

Core network protocols and architectures

Multi-Protocol Label Switching

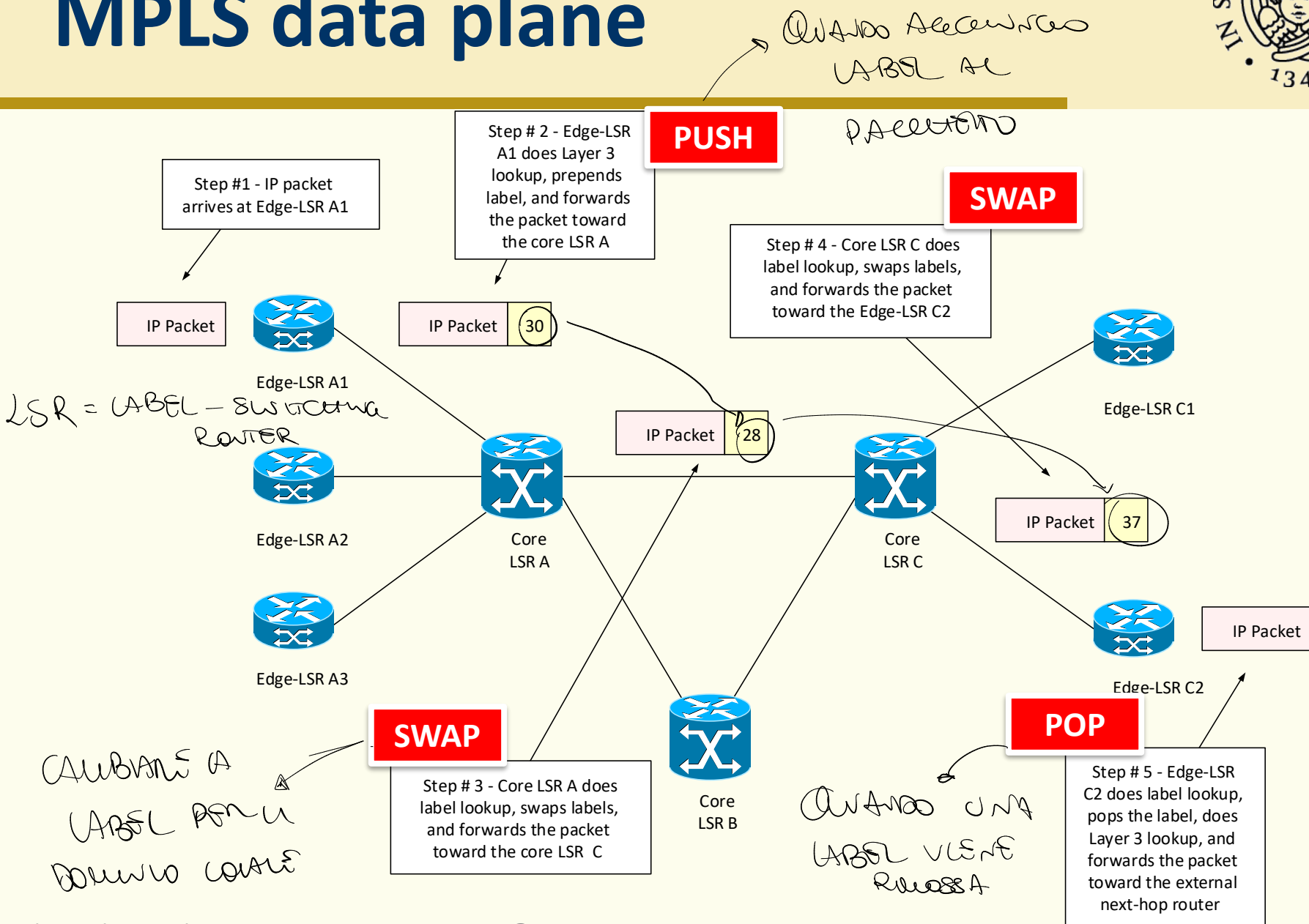
Data plane

Enzo Mingozzi

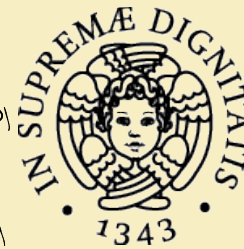
Professor @ University of Pisa

enzo.mingozzi@unipi.it

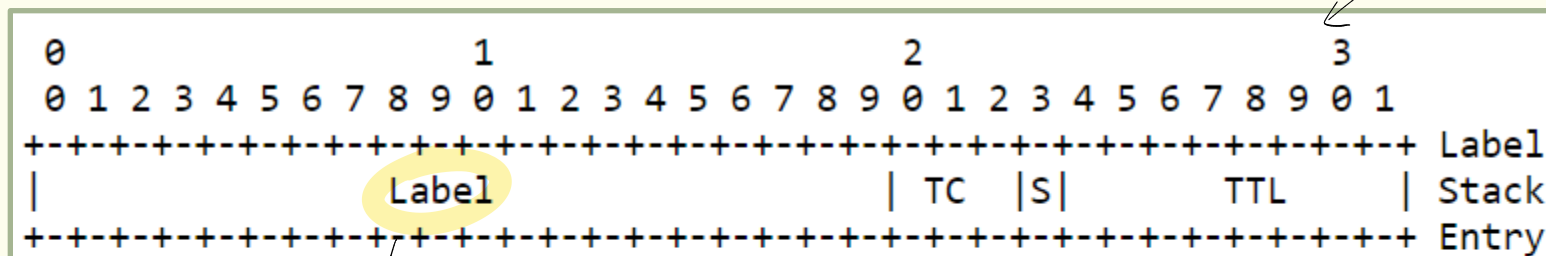
MPLS data plane



DOVE LA POSSIBILITA' NON
NEUN ESTENDI HESADON DI
LARGA PORELLA NON
AVREBBE SONO, DOME!



- **4 octets, after data link layer headers, before any network layer header**
 - A **Label** is a short, fixed length, locally significant identifier which is used to identify a FEC
 - **TC**: Traffic Class
 - **TTL**: Time-to-Live (IPv4 or IPv6 style)
 - **S**: enables label stacking (more on this later on)



SLOO UNHEARDEN 220
 OPANES ACTIN
 ↑ LABEL
 DIVERSE

Label: Label Value, 20 bits
TC: Traffic Class field, 3 bits
S: Bottom of Stack, 1 bit (Fixed)
TTL: Time to Live, 8 bits

PER DIFFERENZIANE
↓ SERVIZIO A CLIENTI
EPLS

→ this to use

MPLS label encoding

- Ethernet



- Ethertype value 0x8847: MPLS unicast packet
- Ethertype value 0x8848: MPLS multicast packet

- PPP



- MPLS Control Protocol (MPLSCP) defined for initial negotiation
- PPP protocol field: 0x8281

- L3 protocol identity is implicit (must be inferable from the label value)

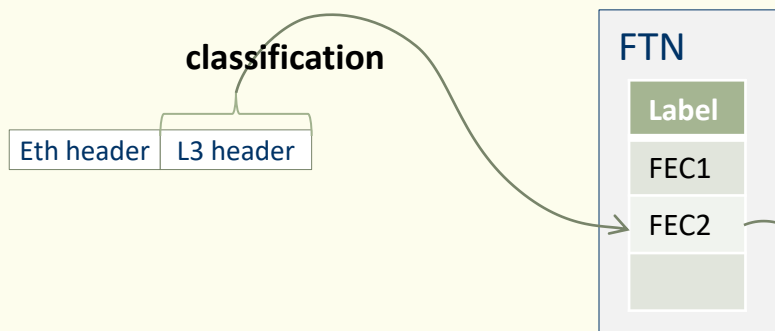
So the core
CO ALLE INTE DECIDE QUARE PROTOCOLS APPARTENONO AD UN RANGE DI LABELS

1 - 1200 → IPv6 1201 - 1600 → AERO

MPLS forwarding operation

3 STRUCTURE DATA ~ 3 CACHED TABLE

FEC-to-NHLFE Map



LSRx

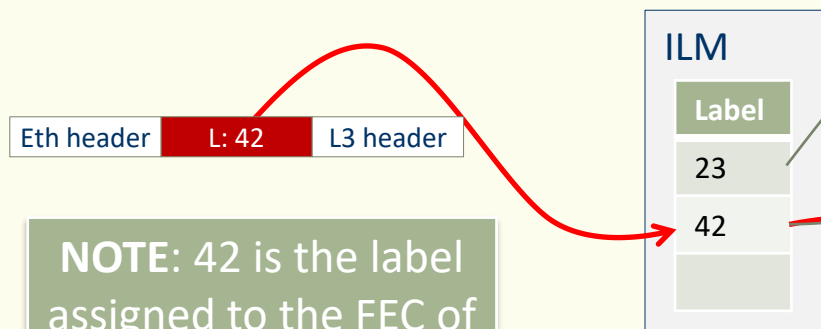
Next Hop Label Forwarding Entry

also present above

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

SE STESSE / DIVERGENZE REPROCESSING

Incoming Label Map



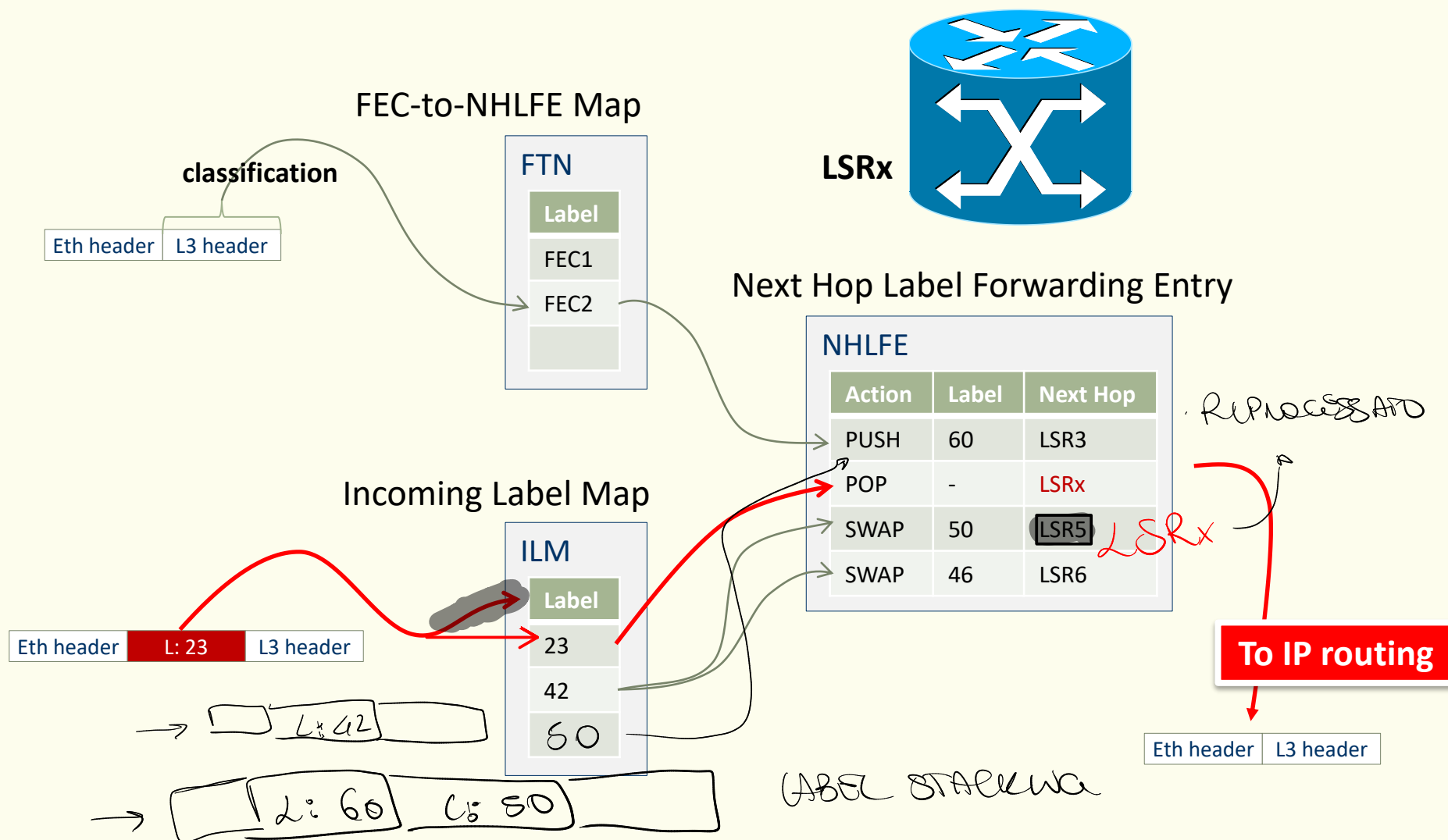
NOTE: 42 is the label assigned to the FEC of this packet by LSRx

*COST FINE
CON OVER PRELIMINARI*

To Next Hop

Eth header L: 50 L3 header

MPLS forwarding operation

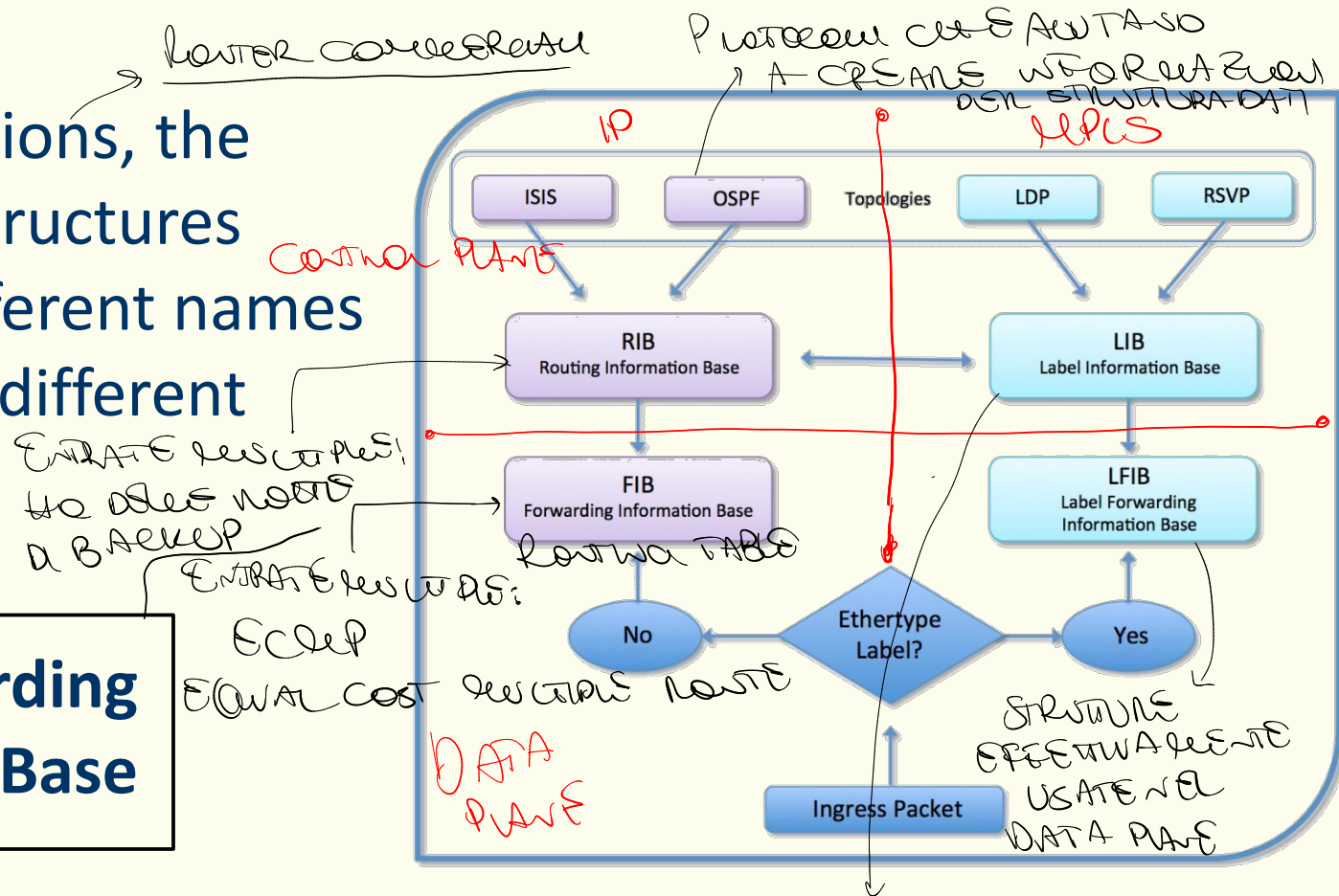


MPLS forwarding



- In concrete implementations, the data plane structures may take different names and/or have different organization

- Label Forwarding Information Base**

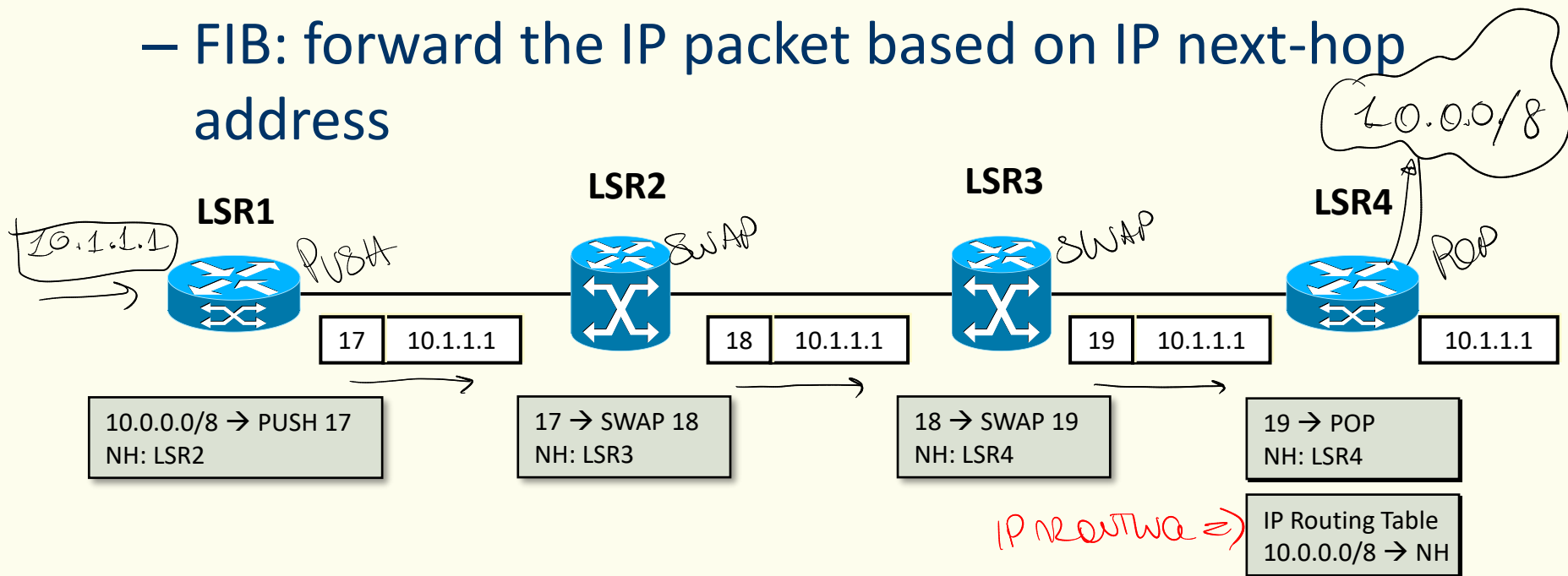


ALL INFORMATION NOW USE W DATA PLANE



Penultimate Hop Popping

- Double lookup at LSP egress
 - LFIB: remove the label
 - FIB: forward the IP packet based on IP next-hop address



Penultimate Hop Popping (PHP)

OTTIMIZZAZIONE

- Single lookup at LSP egress

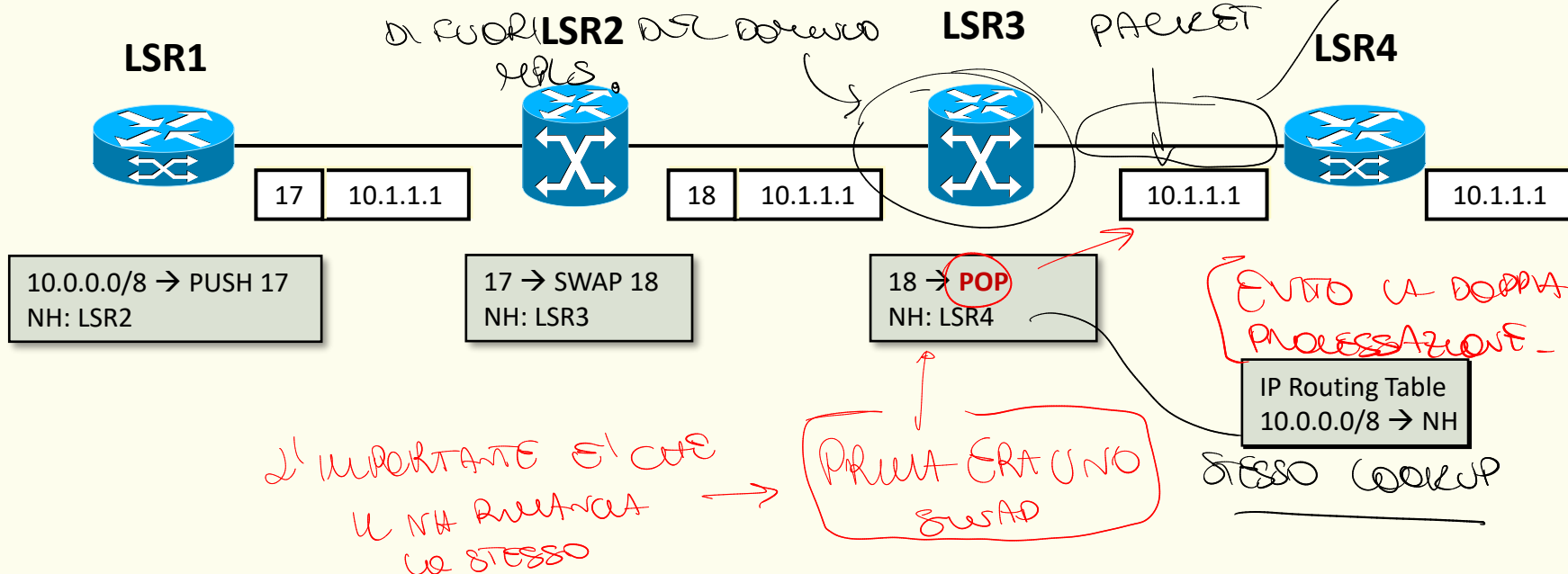
- ~~LFB: remove the label~~

- FIB: forward the IP packet based on IP next-hop address

IL ROUTER E' W CARICO
DI RICONOSCERE LA CLASSE
DI SERVIZIO DAL DESTINATARIO
IP.

PERCHÉ NON CLASSIFICA W FEC?
HO UNA ROUTA CHE PORTA AL
DI FUORI LSR2 DEL DOWNS

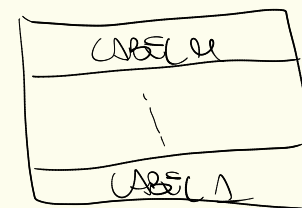
UNLABELED
PACKET



Label stacking

- The MPLS data plane is based on a more general **stack model**
 - A labeled packet carries a number of labels $m \geq 0$
 - Labels are organized as a last-in, first out stack

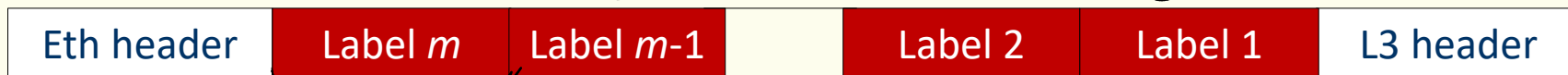
- Label 1, bottom of stack
- Label m , top of stack



OPERAZIONI
DISTRIBUITE
SU UNO
STACK

- Actions in NHLFEs always apply to the top label in the stack

Come saranno accessibili gli LABEL? e BUT S'HA
LABEL CL DE SE S'HA LO NEL BOTTOM STACK OPPURE NO_



UNCO DATA ACCESSIBILE → SWAP, POP, PUSH

Label stacking and actions

NON CI SONO CUESA A

QUANTE AZIONI UN REGISTRO PUO' EFFETTUARE



- **SWAP Lx** → DI SCELTO NON SI FA UNO SWAP LEVITARE
 - replace the label at the top of the label stack with a specified label Lx

- **POP**
 - pop the label stack

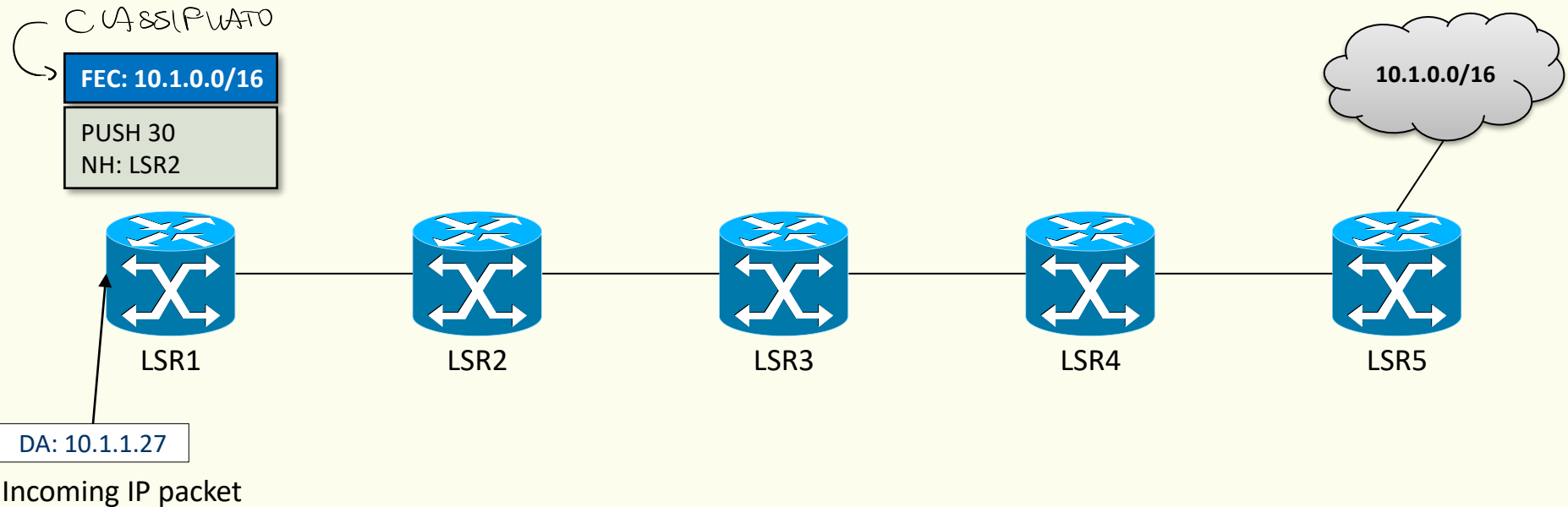
- **PUSH Lx**
 - push one new label Lx onto the label stack
 - Multiple pushes are allowed

SPESSE PRESENTATA COSI' A DUE:

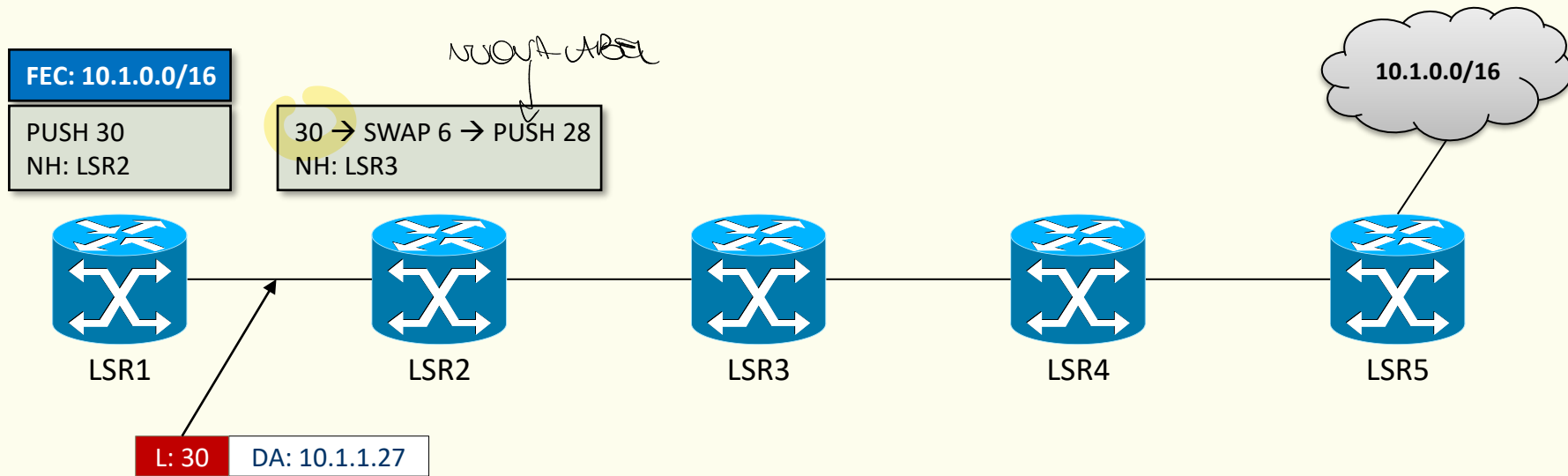
SWAP Lx + PUSH Ly

COMBINAZIONE DI AZIONI TIPIE

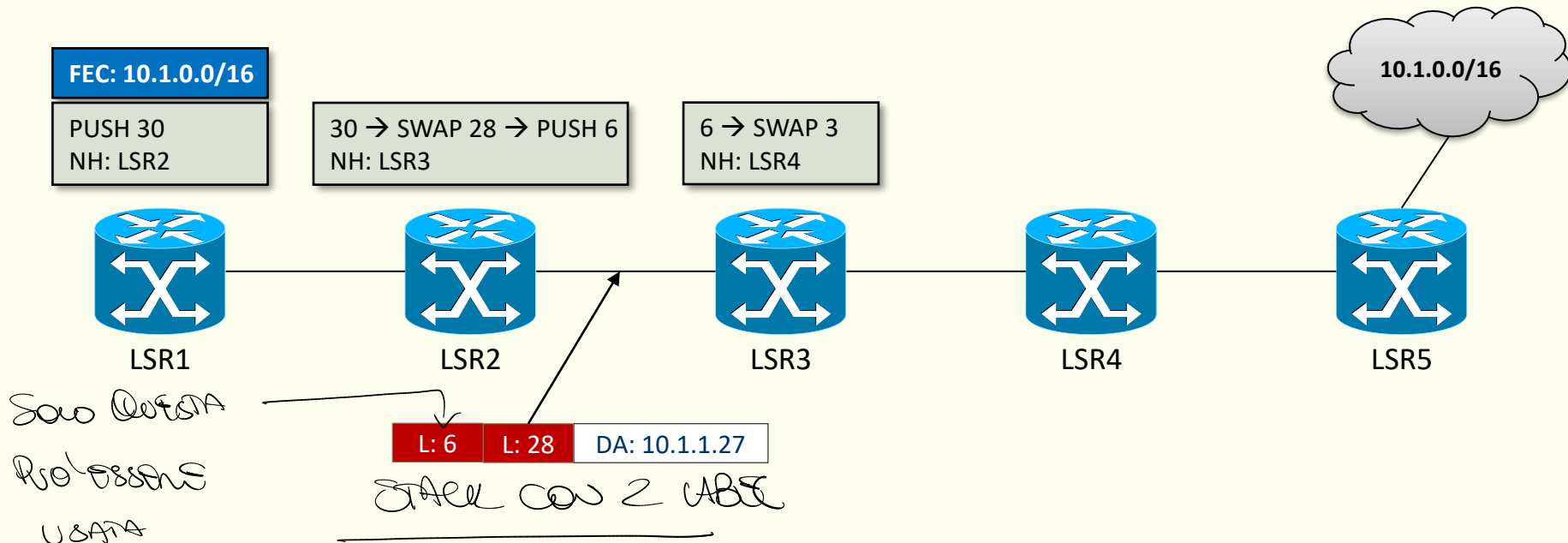
Label stacking – example



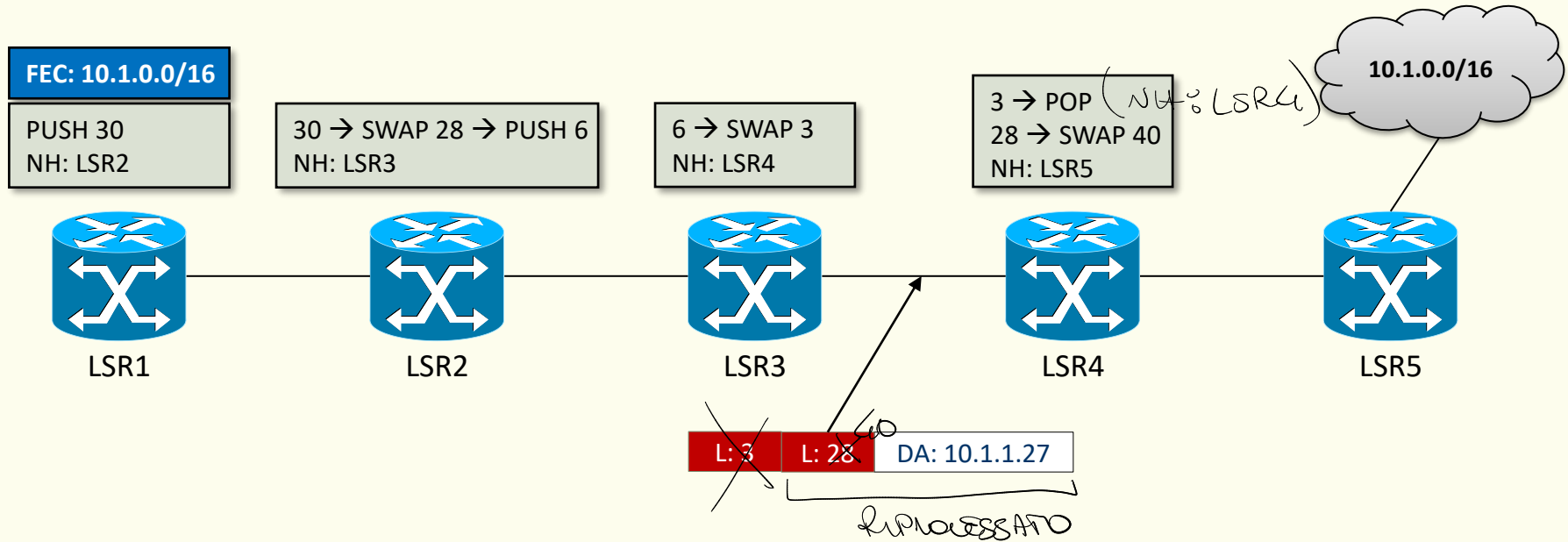
Label stacking – example



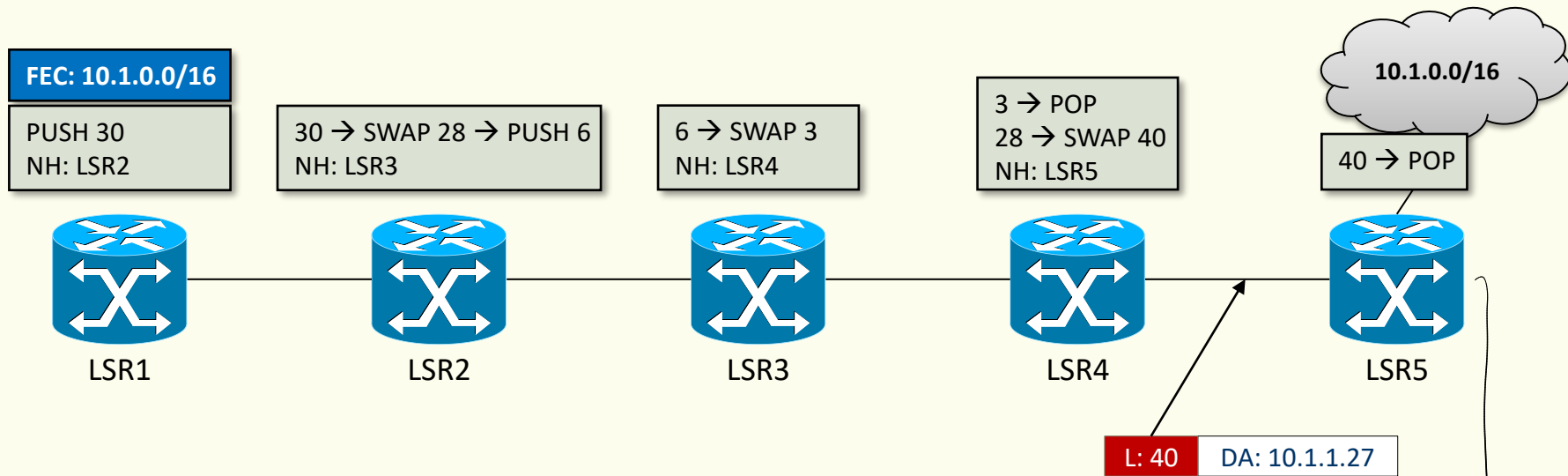
Label stacking – example



Label stacking – example



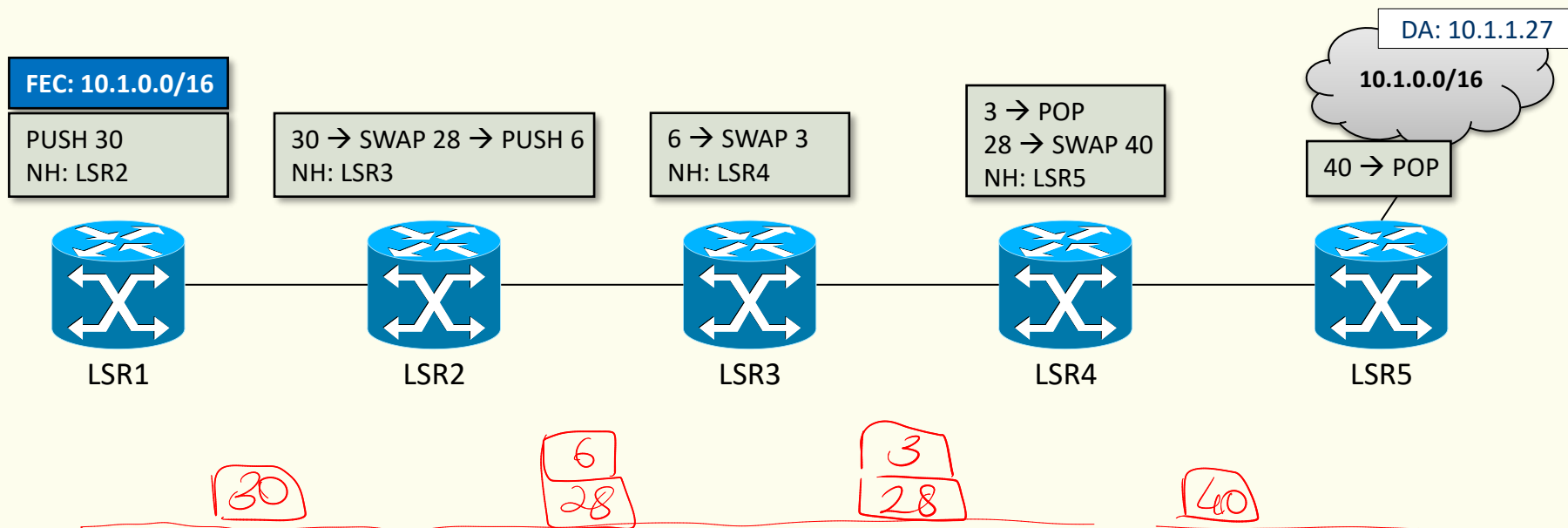
Label stacking – example



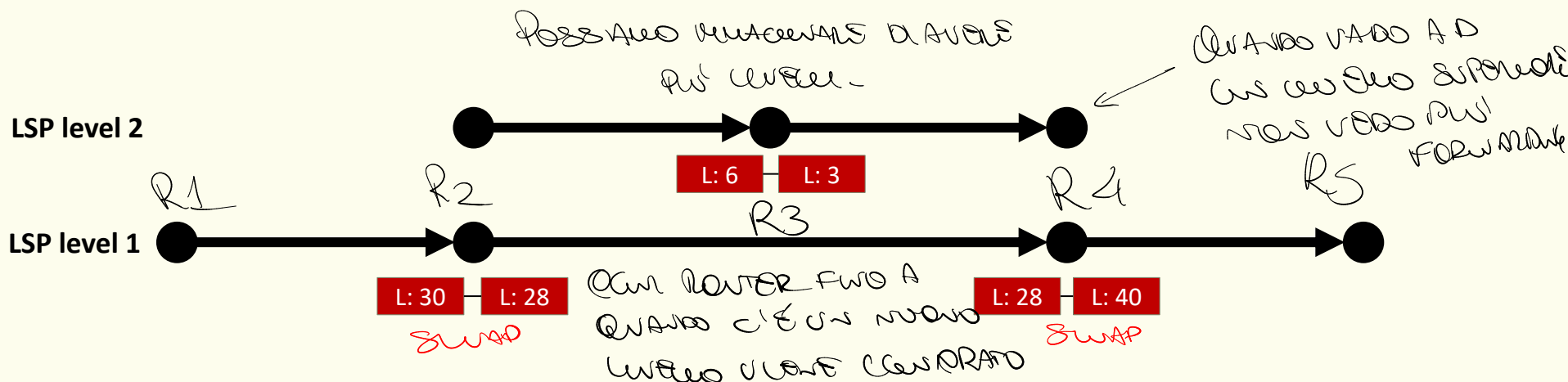
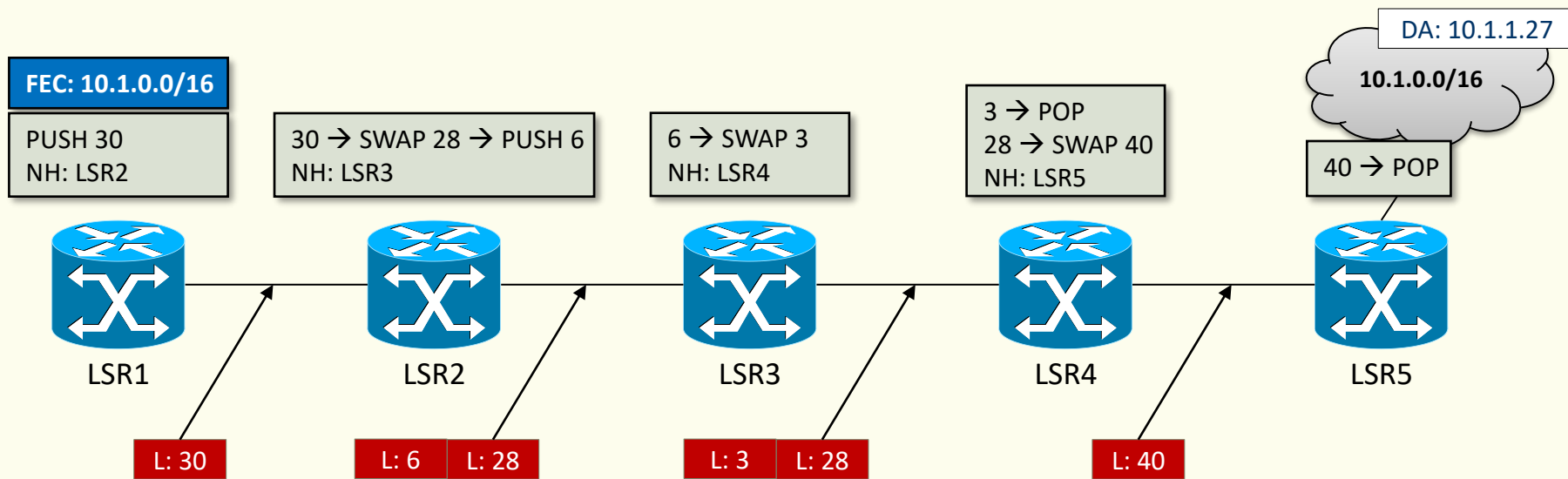
NOW ADDING USATO THAT FOR NOW CONTAINS USSTO

NH: LSR5
↳ UPROX

Label stacking – example

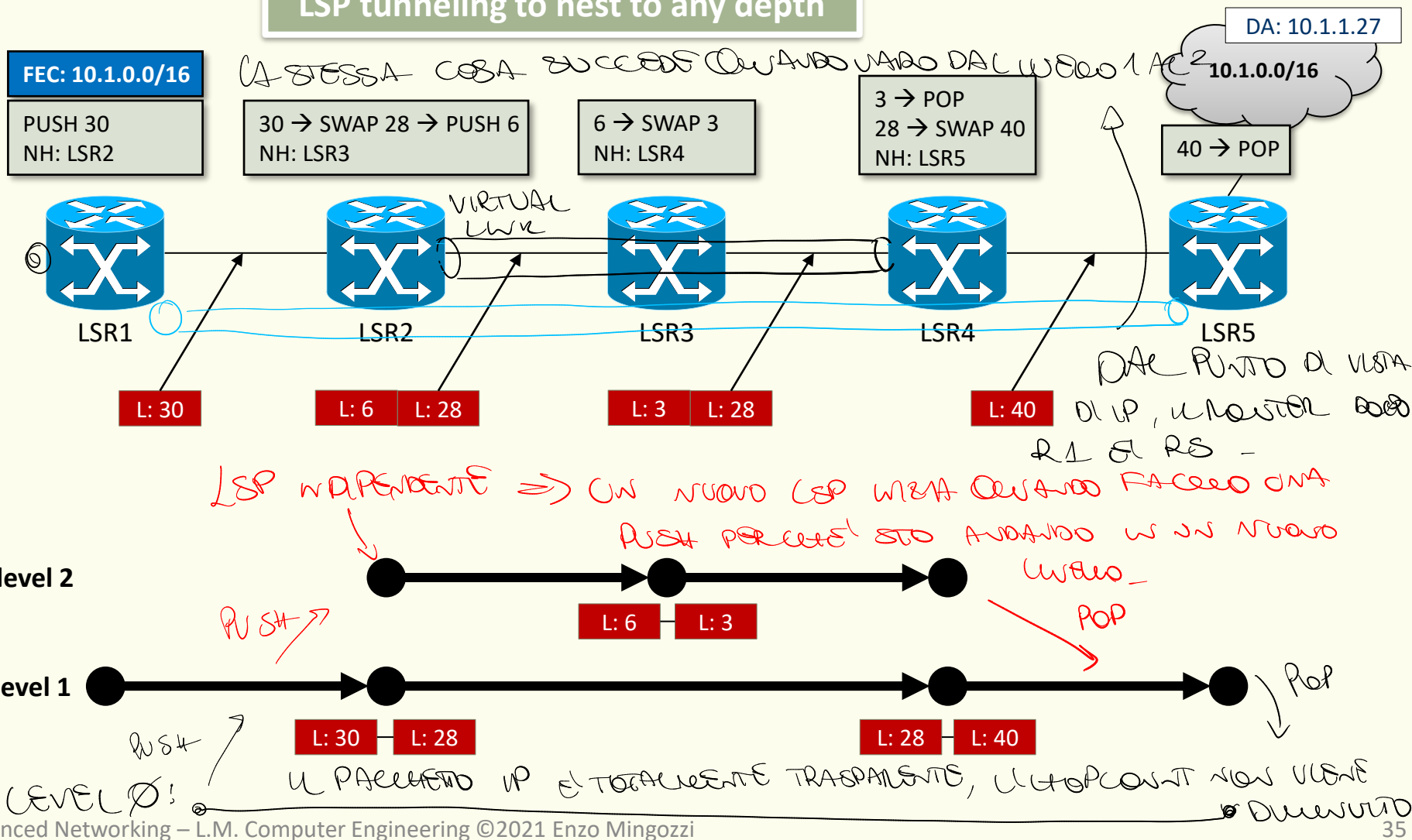


Label stacking – example

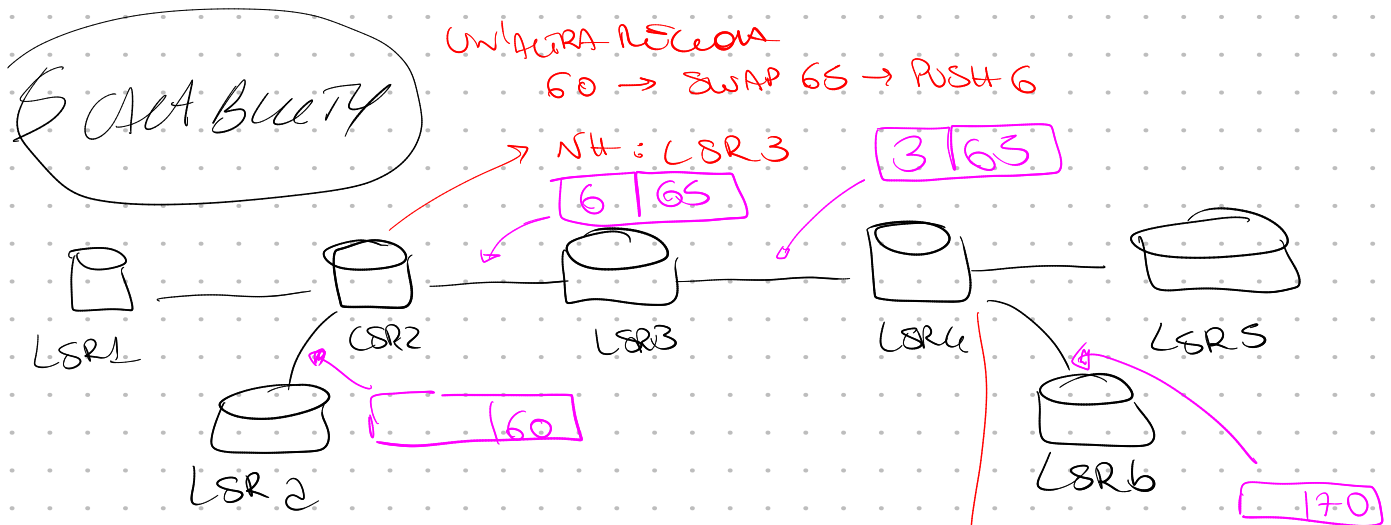


Label stacking – example

The label stack mechanism allows LSP tunneling to nest to any depth



A COSA CI SERVONO QUESTI "TUNNEL"? AD ESSEMPIO TRA R2 E R6 -



AGGIUNGO UN LSP UNICO A
DIVERSE "TUNNELLED" ATTRAVERSO
UN LSP DA UNICO 2 UOGLIO -

UN'AUTRA ESSEMPIO
65 → SWAP 70
NH: LSR5

POTREI FARE ANCHE SENZA CENTRI, MA AVREI BISOGNO DI
ALTRE GABE DIVERSE.

SE HO 1000 LSP DIVERSI CHE CONDIVIDONO UNA STESSA
PORZIONE DI PERCORSO NON HO BISOGNO DI 1000 GABE
DIVERSE, NE BASTA UNA.

MANUTENIBILITÀ

FEATURE PIÙ IMPORTANTE!