Core network protocols and architectures

Multi-Protocol Label Switching

Control plane

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MPLS control plane

- Procedures at each LSR to
  - **create** bindings between FECs and labels
  - **inform** other LSRs of the bindings it creates
  - **combine** information above to construct and maintain the forwarding table used by the label switching component

FTN	
Label	
FEC1	
FEC2	

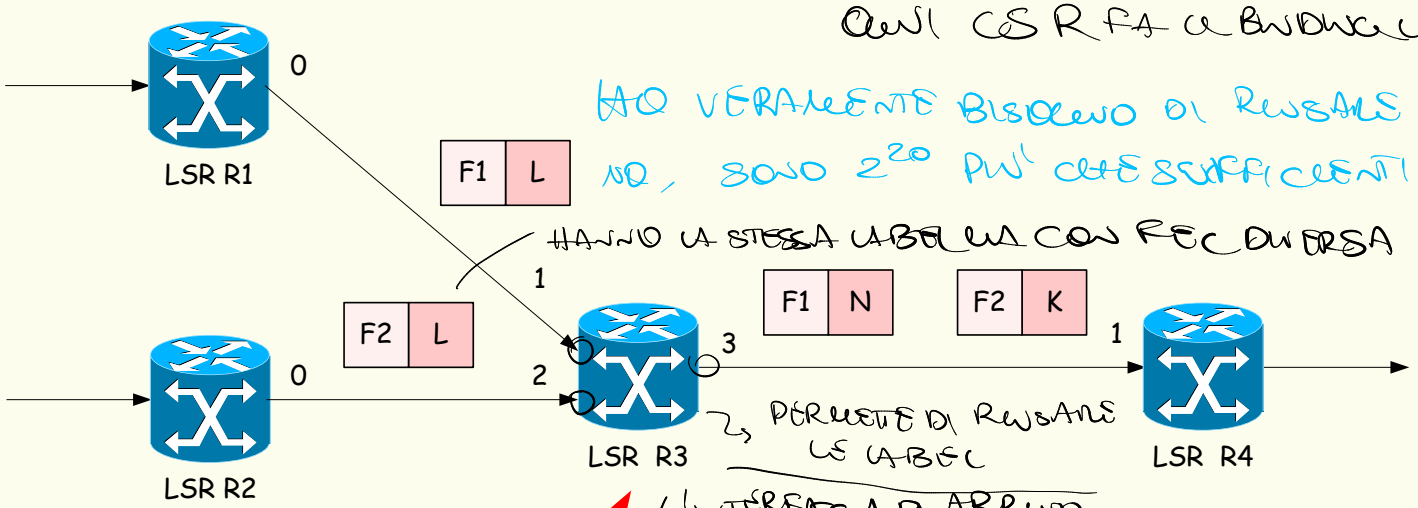
ILM	
Label	
23	
42	

NHLFE

Action	Label	Next Hop
PUSH	60	LSR3
POP	-	LSRx
SWAP	50	LSR5
SWAP	46	LSR6

LSR label scope

- Labels may have "per interface" scope

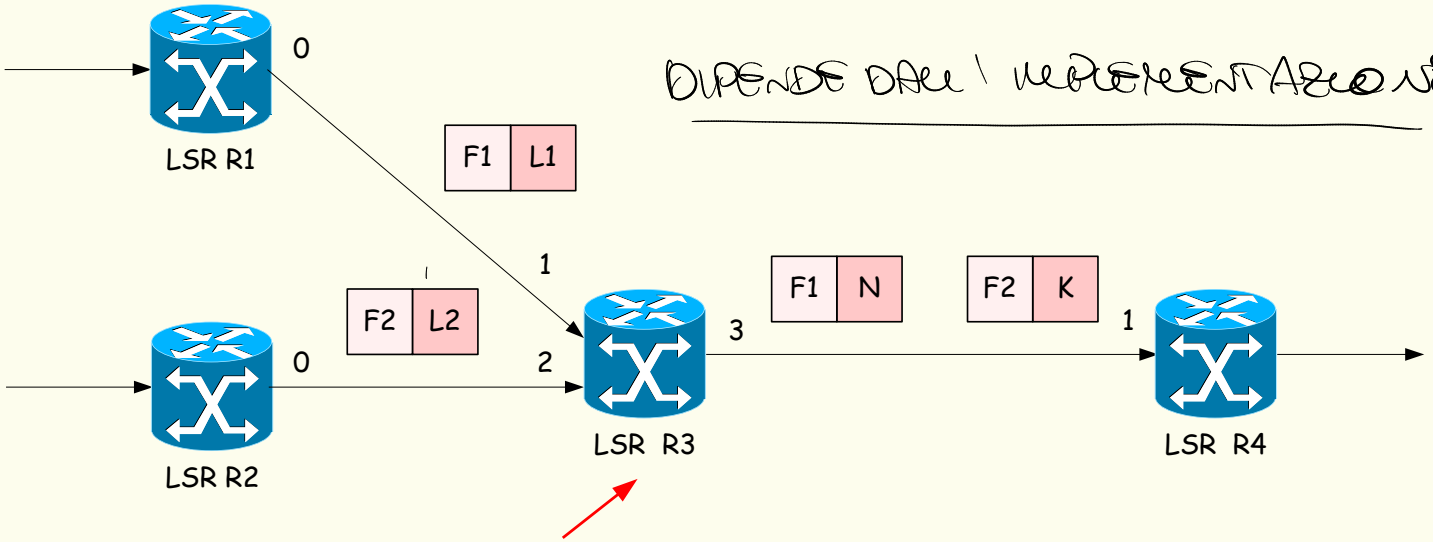


In I/F	In Lab	FEC	Out I/F	Out Lab
1	L	F1	3	N
2	L	F2	3	K
....	....	....	....	....

LSR3 MUST be able to tell which upstream LSR sent the labeled packet

LSR label scope

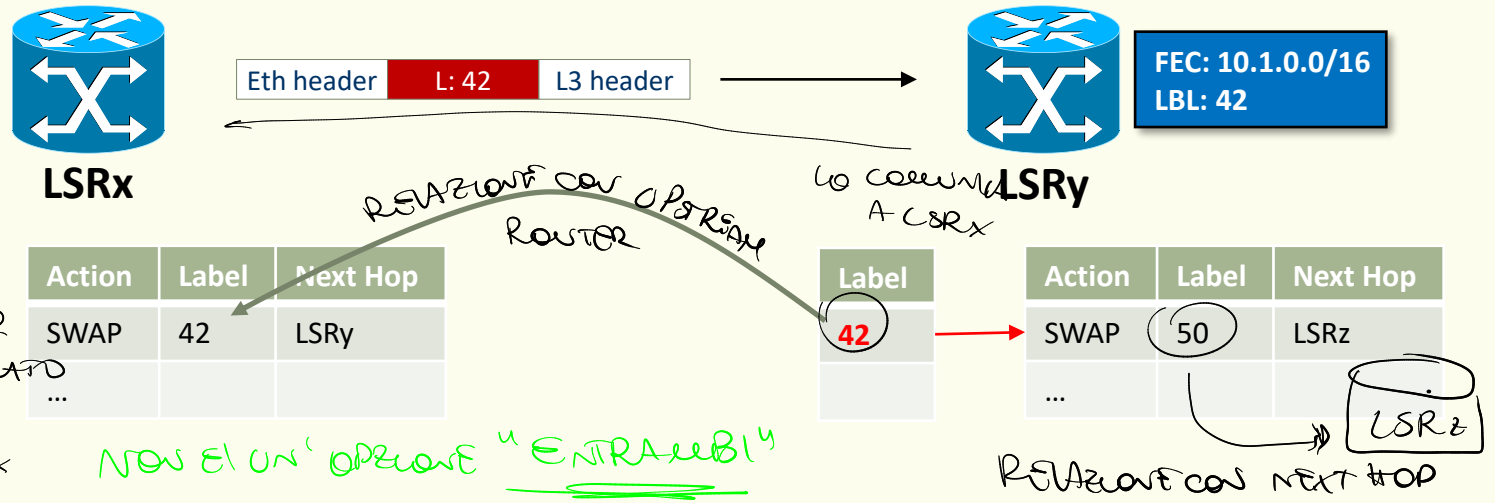
- Otherwise, labels have per-LSR scope



In I/F	In Lab	FEC	Out I/F	Out Lab
1	L1	F1	3	N
2	L2	F2	3	K
....	....	....	....	....

Label assignment and distribution

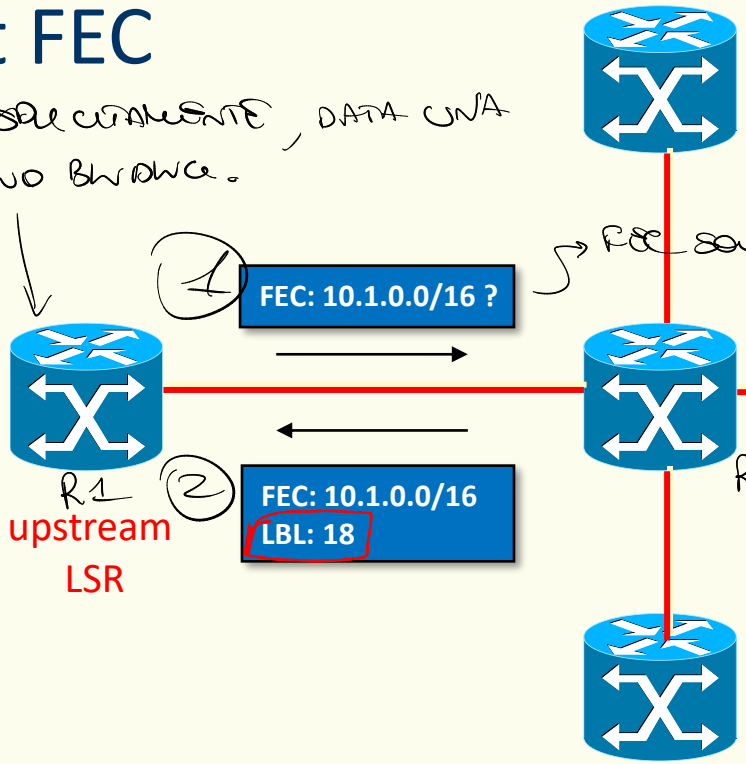
- Labels are **"downstream-assigned"**
  - The binding of a FEC F to a label L is taken by the LSR which is **downstream** with respect to that binding



- A label distribution protocol is then needed

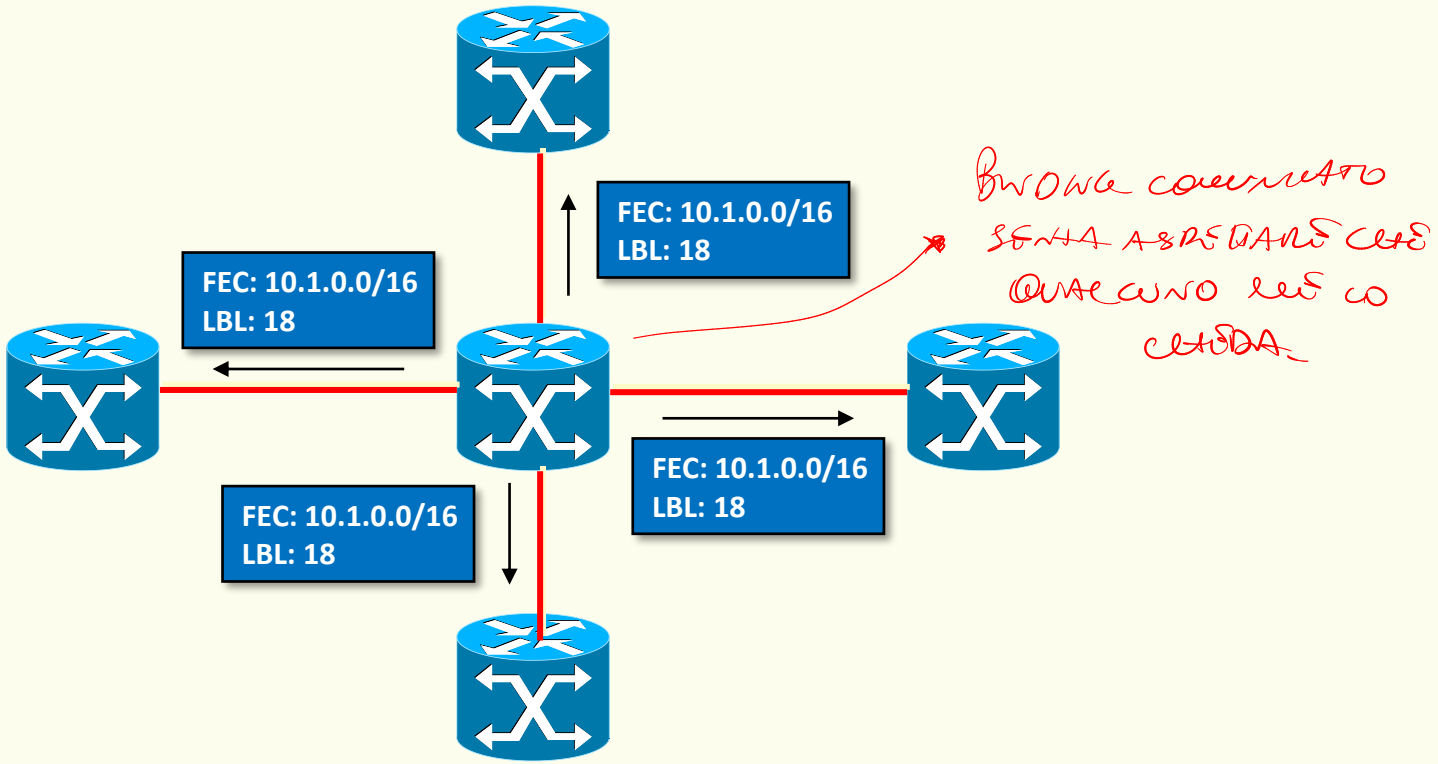
Downstream-on-demand

- An LSR is allowed to explicitly request, from its next hop for a particular FEC, a label binding for that FEC



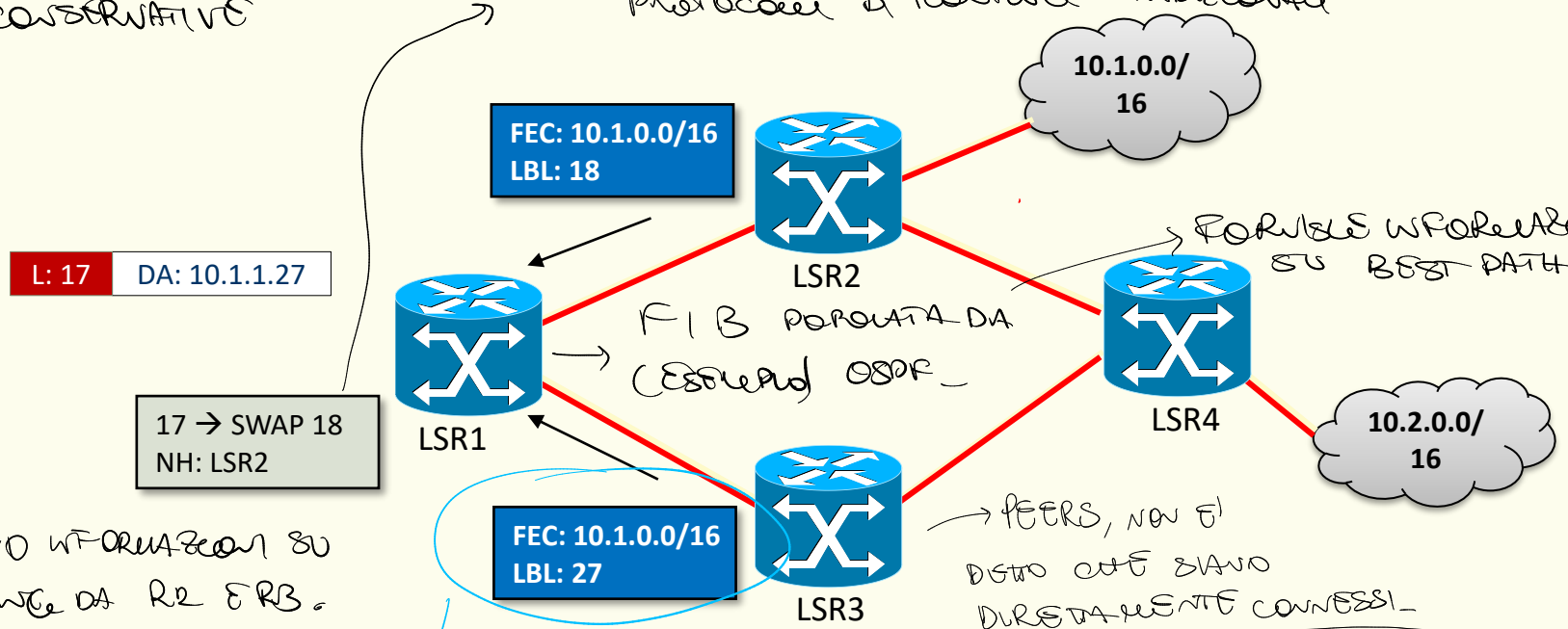
Unsolicited downstream

- An LSR is allowed to distribute bindings to LSRs that have not explicitly requested them



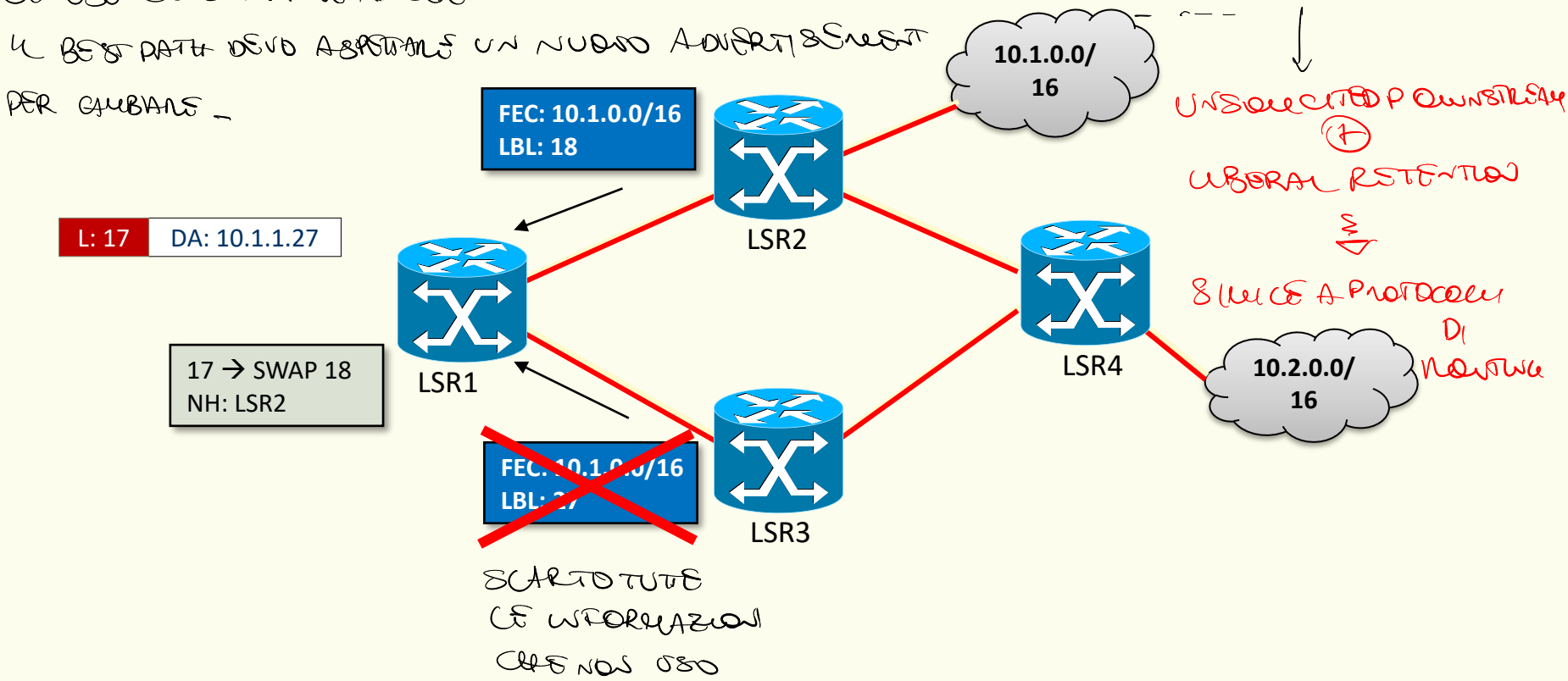
Label retention modes

- Liberal label retention mode



Label retention modes

- Conservative label retention mode



LSP setup control

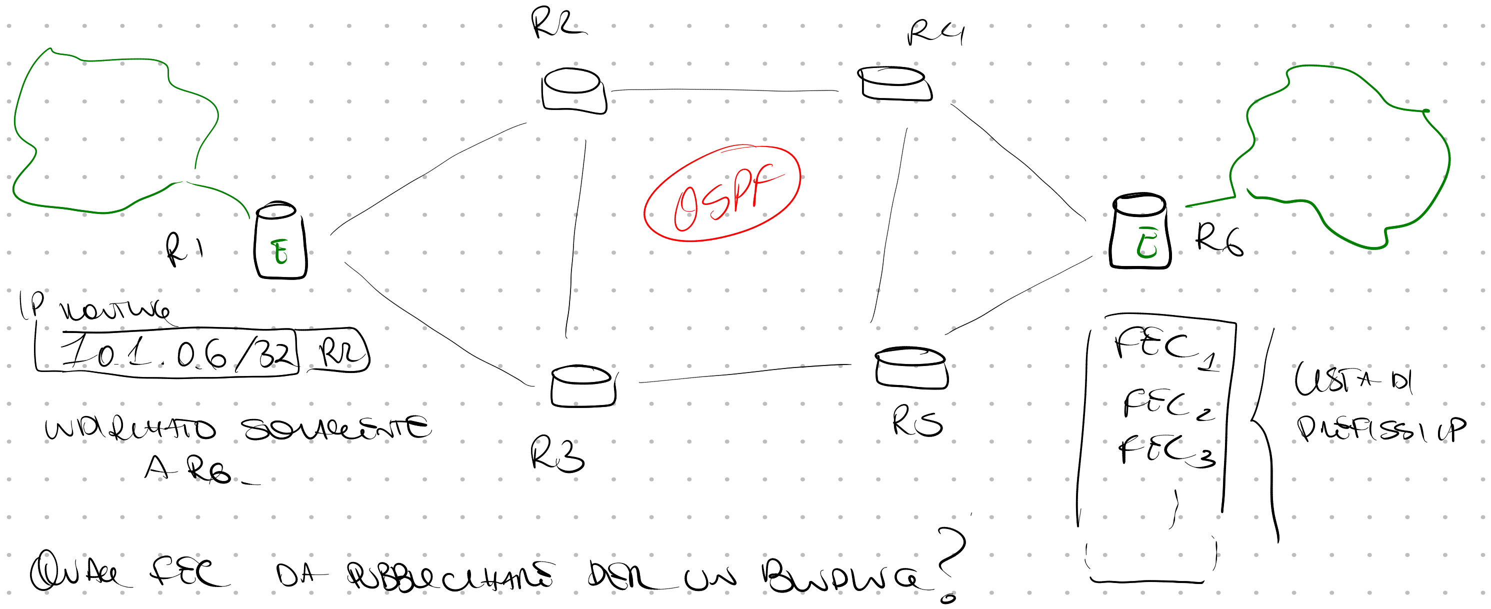
- **FEC-to-label bindings** are only distributed for the purpose of establishing label-switched paths
- **Which FEC to advertise a binding for?**
  - The choice of FEC determines which LSPs are set up
- **When to advertise this binding?**
  - This determines who has control over the LSP setup

- Two modes of operation: **ordered** control vs. **independent** control

TRANSIT DOMAIN:

NON CI SONO VINCOLI SU COME CLASSIFICARE I PACCHETTI

LABEL SONO AGGIUNTE IN R1 O R6 E SONO RIMOSSE IN R1 O R6.



QUALE FEC DA ABBINARE PER UN BINDING?

FEC SONO UN INSIEME DI PREFISSI IP (DESTINATION-BASED).

→ MA ALLORA PERCHÉ USARE MPLS?

RICORDIAMOCI CHE LA CLASSIFICAZIONE È FATTA SOLAMENTE NEI ROUTER EDGE, I CORE ROUTER NON LA FANNO PER NIENTE.

VERO CHE USO L'INTERA TABELLA DI ROUTING, MA LA USO UNA VOLTA SOLA. (QUANDO È LASCIATO AI ROUTER ← AUTOMATIC CONFIGURATIONS)

QUALI SONO I PREFISSI IP CHE USO EFFETTIVAMENTE?

1) USARE LA TABELLA DI ROUTING IP → SE È UN DOMINIO DI ROUTING SINGOLO AVRANNO TUTTI LE STESSE ENTRATE

IP ROUTING TABLE

ab.c.d/m	NH

→ FEC_i → L_i

AD OGNI ENTRATA DELLA TABELLA IP ASSOCIO UNA FEC.

UNICO VINCOLO È CHE LE CLASSI SIANO COERENTI TRA I ROUTER.

BINDING REGOLATO DA ROUTING TABLE.

PERCHÉ È UNA BUONA SOLUZIONE? SE OGNI ROUTER FA IL BINDING PER INSIEMI DIVERSI DI PREFISSI IP, LA SOLUZIONE NON FUNZIONA.

PER FUNZIONARE DOBBIAMO AVERE FEC COERENTI! LE TABELLE DI ROUTING SONO UGUALI NEI ROUTER? → !! LE ENTRATE SONO TUTTE UGUALI

2) SDN CHE DICE QUELLO CHE FARE AL ROUTER

VOGLIO ESSERE IN GRADO DI IDENTIFICARE UNIVOCAMENTE → 10.1.0.6/32 SE PUBBLICIZZO QUESTA RETE STO DICENDO COME RAGGIUNGERE R6

CONFIGURARE L'INTERFACCIA DI LOOPBACK DI UN ROUTER CON UN INDIRIZZO PRIVATO TIPO 10.1.0.6 → OSPF IDENTIFICA IL ROUTER CON QUESTO INDIRIZZO

ARRIVA UN PACCHETTO COSA FACCIO?

SE È UN PACCHETTO INDIRIZZATO FUORI DALLA RETE, POSSO OTTENERE L'ULTIMO ROUTER NEL DOMINIO CHE CO GESTISCE (ASBR) – A QUEL ROUTER, CONOSCO L'INDIRIZZO DI LOOPBACK DELL'ASBR –
QUALE CAMPO ASSOCIO AL PACCHETTO LA CAMPO RELATIVA ALL'INDIRIZZO DI LOOPBACK –

↳ SE VOGLIO VEDERE SE R6 È RAGGIUNGIBILE DA R1, POSSO PINGARE DALLA INTERFACCIA DI LOOPBACK DI R1 ALLA LOOPBACK DI R6, CONSIDERANDO CHE CI SIA UNA QUALSIASI ROTTA

OSPF

IL NEXT-HOP VIENE DECISO ATTRAVERSO UN PROTOCOLLO (LEAST COST PATH)

↳ COSA SIGNIFICA? CHE VEDENDO LA RETE DA FUORI NON SI PUÒ DIRE SE SI STA USANDO LA FORWARDING LABEL NEL DATA PLANE.

IL PERCORSO È LO STESSO I ROUTER PRENDONO DECISIONI INTERNE DIVERSE

→ MA LA SELEZIONE DEL NEXT-HOP VIENE FATTA ATTRAVERSO UN PROTOCOLLO

↓

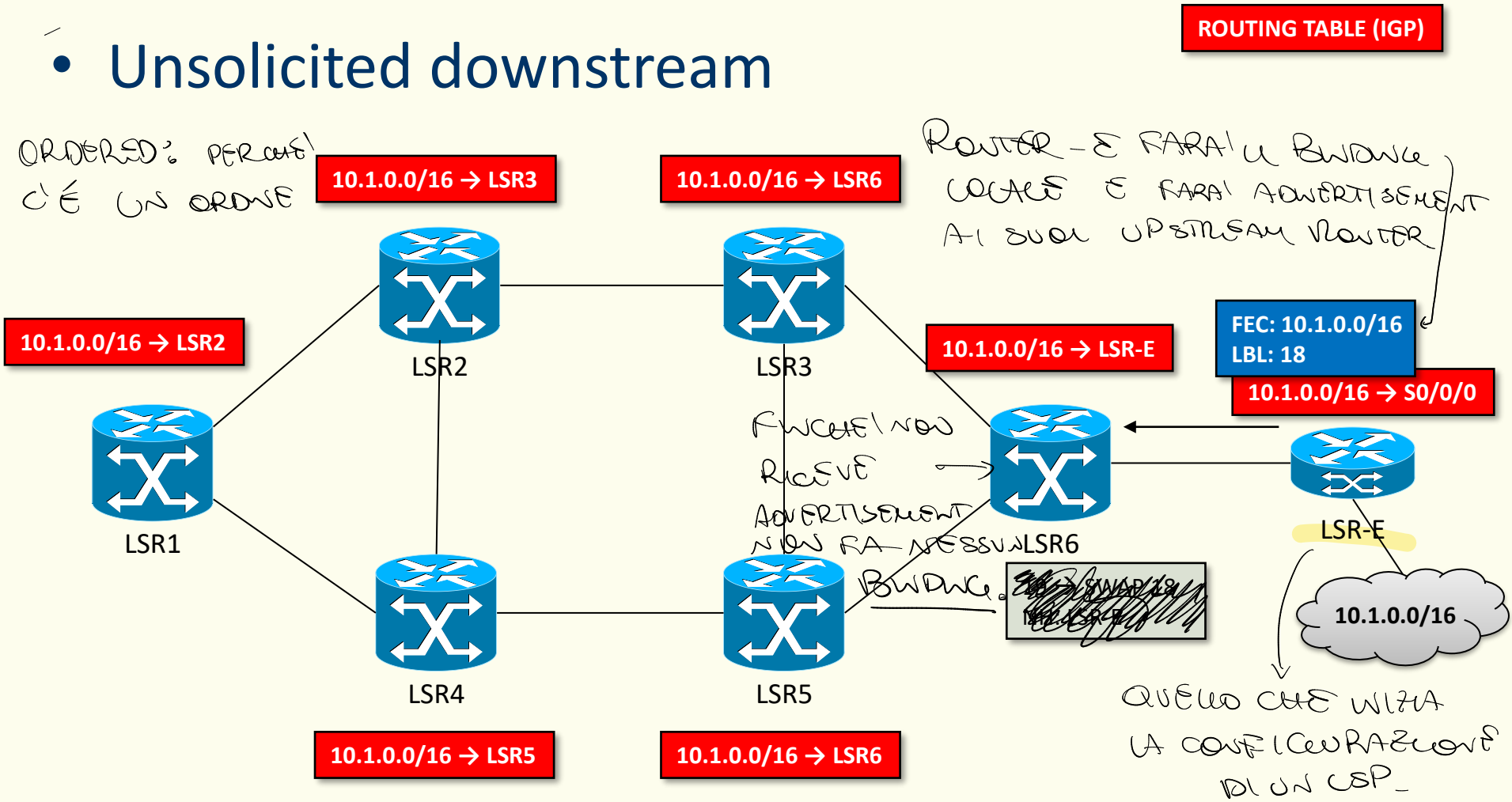
SE FINTA UN PROTOCOLLO NON POSSO USARE MPLS –

QUALCHE VOLTA SI PUÒ SCEGLIERE UN PATH CHE NON È QUELLO A LEAST COST –

Ordered control

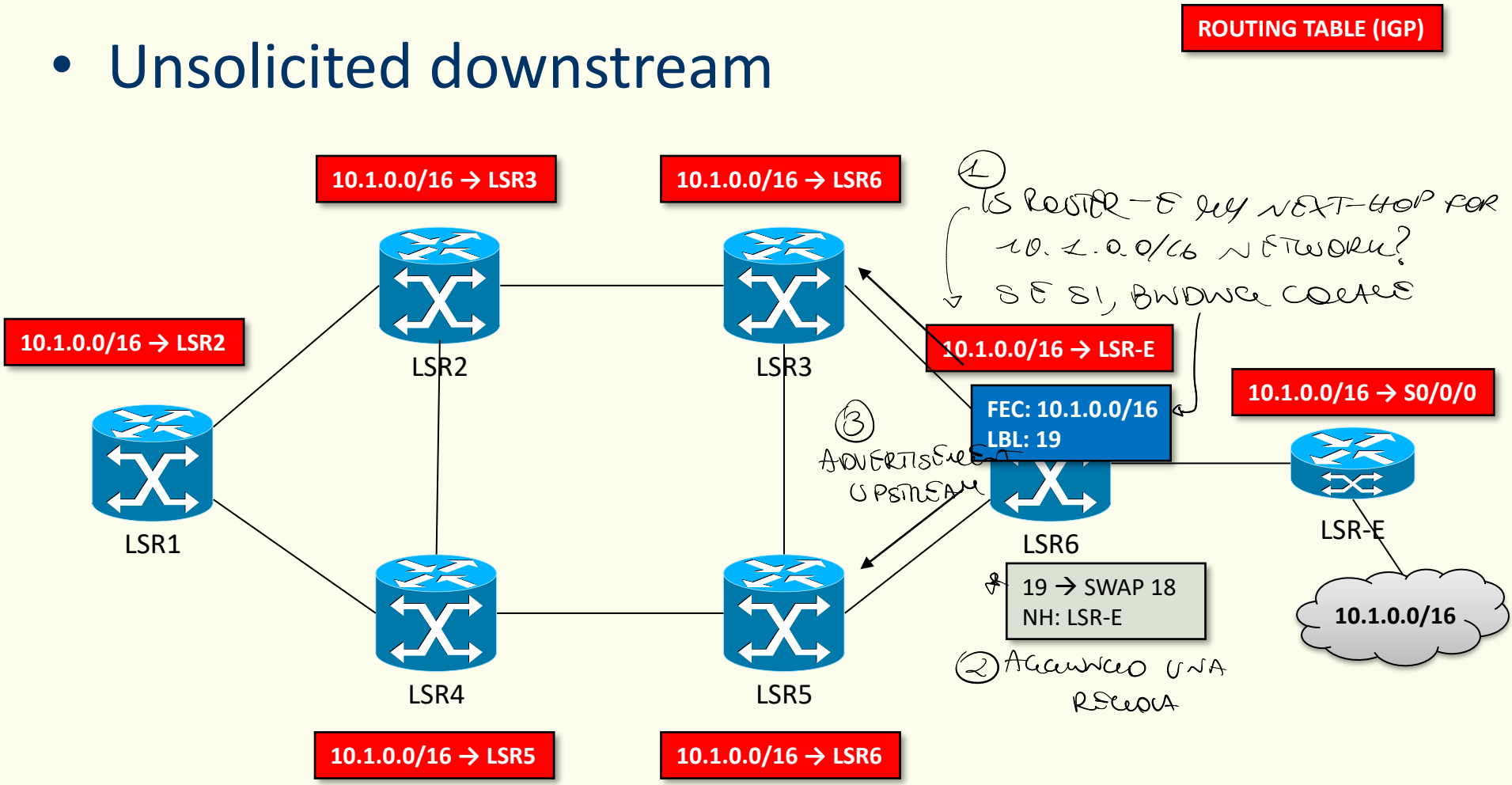
CHI HA IL CONTROLLO QUANDO SI FA IL SETUP DI UN LSP?

- Unsolicited downstream



Ordered control

- Unsolicited downstream



Ordered control

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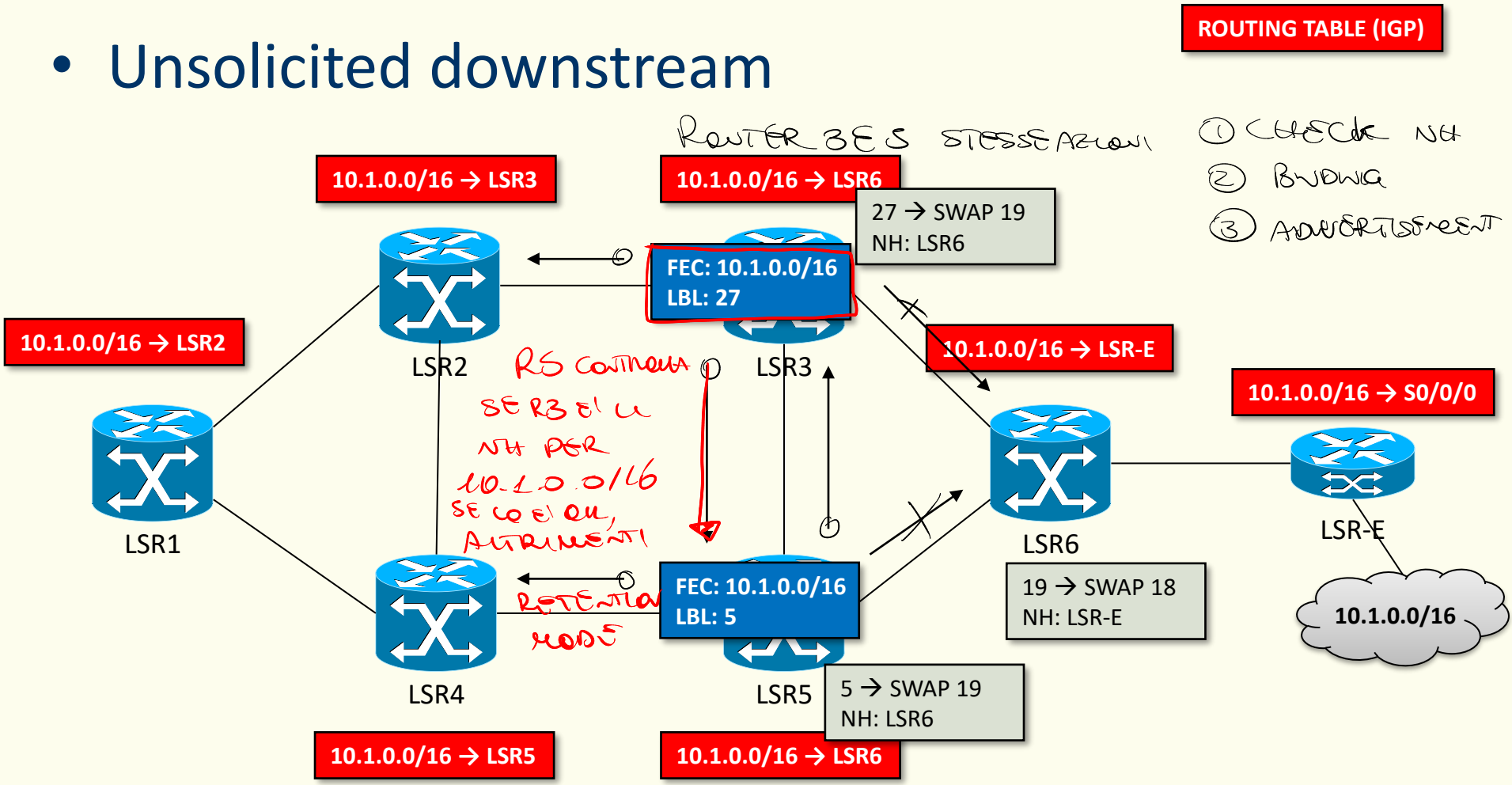
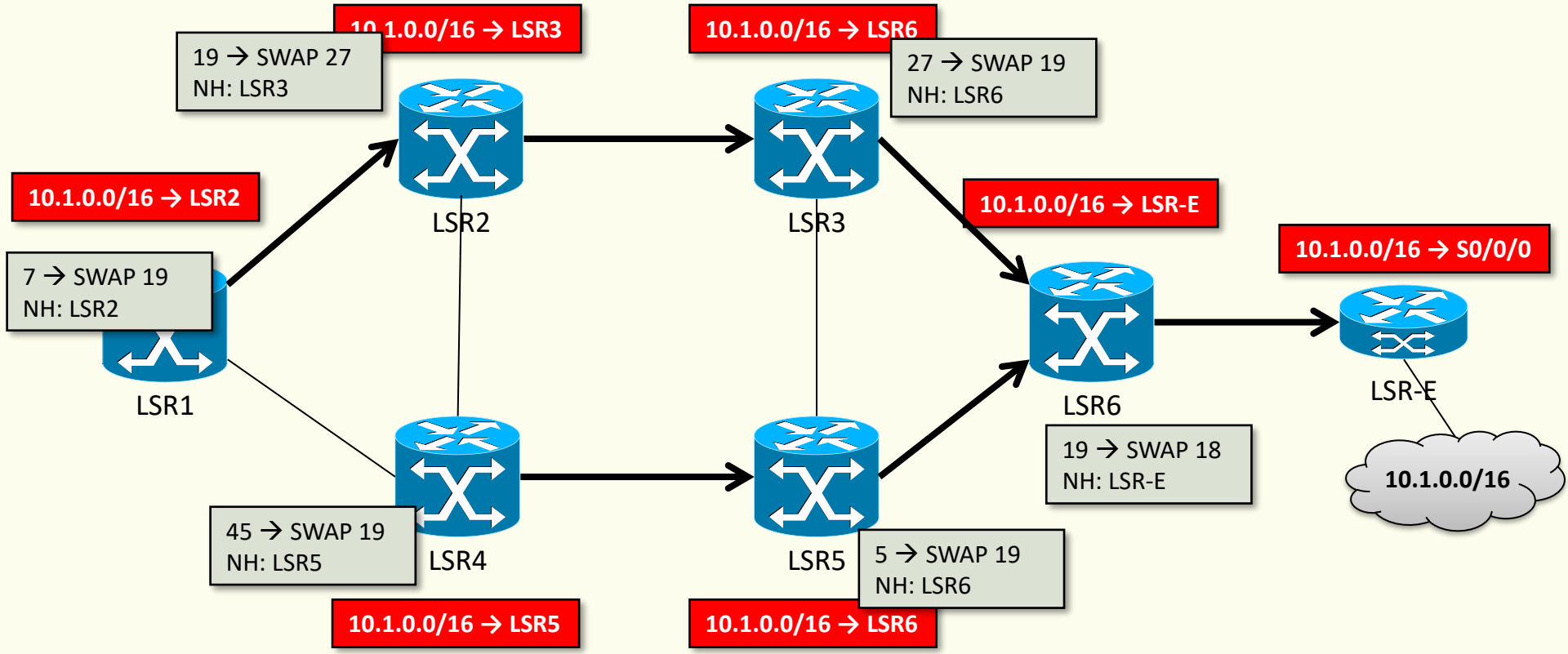


Ordered control

OSPF / IS-IS

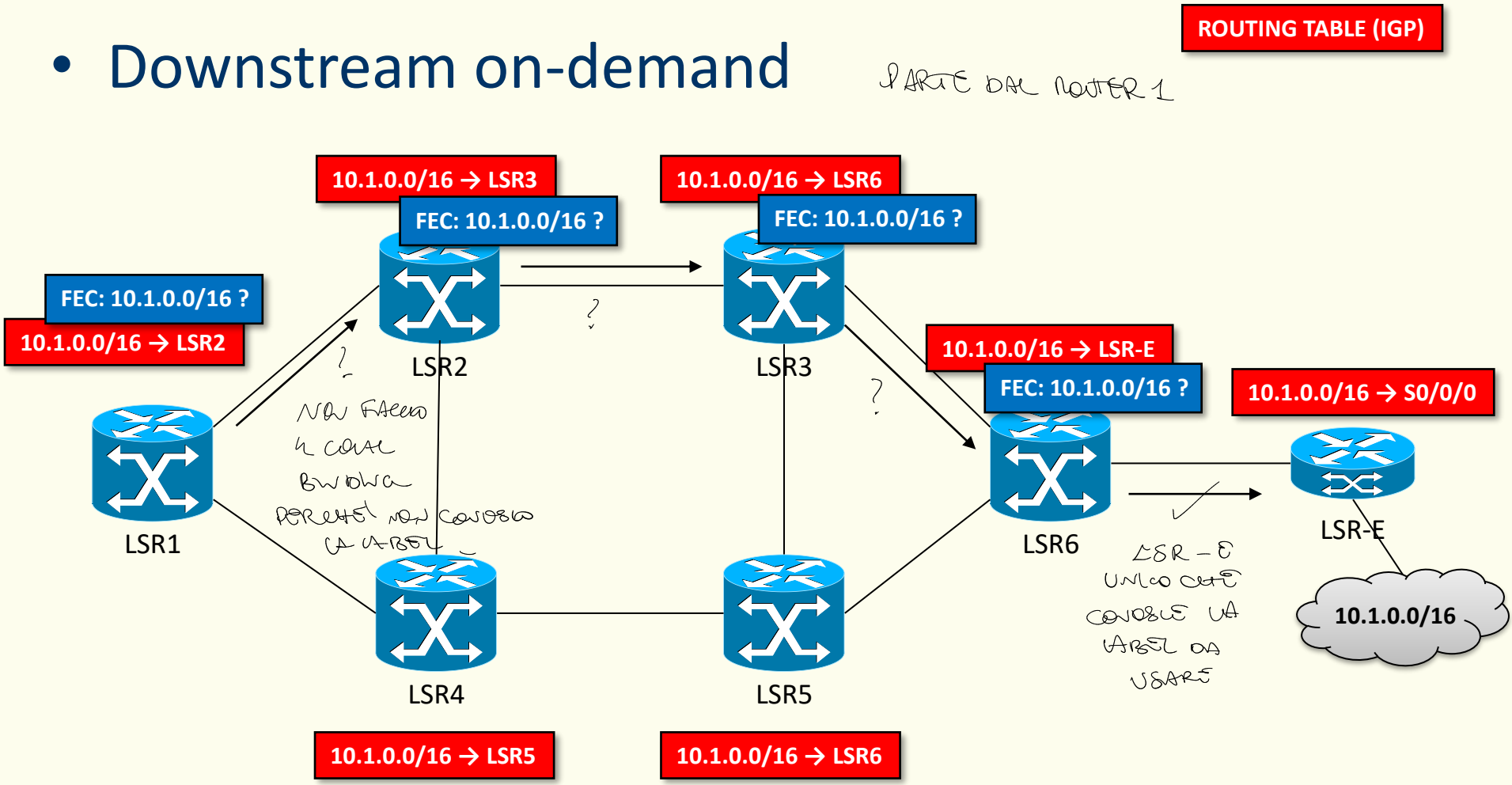
ROUTING TABLE (IGP)

- Unsolicited downstream



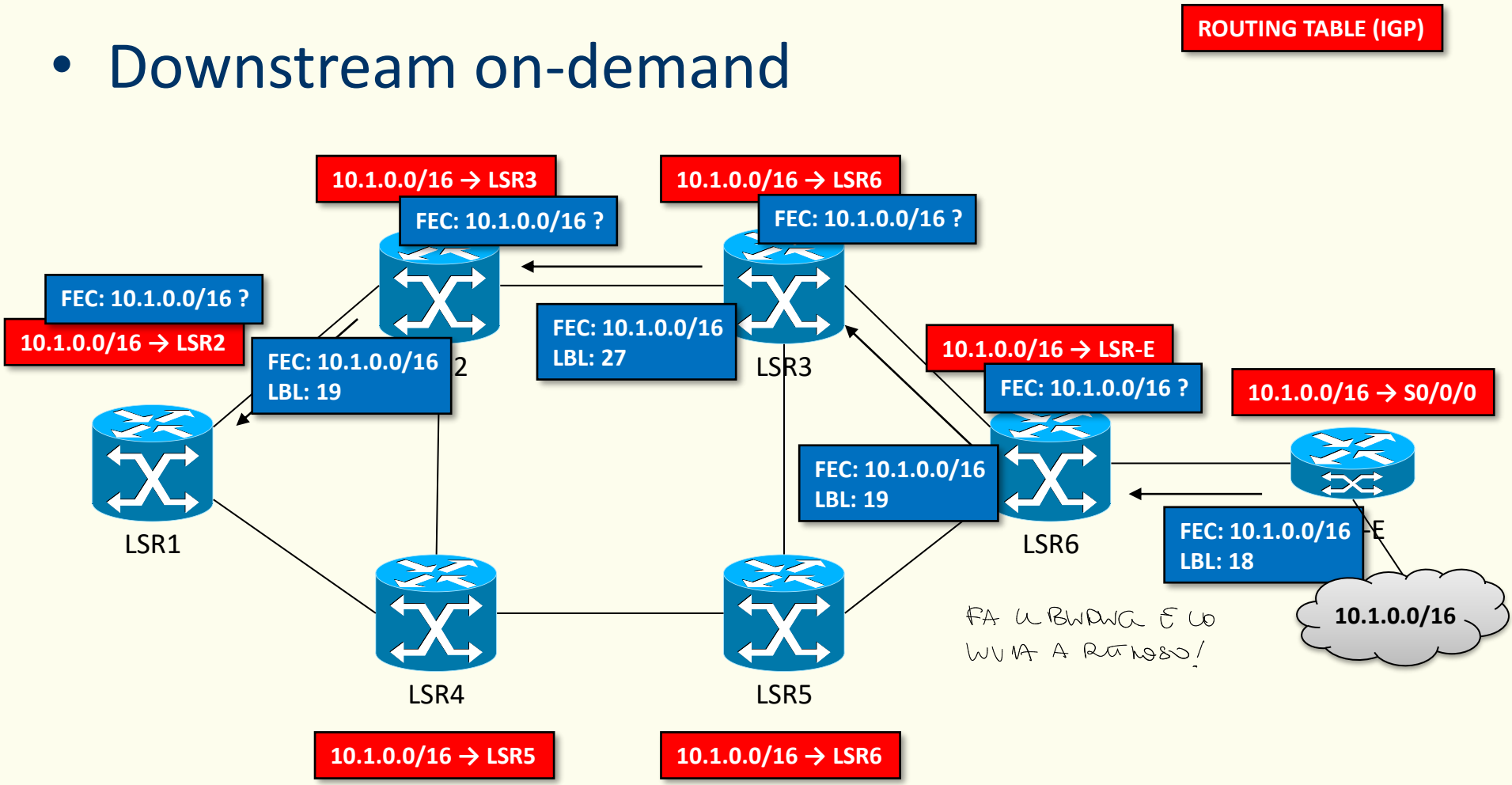
Ordered control

- Downstream on-demand



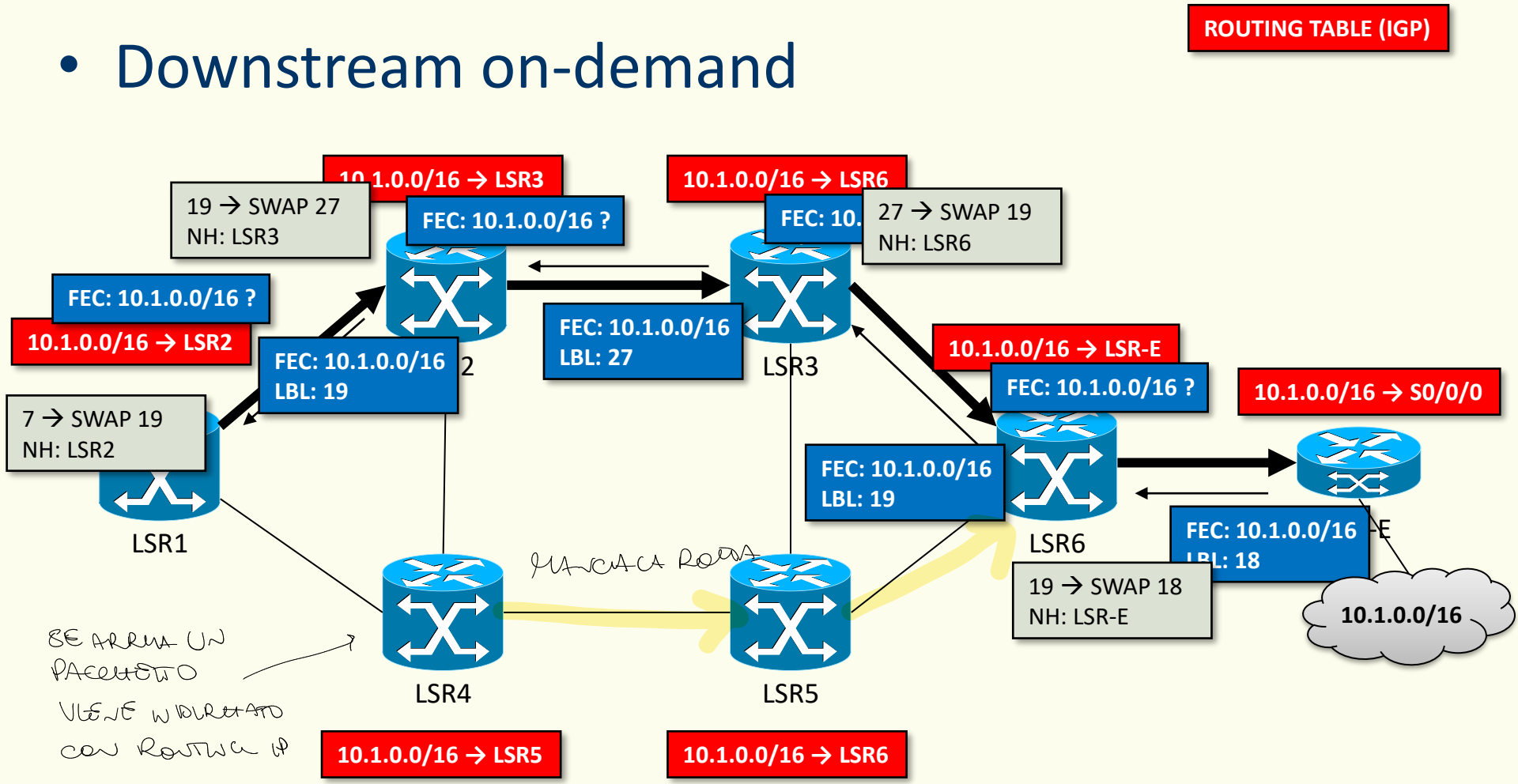
Ordered control

- Downstream on-demand



Ordered control

- Downstream on-demand



SE ARRIVA UN PACCHETTO VIENE INDIRIZZATO CON ROUTING IP

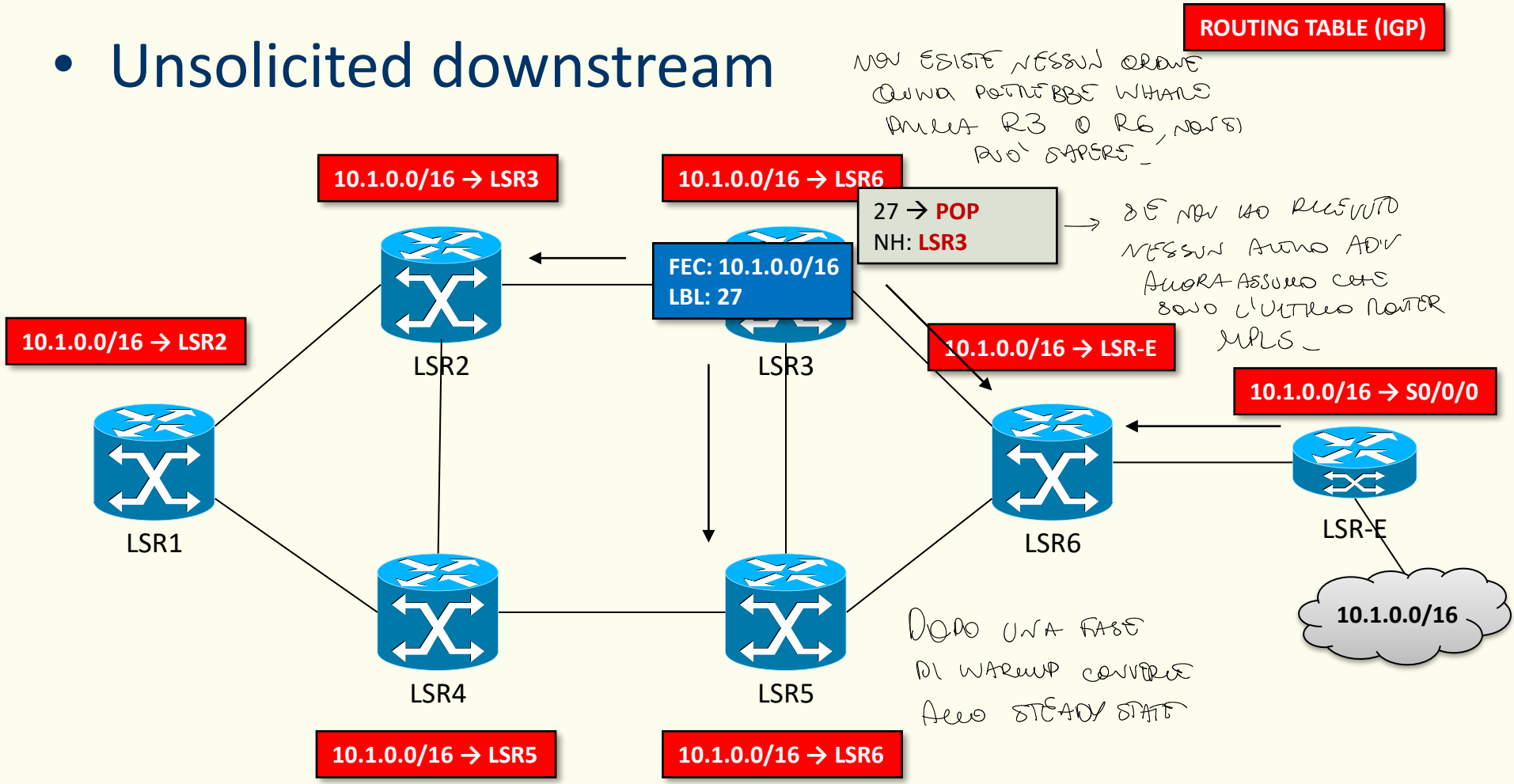
COSA SUCCEDE SE RIC. WIZA UNA LSP?

a) CREA UNA NUOVA LSP POINT-TO-POINT

b) USARE LA BANDA GIA' DISPONIBILE

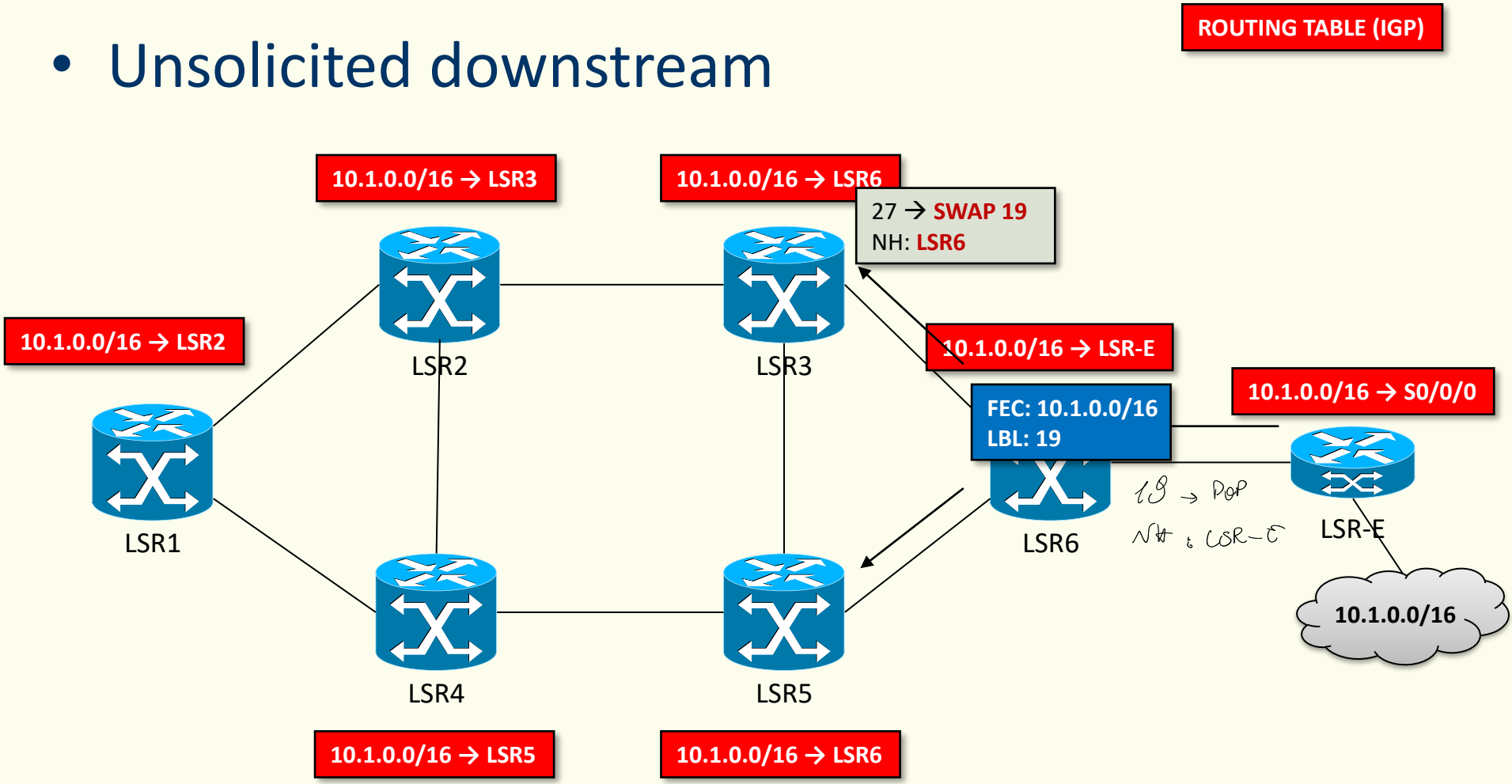
Independent control

- Unsolicited downstream



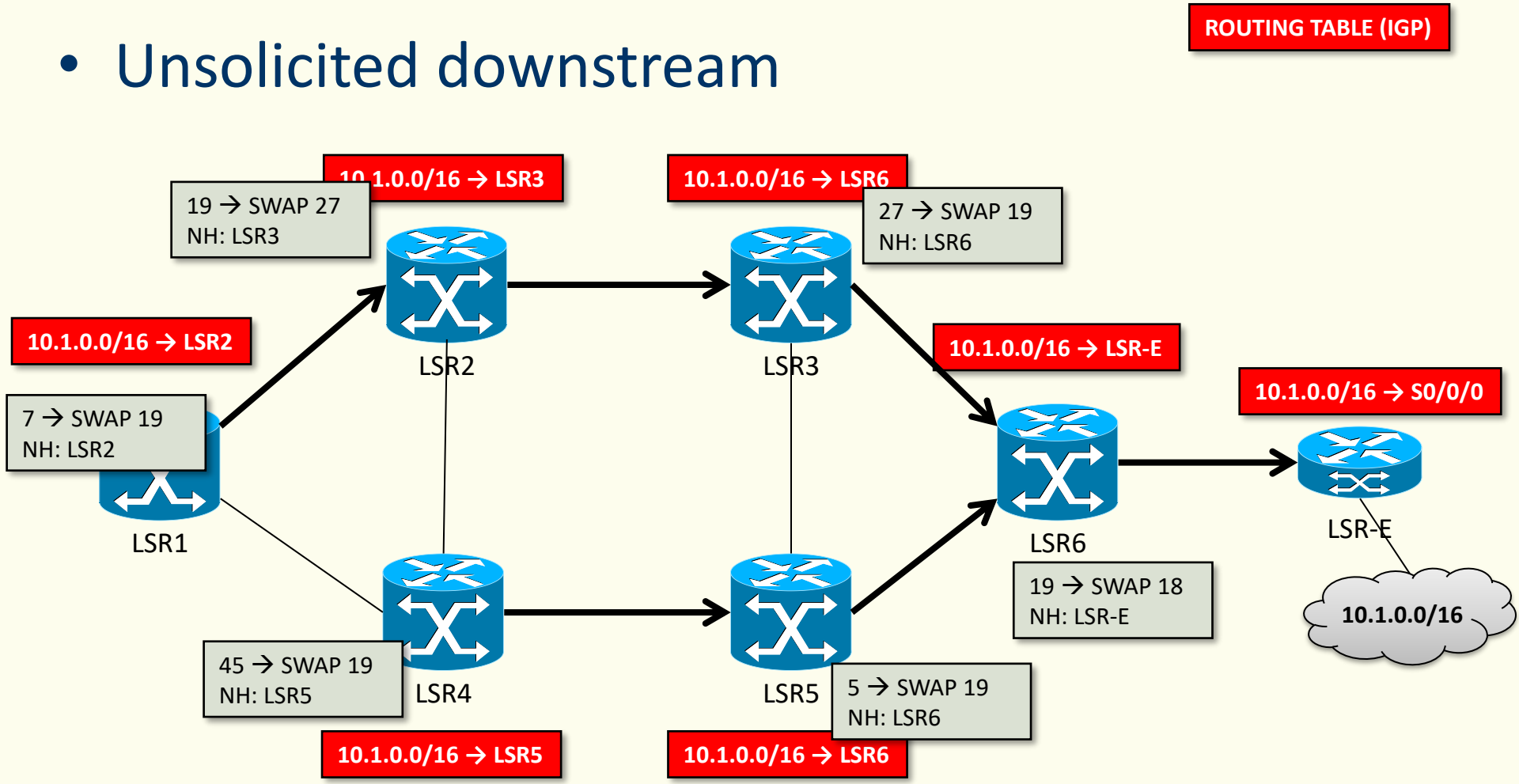
Independent control

- Unsolicited downstream



Independent control

- Unsolicited downstream

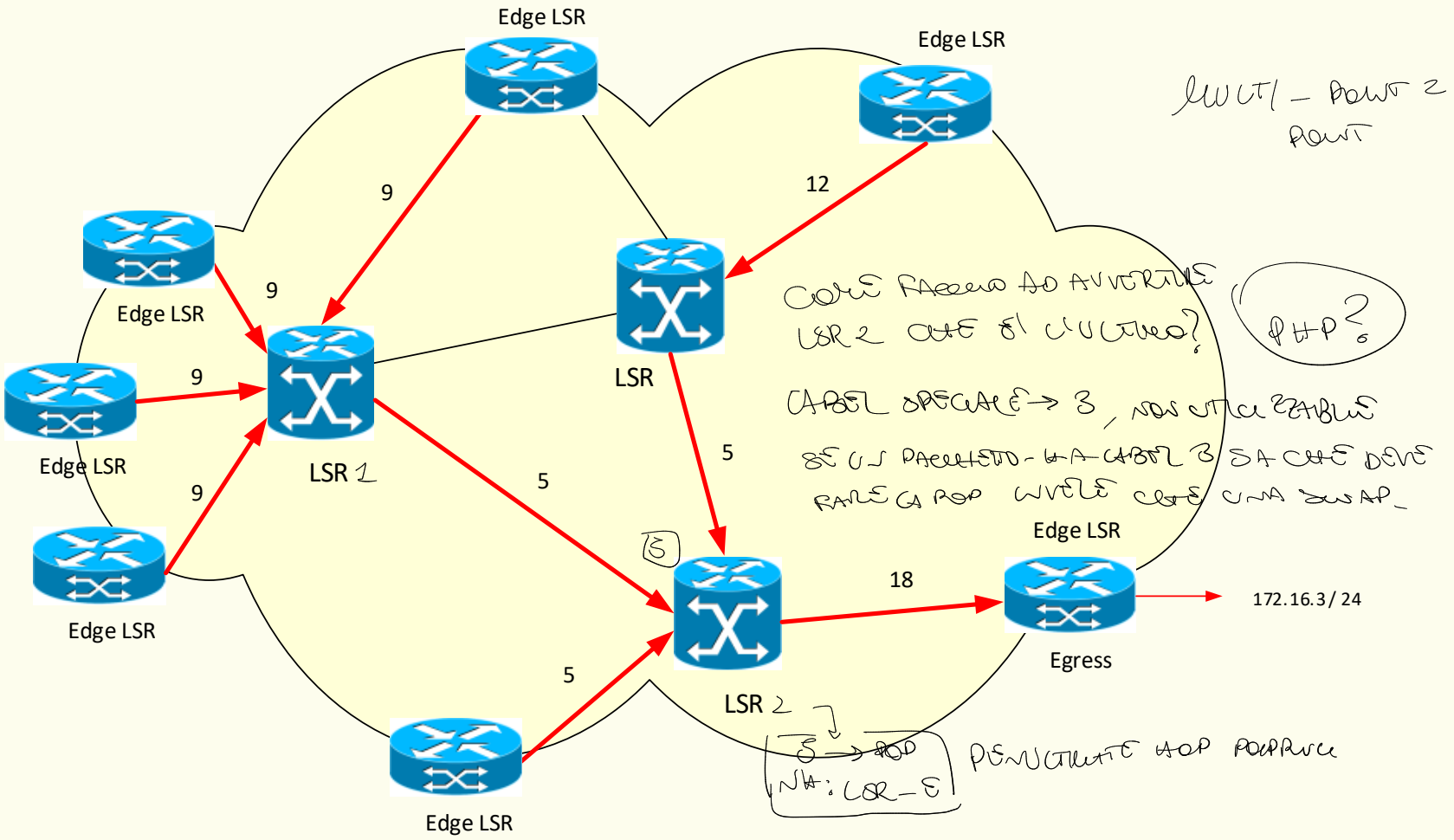


LSP setup control

- **Which FEC to advertise a binding for?**
- **When to advertise this binding?**

- **Ordered control**
  - Egress (or Ingress) LSRs have control over which LSP are setup
  - Default behaviour: FEC mapping to the LSR loopback address
- **Independent control**
  - All routers advertise FECs independently (but it should be in a consistent manner)
  - Default behaviour: FEC mapping for all prefixes in the routing table

Aggregation (MP2P)

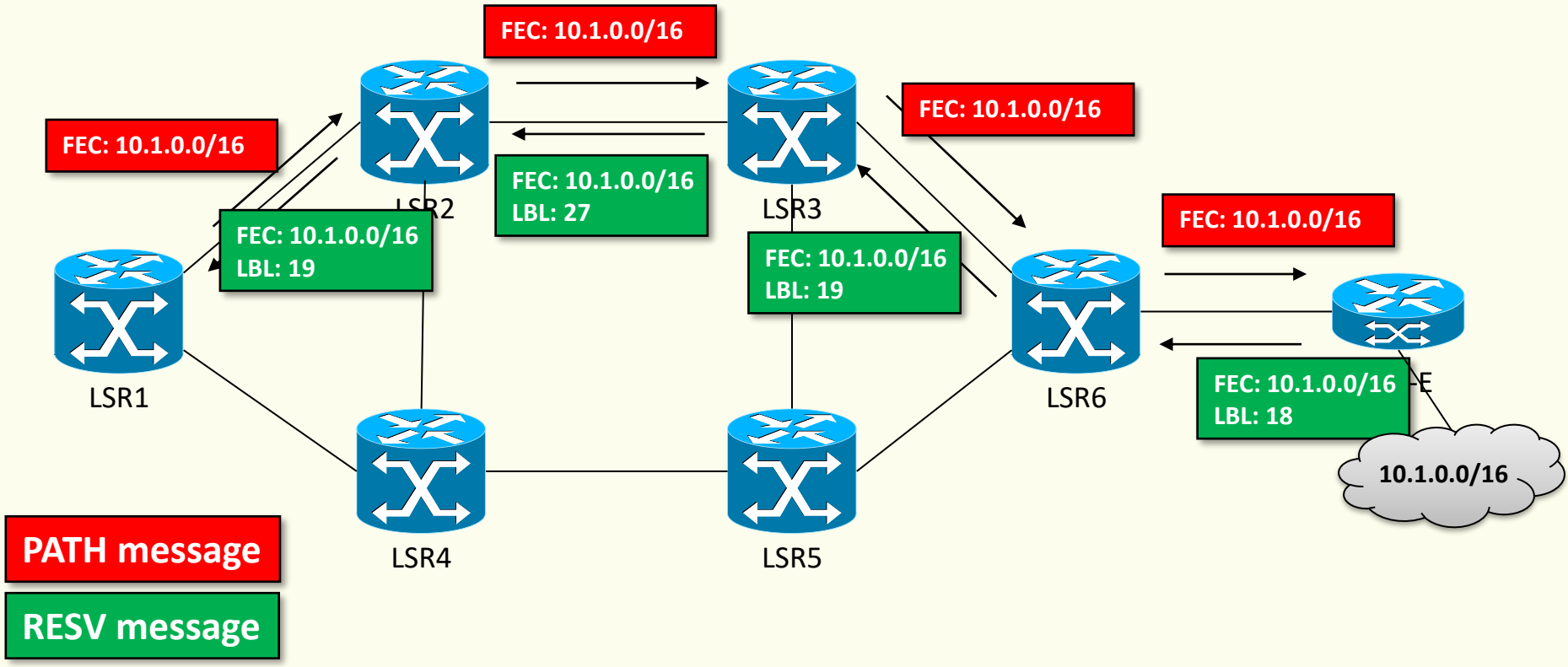


LDP - Label Distribution Protocol

- Specifically designed for label distribution
- Relies on an IGP for all routing-related decisions
  - LSR A that receives a mapping for label L for FEC F from its LDP peer LSR B will use label L for forwarding if and only if B is on the IGP shortest path for destination F from A's point of view
- Major functions (with related messages)
  - Neighbour discovery (UDP)
  - Session establishment and maintenance (TCP)
  - Label advertisement
  - Notification

RSVP for label distribution

- Ordered control with downstream on-demand



References

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- RFCs
  - **RFC3031**, Multiprotocol Label Switching Architecture, Jan. 2001
  - **RFC3032**, MPLS Label Stack Encoding, Jan. 2001
  - **RFC5036**, LDP Specification, Oct. 2007