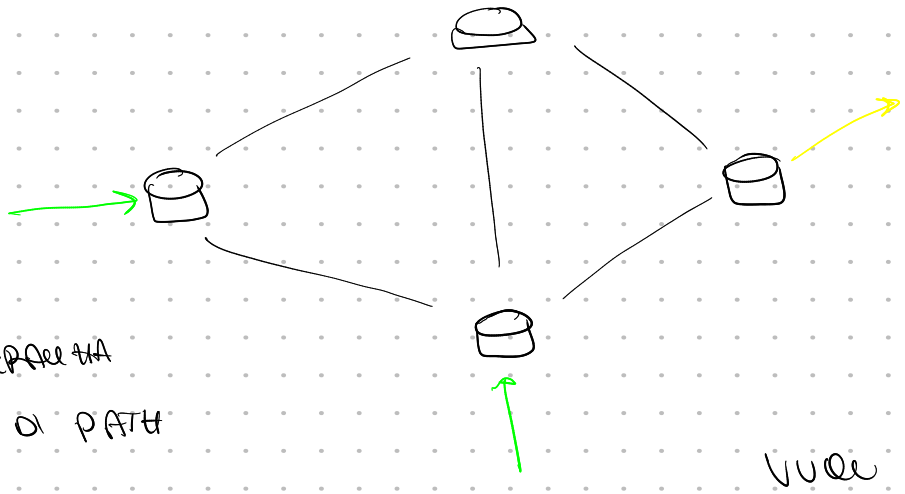
SI APPLICA AD OGNI HOP (ASTRATTO ONO)
SI RIFERISCE AL SEGUENTE ATTRAVERSATO DALL'HOP PRECEDENTE A QUESTO.



SPECIFIC HOP

SE /32 È UN NODO ALTRIMENTI UN GRUPPO

LOOPBACK ADDRESS: 172.16.0.0/24



IPv4 ADDRESS = 172.16.00.

PREFIX LENGTH = 24

CENTRALINA

L'IDEA DI PATH

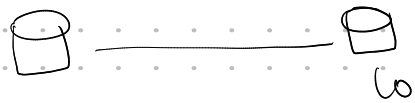
VUOL DIRE CHE VOGLIO CHE IL PATH PASSI DA QUESTA RETE, NON IMPORTA COME.

PERCHÉ IL SOURCE NON POTREBBE USARE QUESTA FUNZIONE?

NON CONOSCE LA TOPOLOGIA DELLA RETE.

NON SO QUALE È IL BEST PATH MA SO CHE CI DEVO PASSARE

- STRICT VS LOOSE HOPS



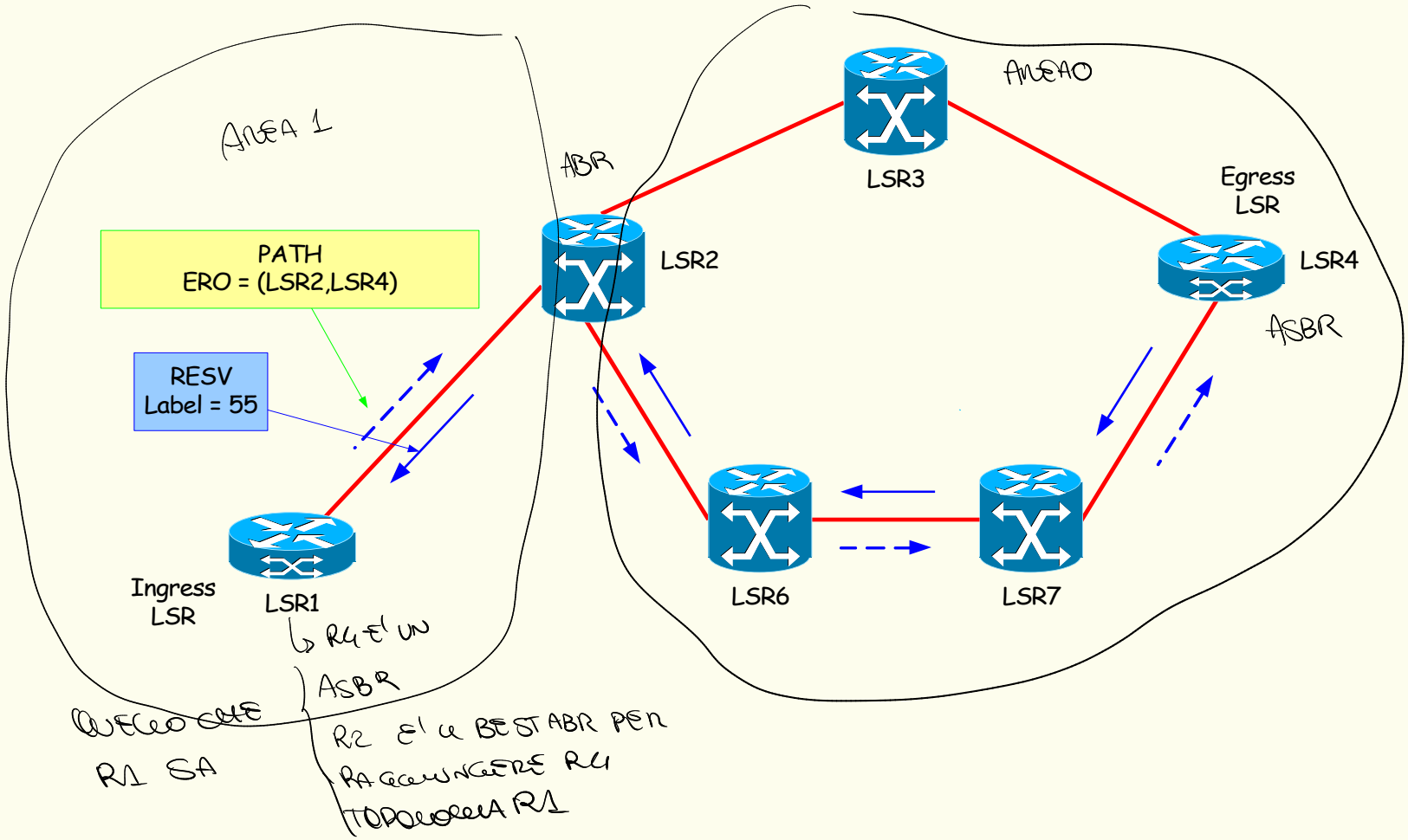
LOOPBACK: 172.16.0.1/32

PUÒ ESSERE STRICT OR LOOSE

STRICT → L'HOP PRECEDENTE DEVE ESSERE DIRETTAMENTE COLLEGATO

LOOSE → TRA IL PRECEDENTE HOP E QUESTO CI PUÒ ESSERE QUALSIASI HOP

RSVP-TE


AREA 1
AREA 0
ABR
LSR3
Egress
LSR
LSR2
LSR4
ASBR
PATH
ERO = (LSR2,LSR4)
RESV
Label = 55
Ingress
LSR
LSR1
LSR6
LSR7
È UN
ASBR
R2 È LA BEST ABR PER
RAGGIUNGERE R4
TOPOLOGICA R1
CHE
R1 SA

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!**

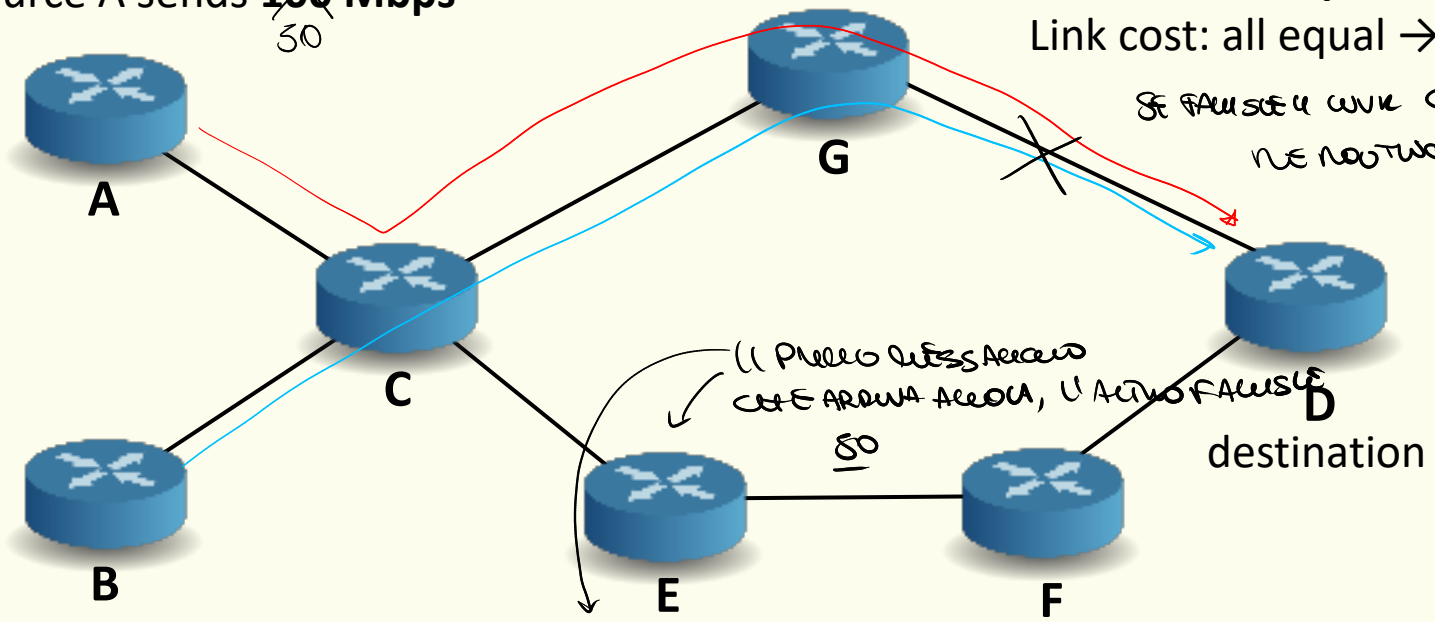
LSP priorities

- 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]

source A sends ~~100~~ 30 **Mbps**

All link **150 Mbps**, but **E-F** (**50 Mbps**)
Link cost: all equal → Path cost = #hops



source B sends **40 Mbps**
Customer B buys a service with strict guarantees

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

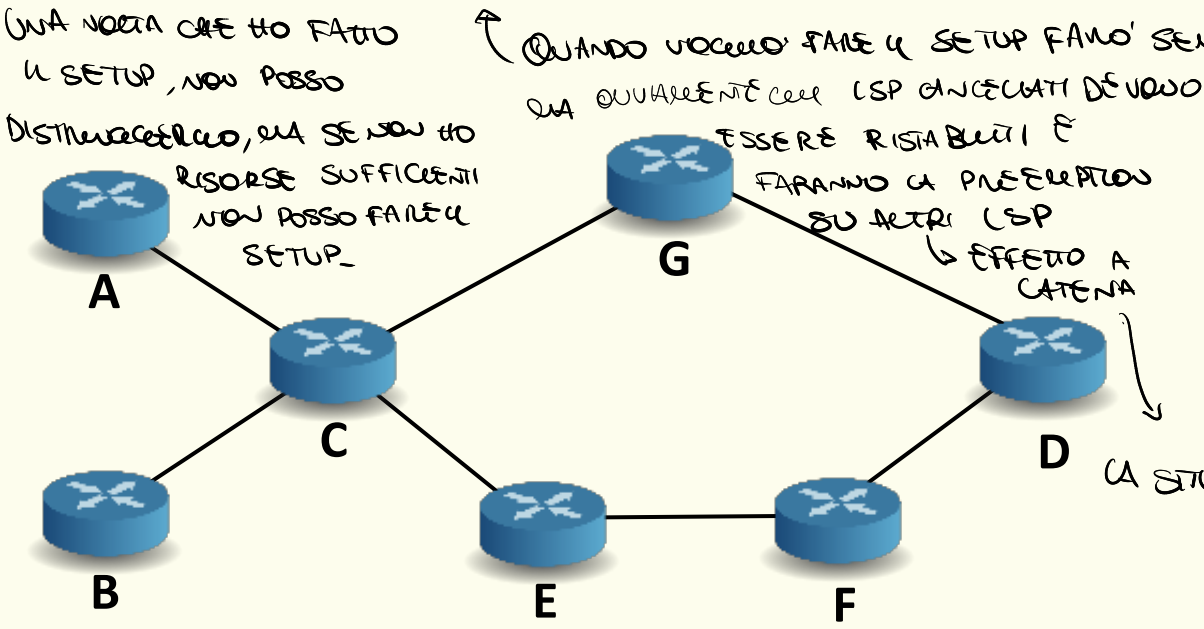
find paths between source/destination pairs that **comply with bandwidth constraints**, enforce the **priority of the path** sourced at B over that sourced at A

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

PROCESSO DI RICALCOLARE IL PATH PER UNO O PIÙ LSP CHE GIÀ ESISTONO (IL PATH GIÀ E' CONFIGURATO NEL DATA PLANE) DOVUTO AI CAMBIAMENTI DINAMICI CHE AVVENGONO NELLA RETE.

- 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

NON TUTTI GLI LSP STANNO ANCORA USANDO IL MIGLIOR PATH

HA UN COSTO! NON SOLO LA POTENZA COMPUTAZIONALE PER RICALCOLARE IL CSPF MA ANCHE IL SETUP DEI PATH.

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

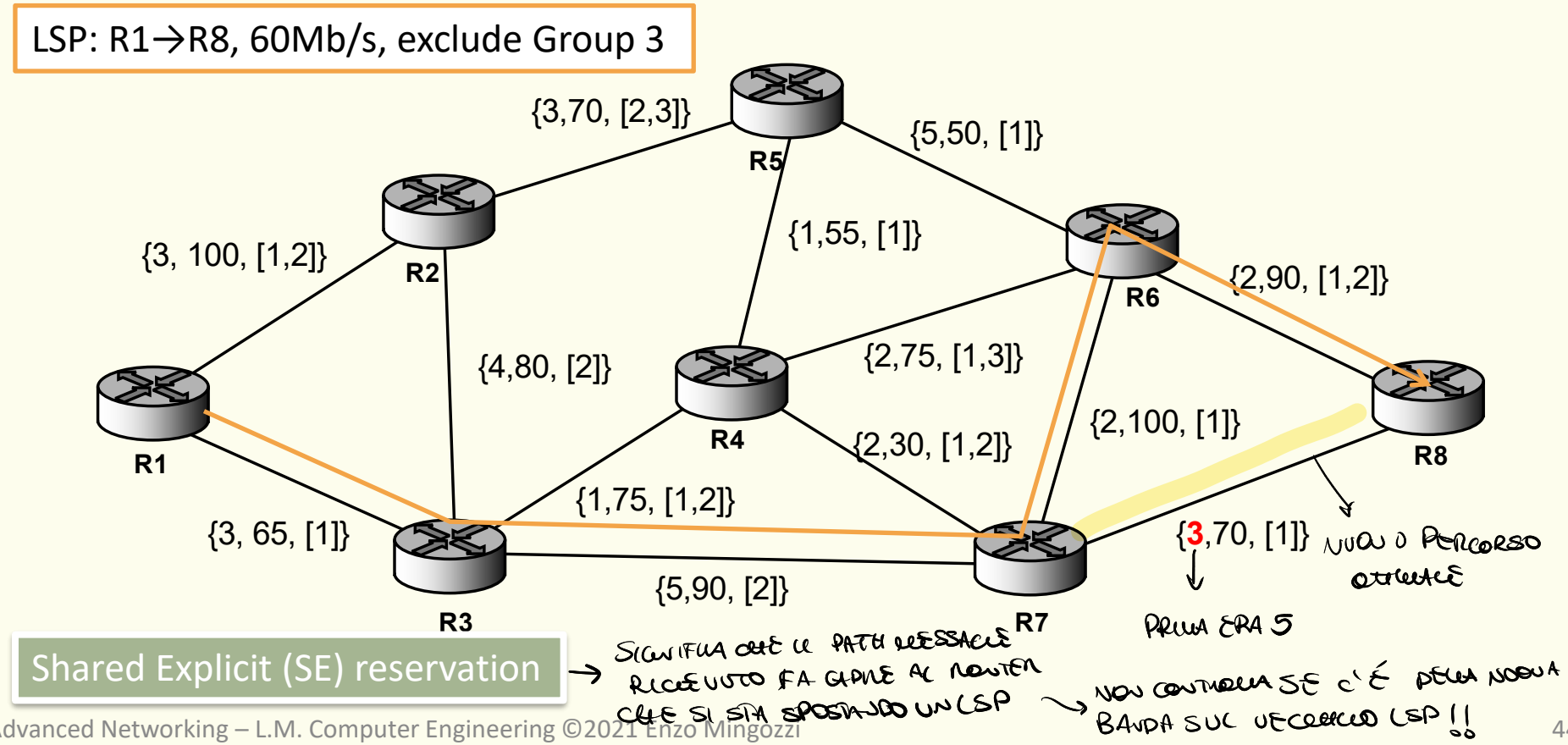
POTREI VOLERE UNA CONTINUITÀ DI SERVIZIO, CREANDO NUOVI PATH PRIMA DI DISTRUGGERE I VECCHI.

↓

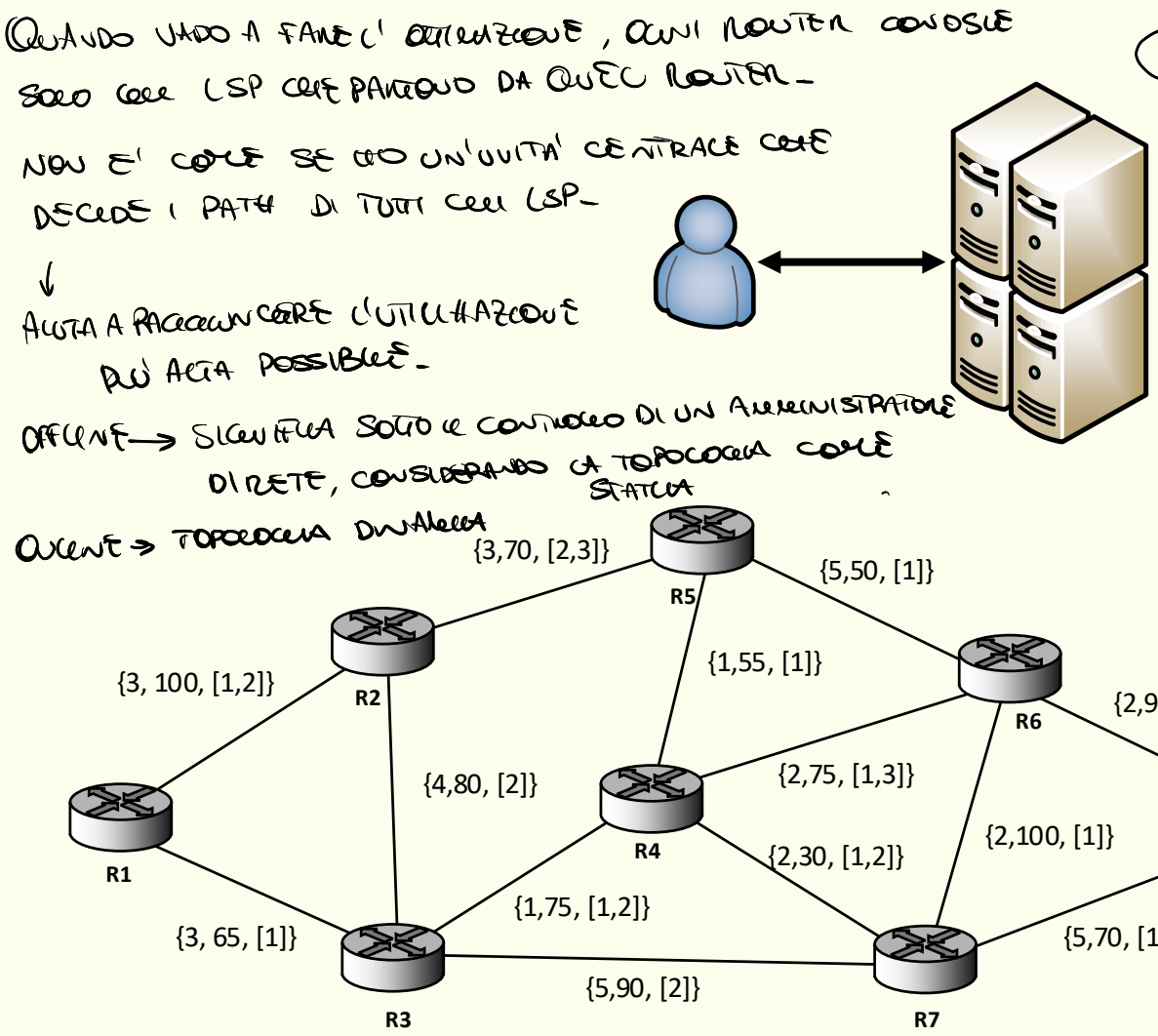
MAKE BEFORE BREAK

Reoptimization

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

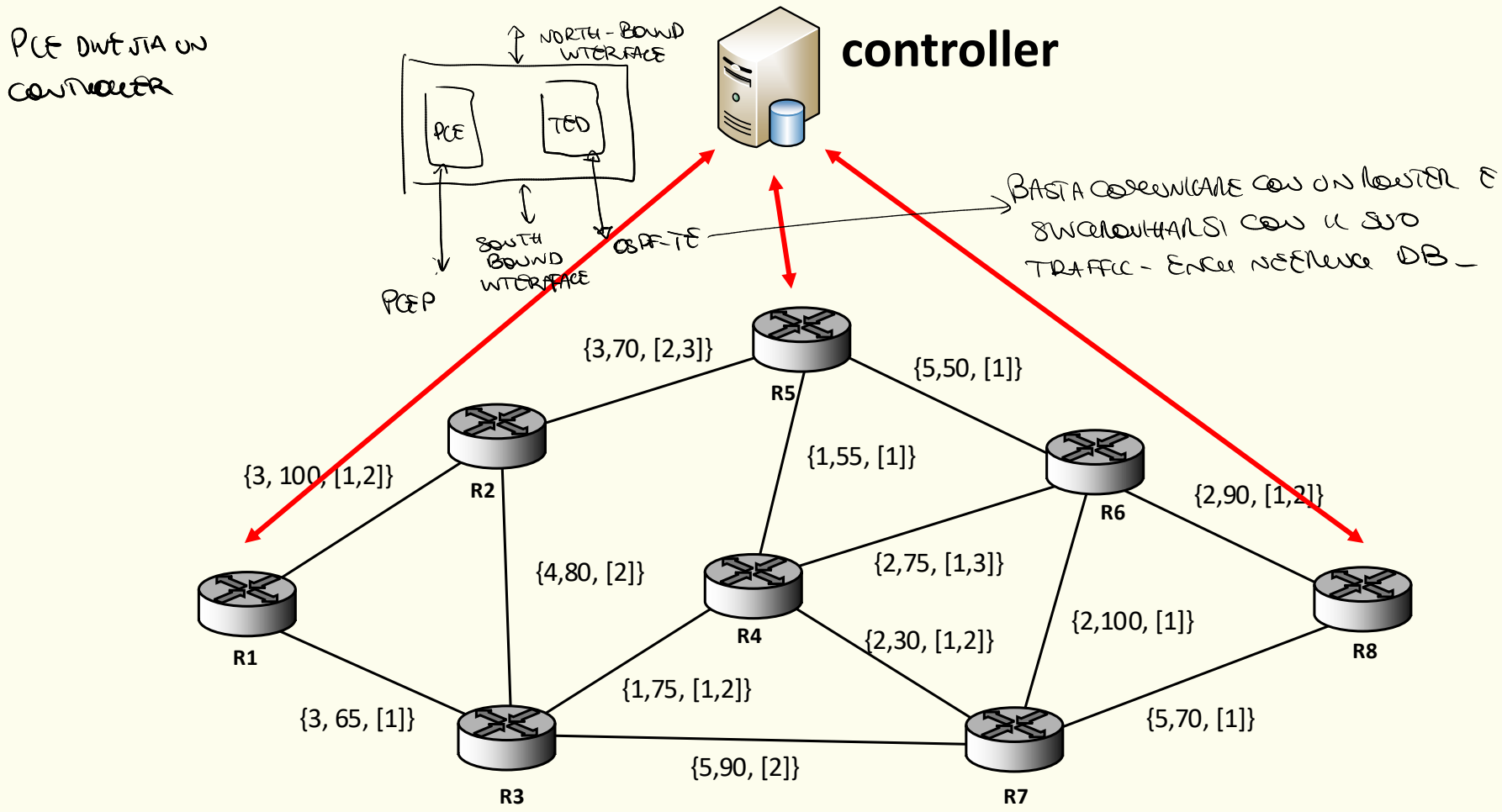


Centralized (offline) TE



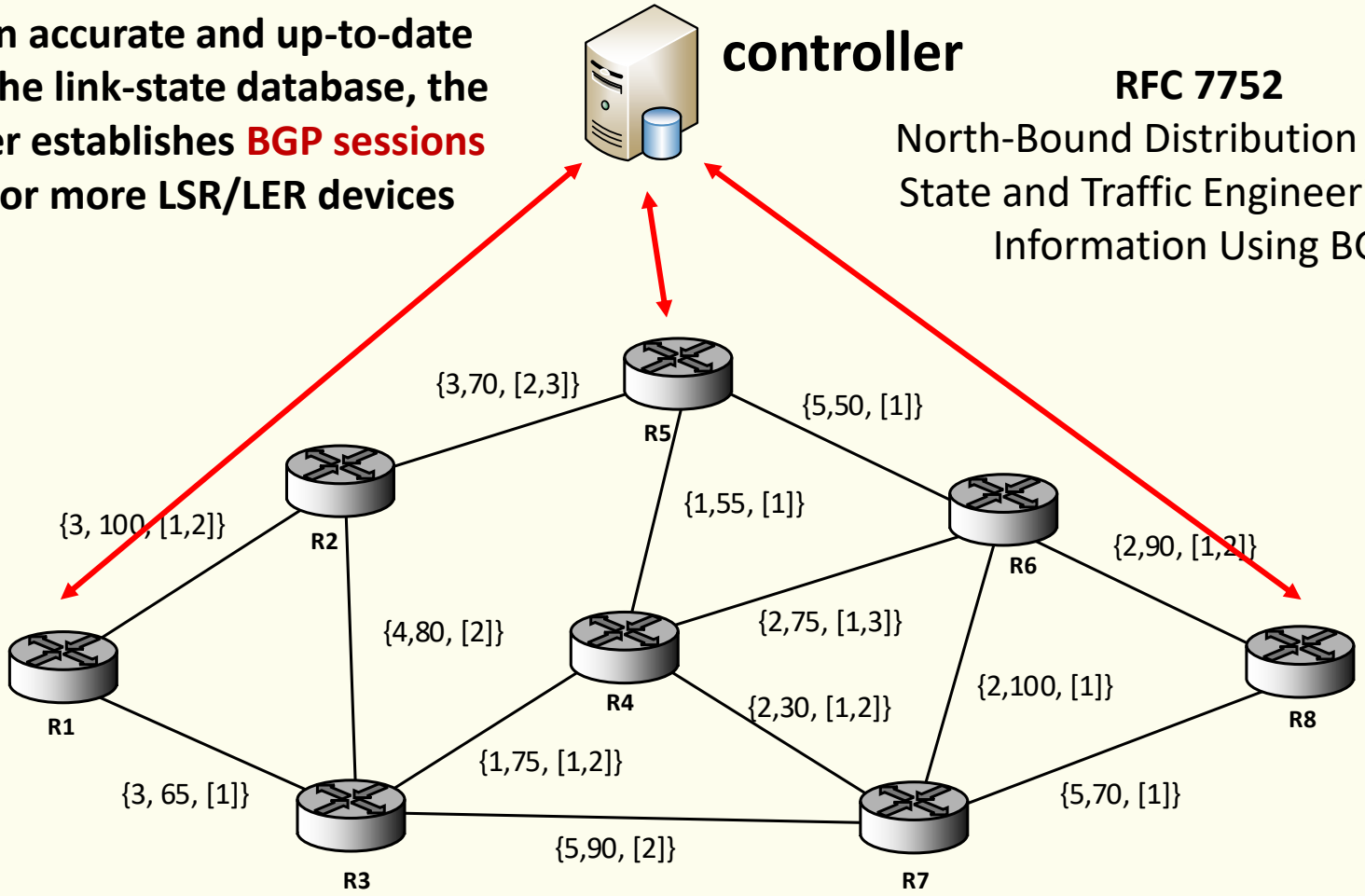
- Traffic demand estimation
- Topology and network state discovery
- Route computation
- Network configuration

Centralized (online) TE



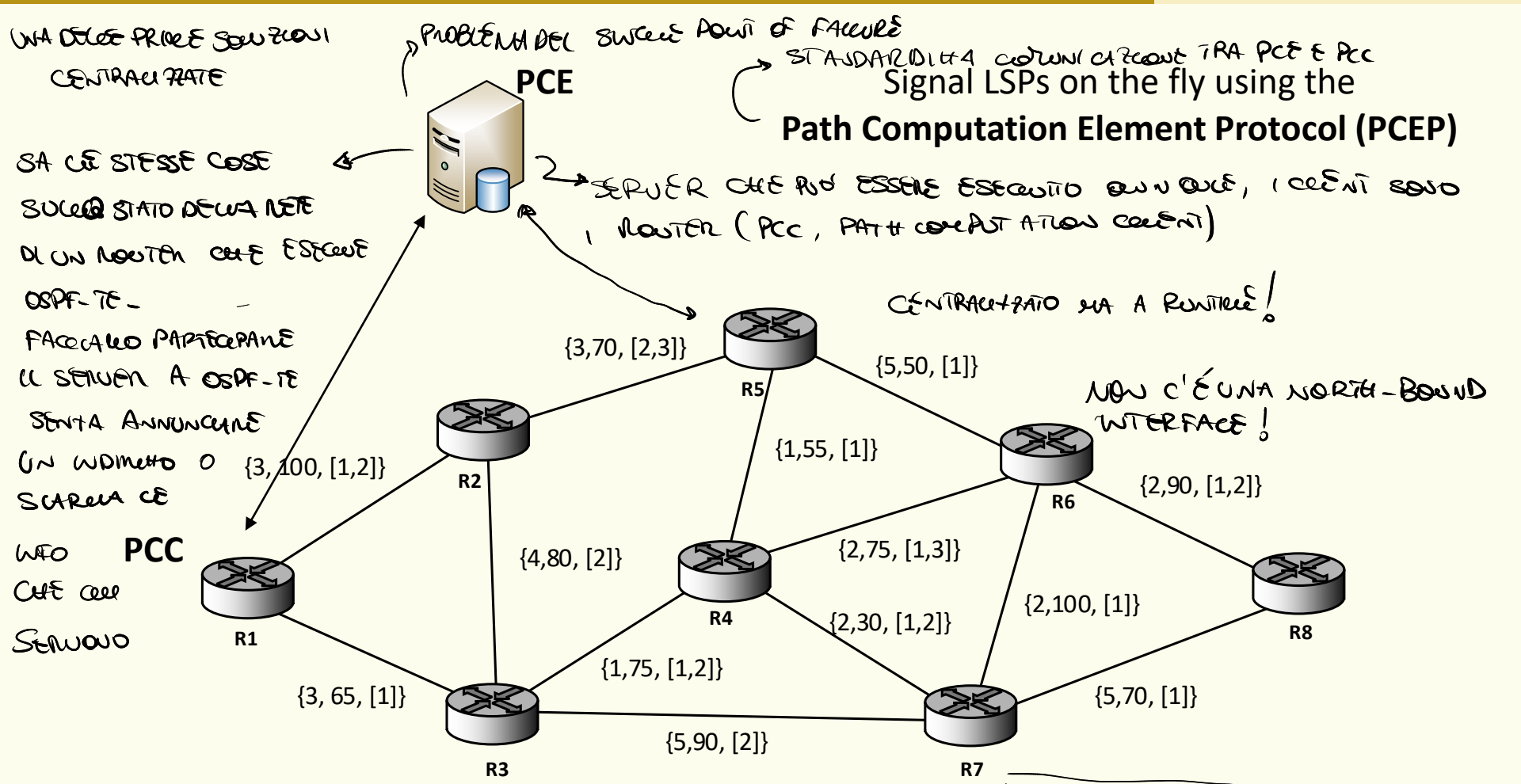
Centralized (online) TE

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



SE VOGLIAMO ELEVARE IL PCE A CONTROLLER DOBBIAMO ESTENDERLO PREVEDENDO PCE-INITIATED LSP SETUP.

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

   ELIMINA IL PACKET-LOSS!

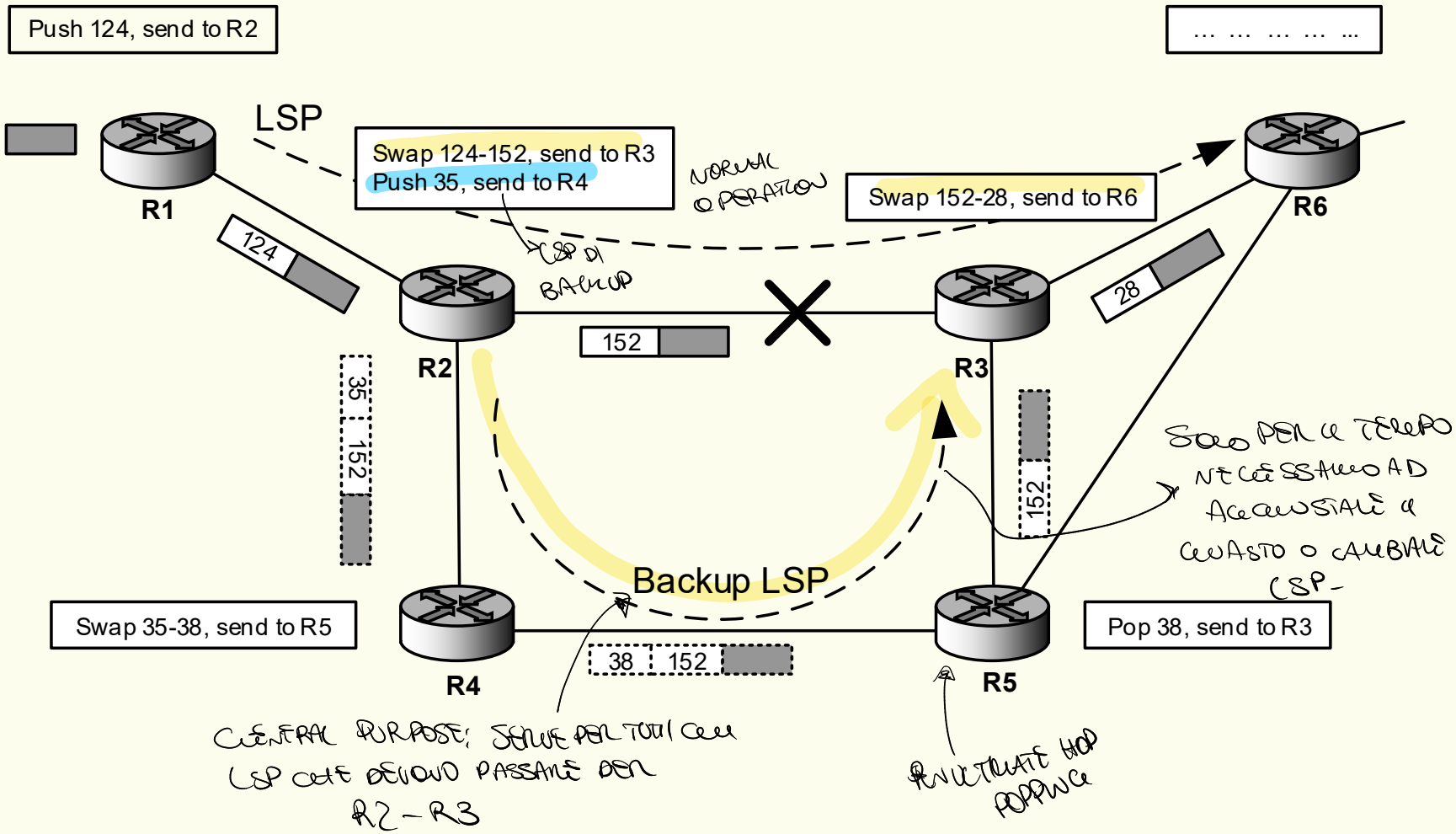
   OVVIAMENTE NON DEVONO CONDIVIDERE LINK

   ASSUMENDO CI SIANO DEI SEGNALI SUL MONITORAGGIO PER TROVARE GLI ERRORI (SE CI SONO)

2. Local protection using **fast reroute**
   - Link vs. node protection
   - One vs. many LSP protected

   PROTEGGO TUTTI GLI LSP CHE PASSANO DA UN CERTO LINK O DA UN CERTO NODO

Link protection, many LSPs



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