

P4 虛擬網路設計與實作

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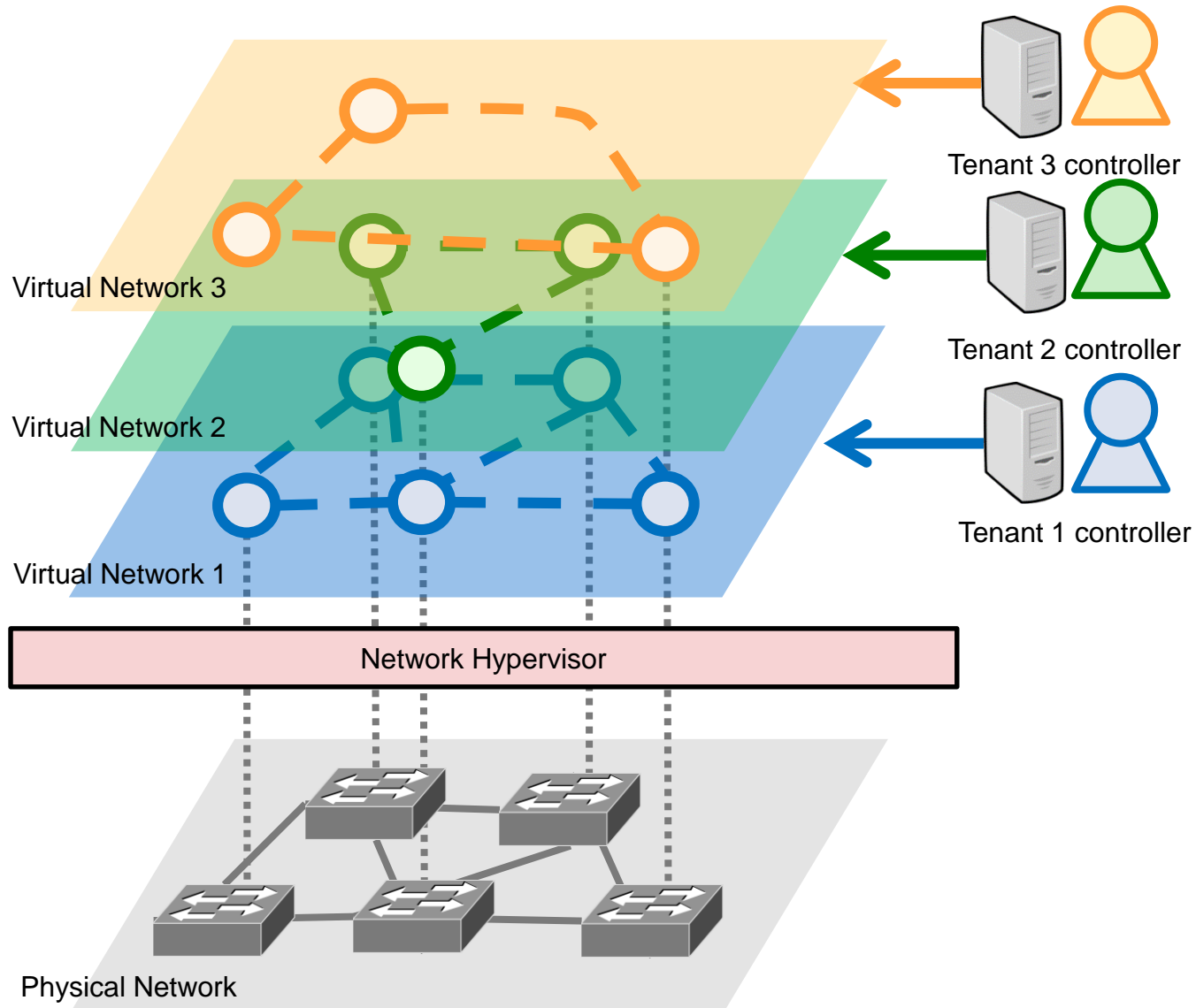
Industrial Technology Research Institute

工業技術研究院

Outline

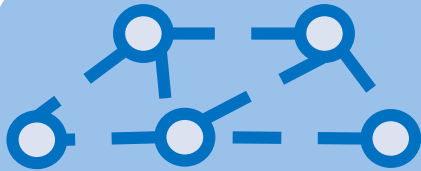
- Introduction to Network Virtualization
- P4 Data Plane Virtualization
- P4 Network Virtualization
- P4 Switch Virtualization
- Multicolor Marker (MCM) based Meter
- Experimental Results
- Conclusion

Network Virtualization

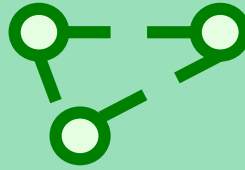


Network Resources Sharing

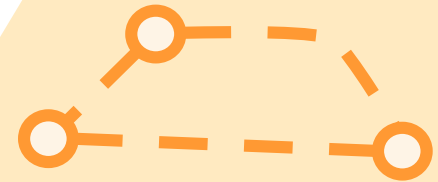
Virtual Network 1



Virtual Network 2



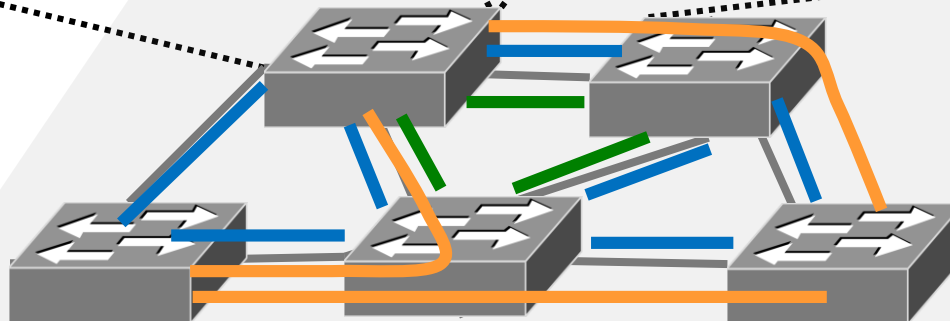
Virtual Network 3



Sharing Switch resources

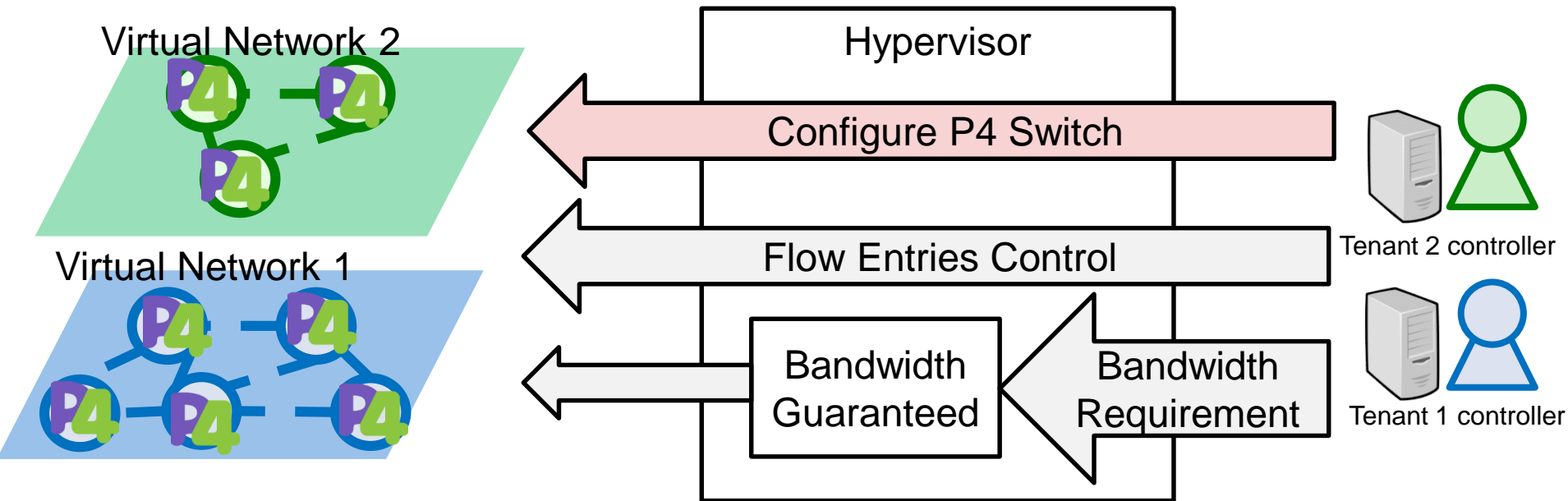


Bandwidth Guarantee & Qos Flow



Physical Network

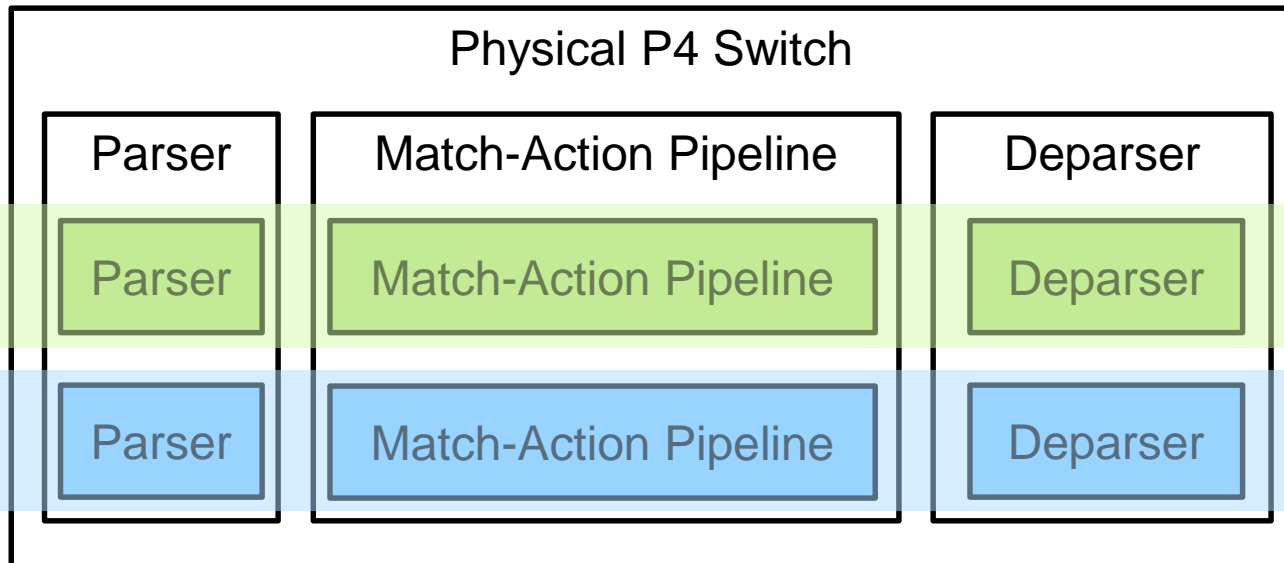
P4 Network Virtualization : P4 Virtual Network



P4 data plane virtualization

VN 2

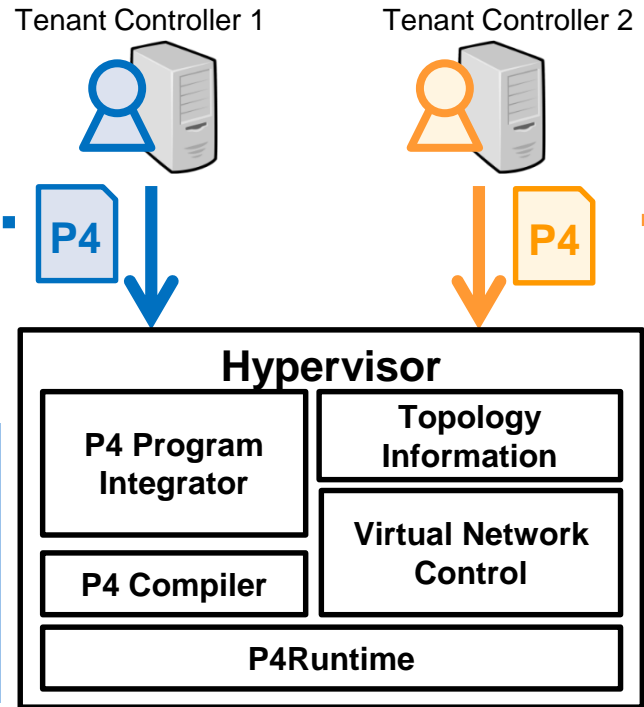
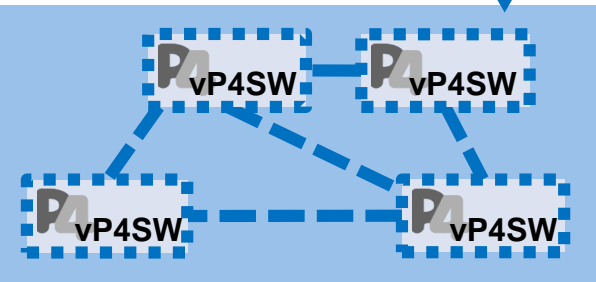
VN 1



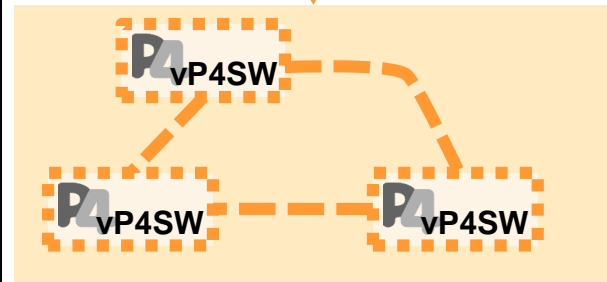
Architecture of P4 Network Virtualization (1)

- **Virtual P4 Network**
 - Virtual Link
 - Virtual Port
 - **Virtual P4 Switch**
 - Dynamical Control
 - Dynamical Reconfiguration

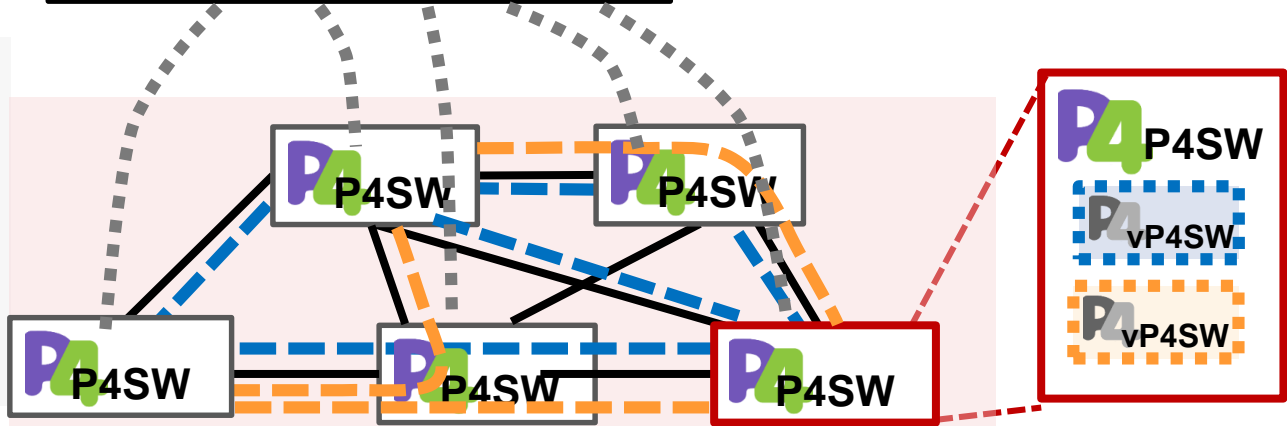
Virtual Network 1



Virtual Network 2

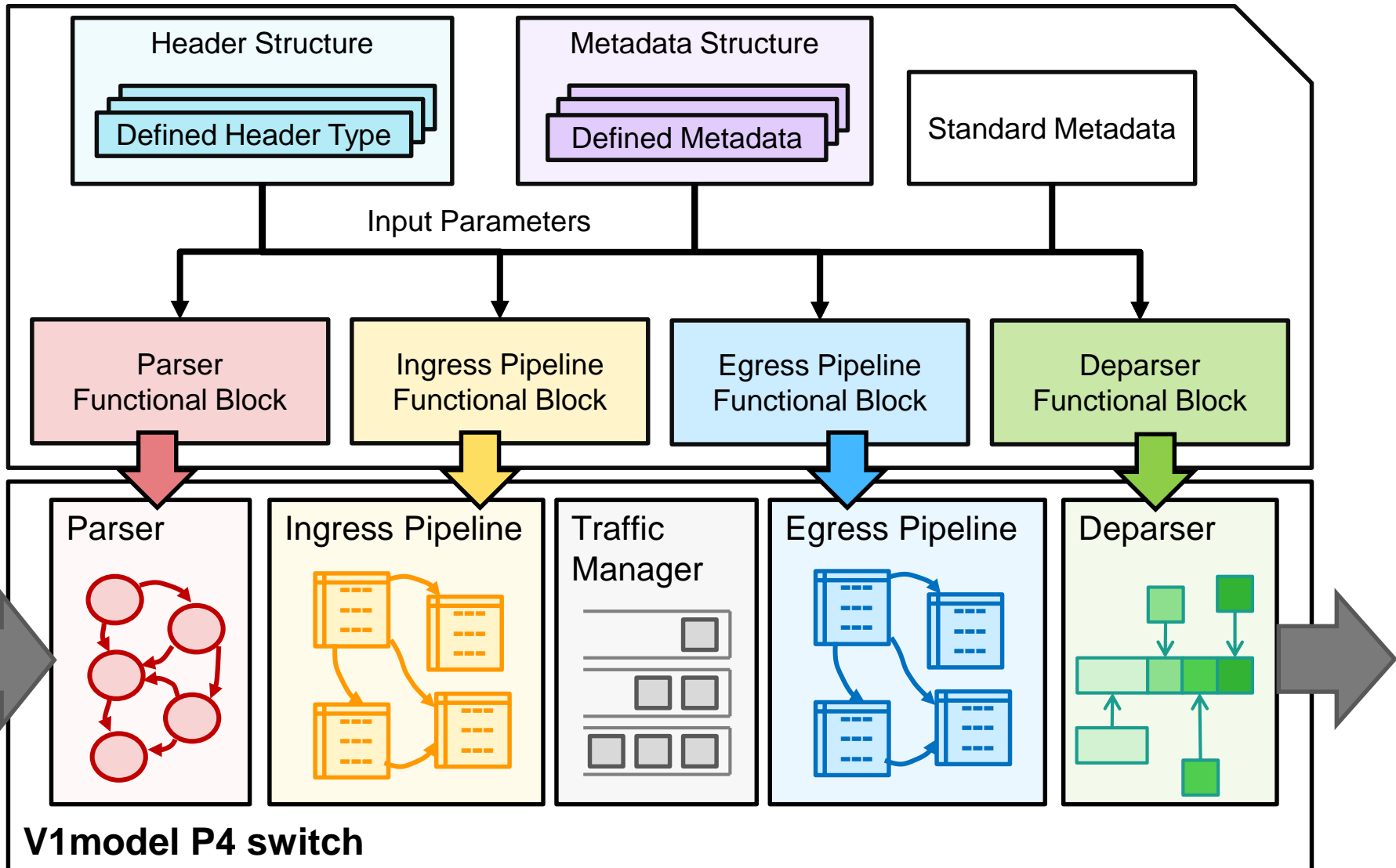


- **P4 Network Virtualization**
 - Traffic Isolation
 - Virtual Link and Virtual Port Mapping
 - **P4 Switch Virtualization**
 - Data Plane Virtualization
 - Live Reconfiguration
 - **Multicolor Marker (MCM) Meter**
 - Inter-VN : Bandwidth Guarantee
 - Intra-VN : Priority Differentiation

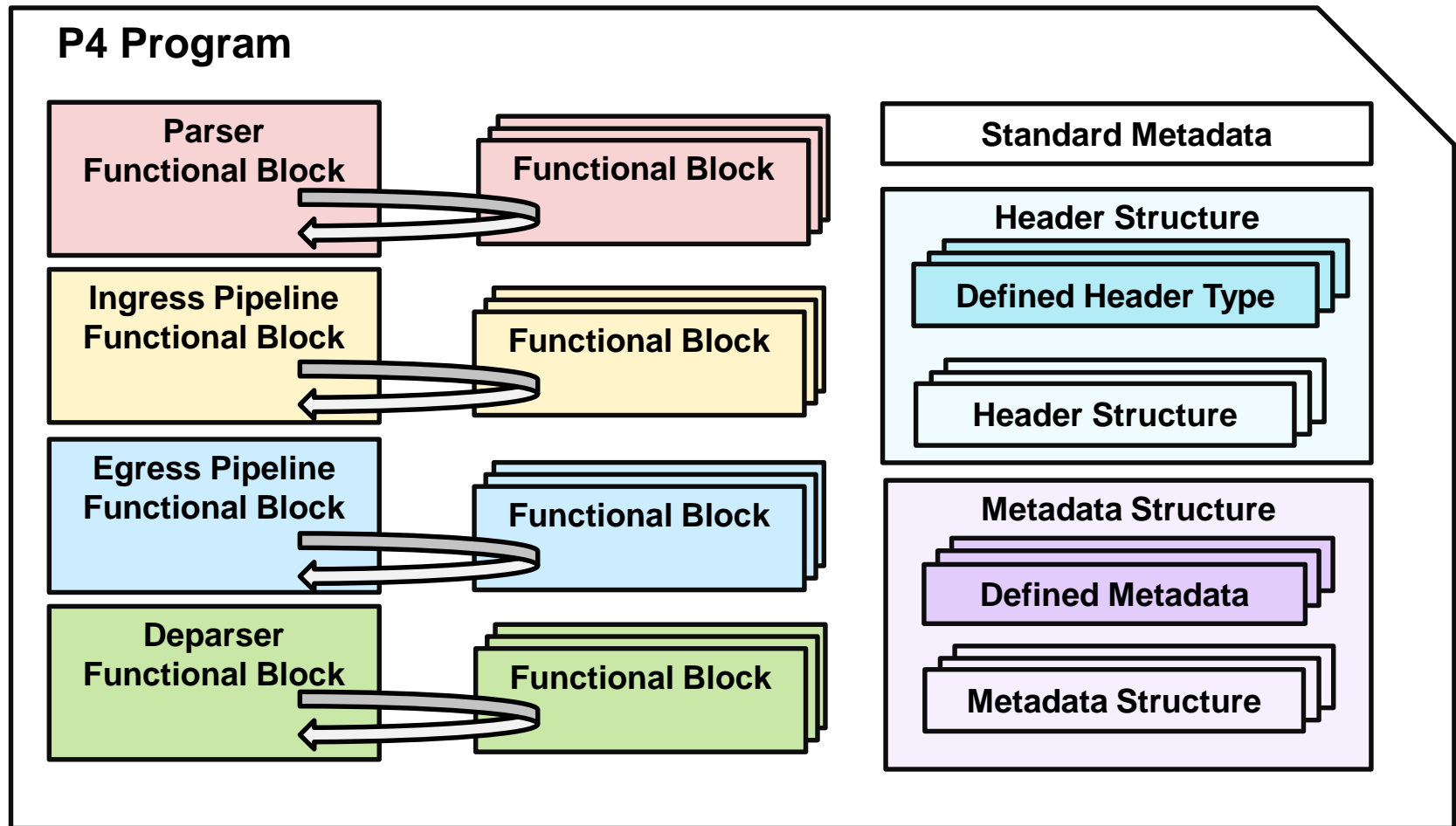


Physical Network

P4-16 Program



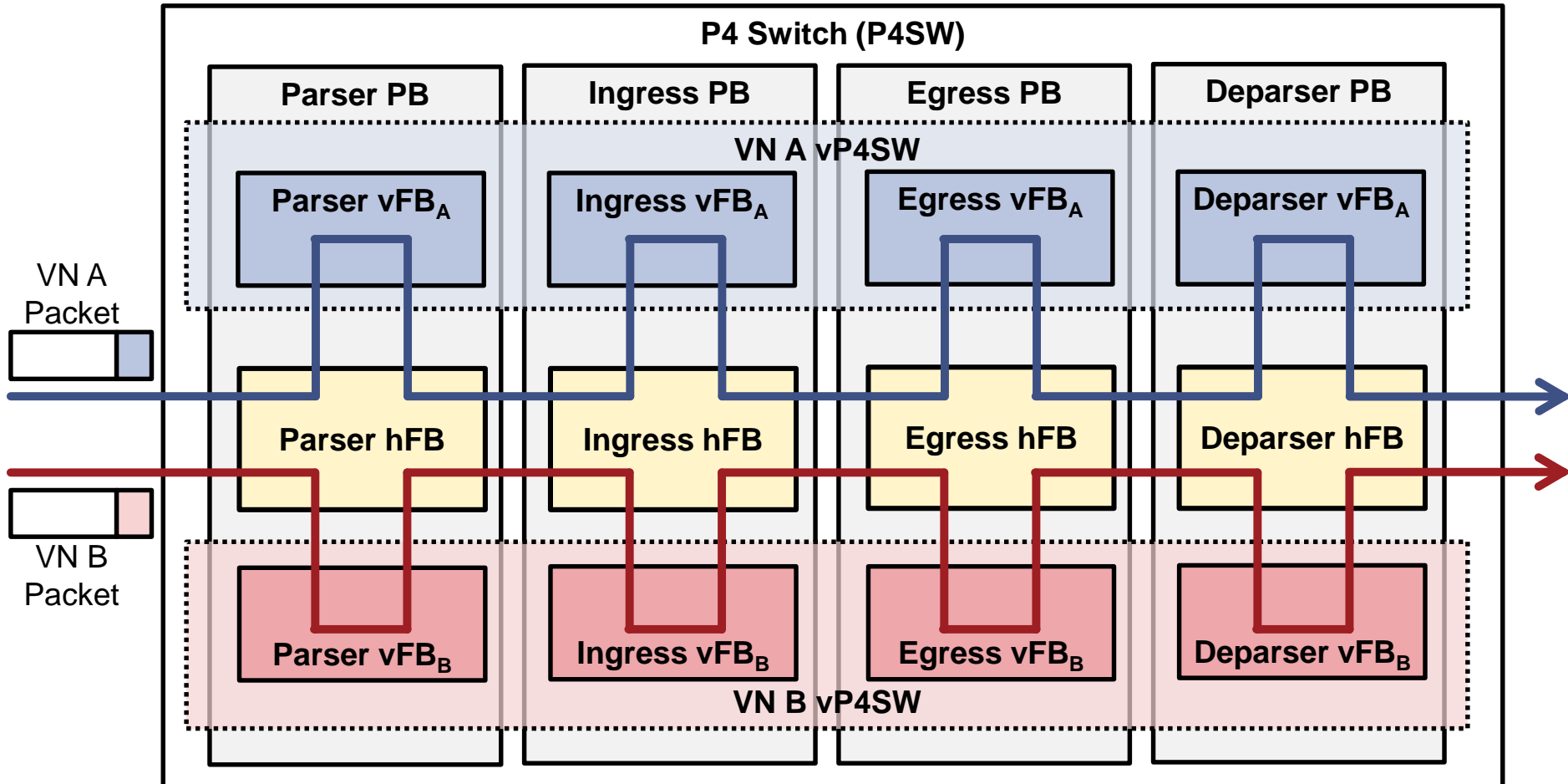
P4 Switch Virtualization (1)



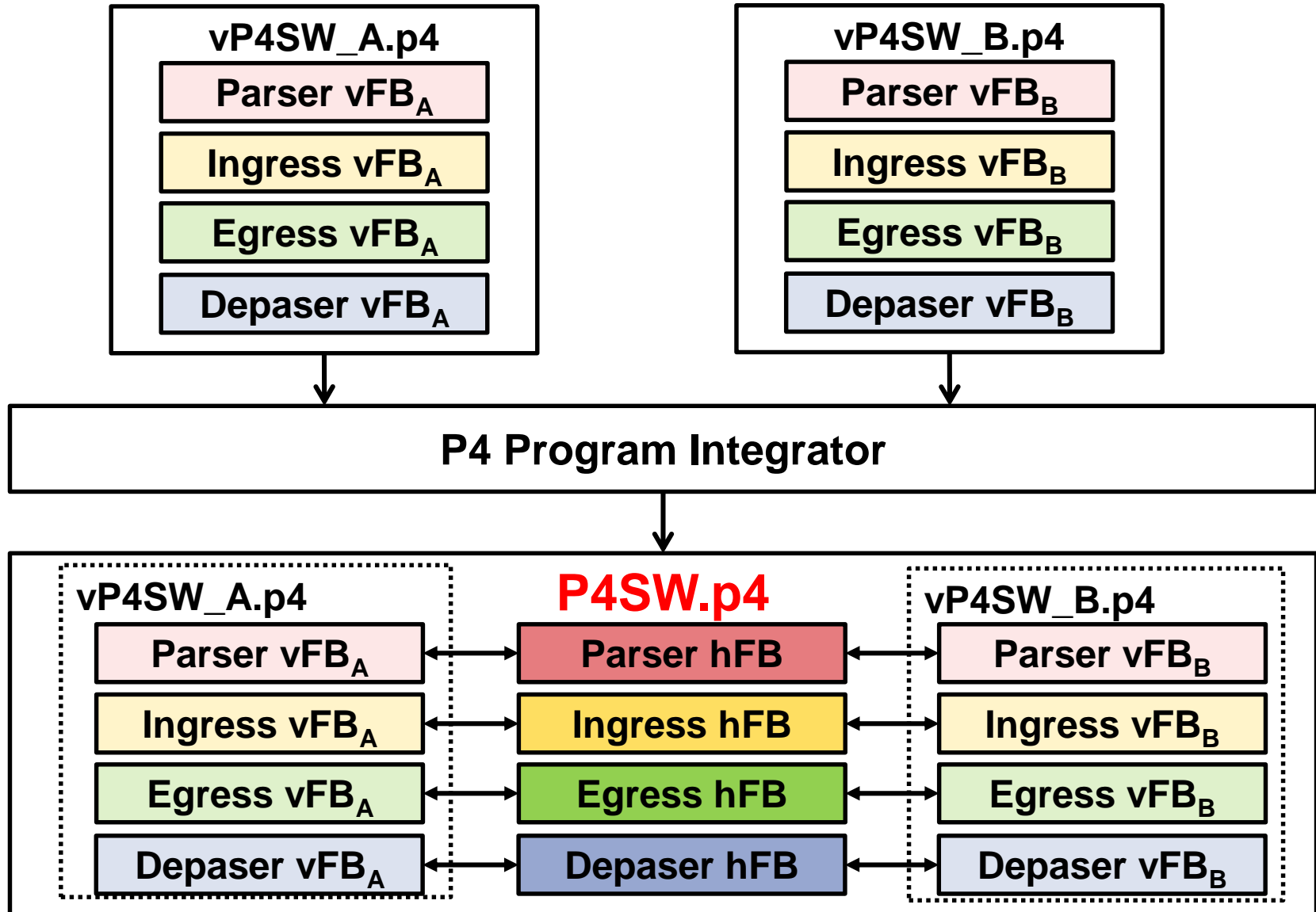
P4 Switch Virtualization (2)

hFB : hypervisor Functional Block

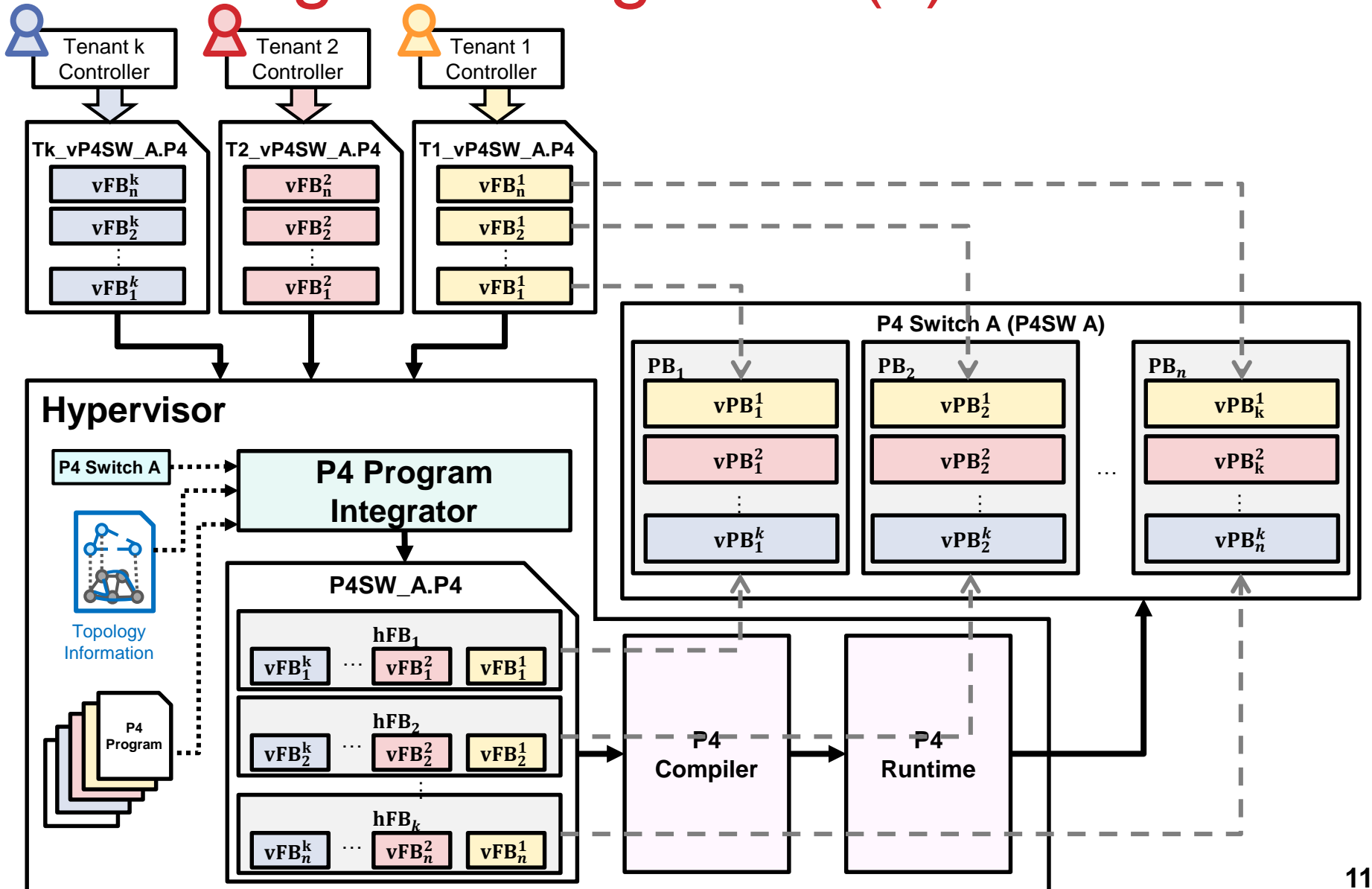
vFB : virtualized Functional Block



P4 Program Integration (1)

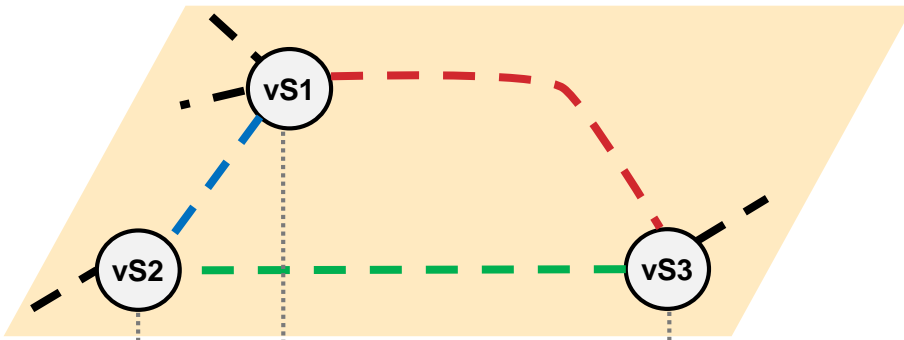


P4 Program Integration (2)

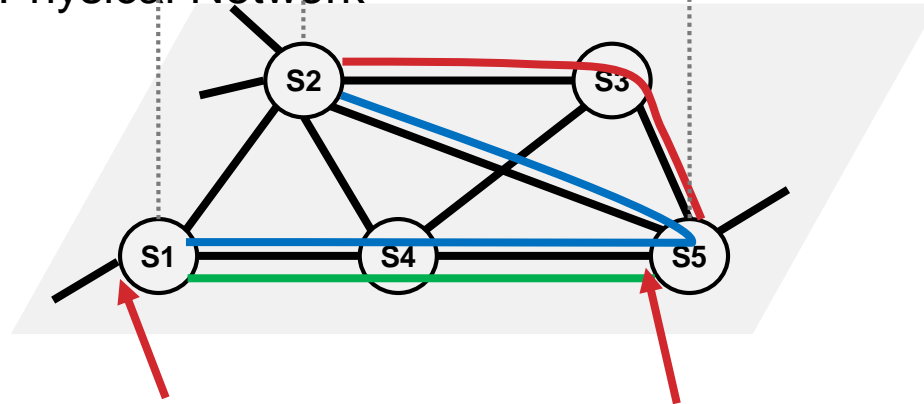


Virtual Topology

Virtual Network

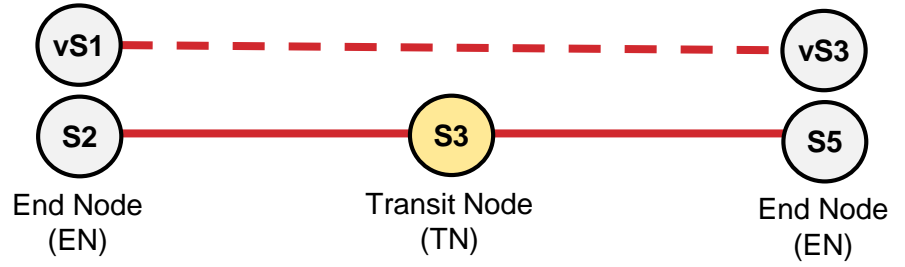


Physical Network

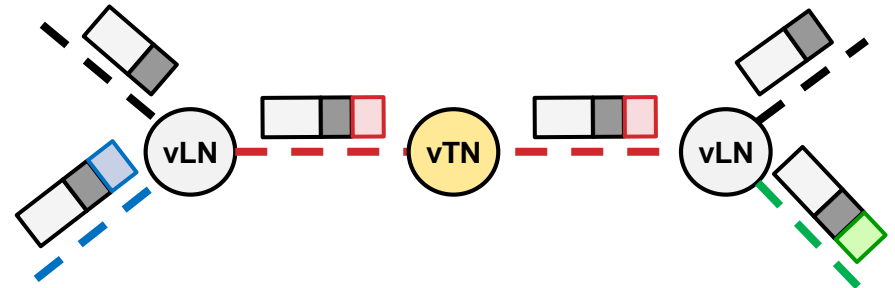


Access port

Network port



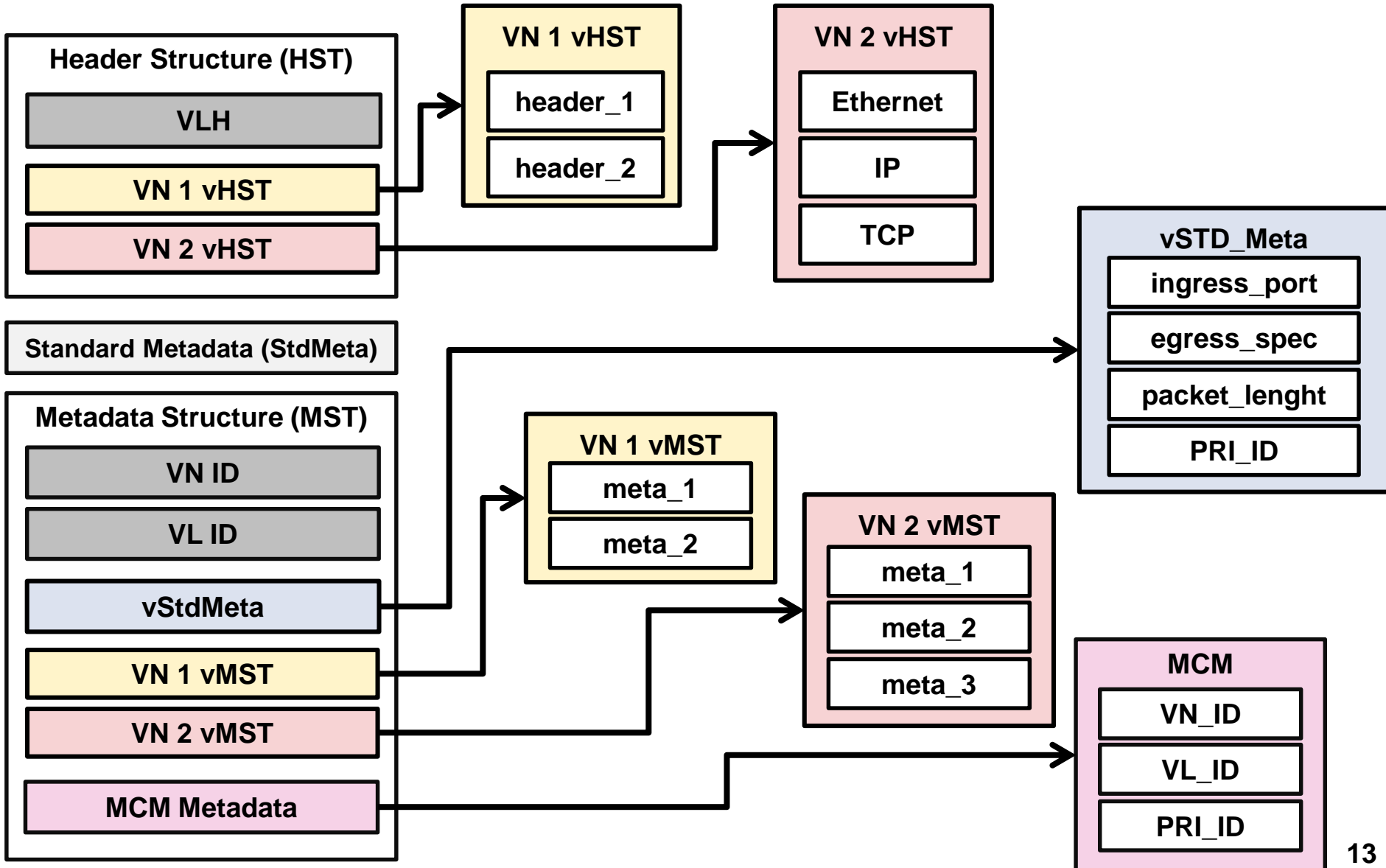
S5 : vTN for vLink vS1 ↔ vS2
 vLN for vLink vS2 ↔ vS3 and vLink vS1 ↔ vS3



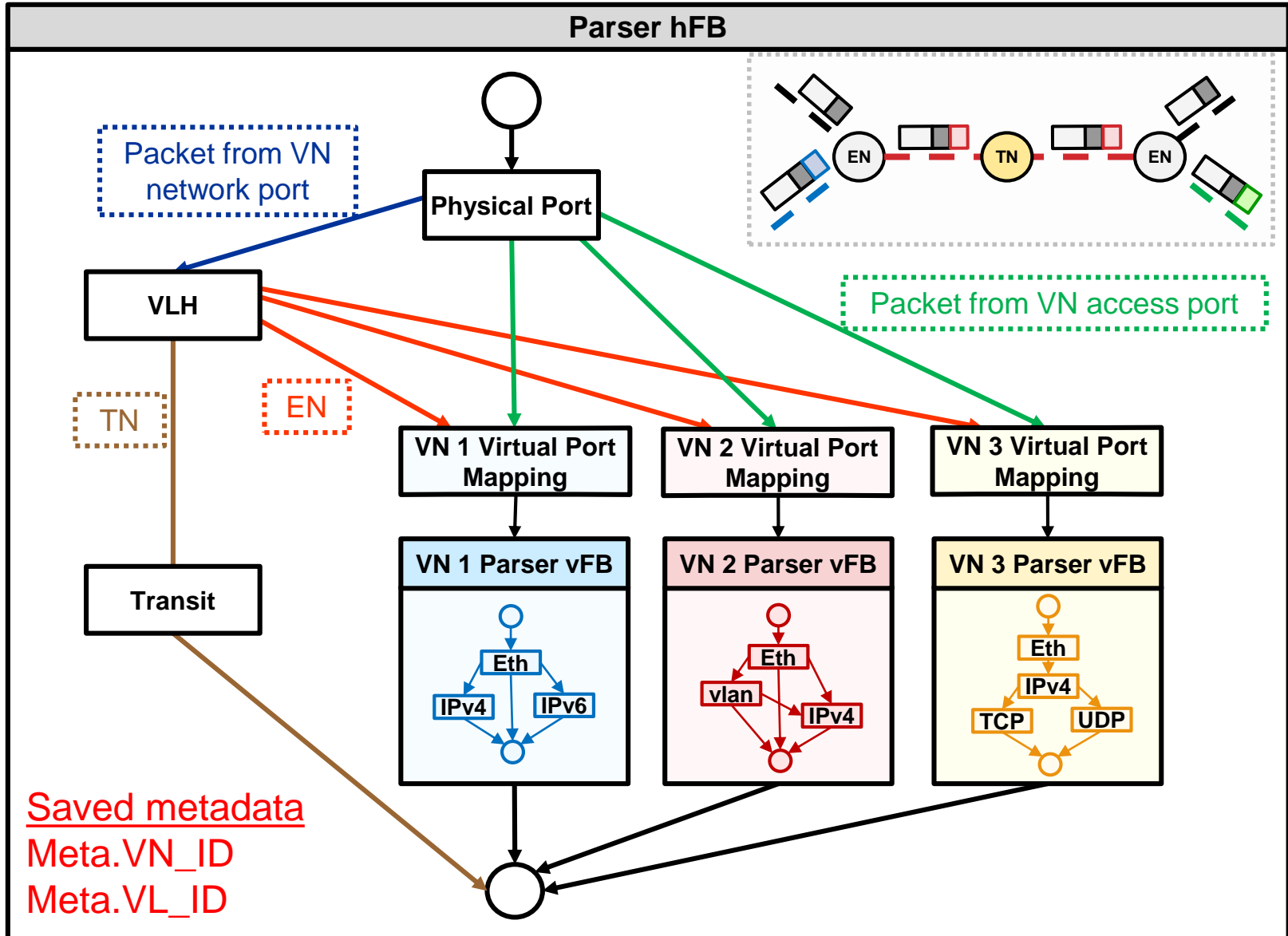
Virtual Link Header (VLH)

0	8	16	24
VN ID	VL ID	Priority ID	Packet

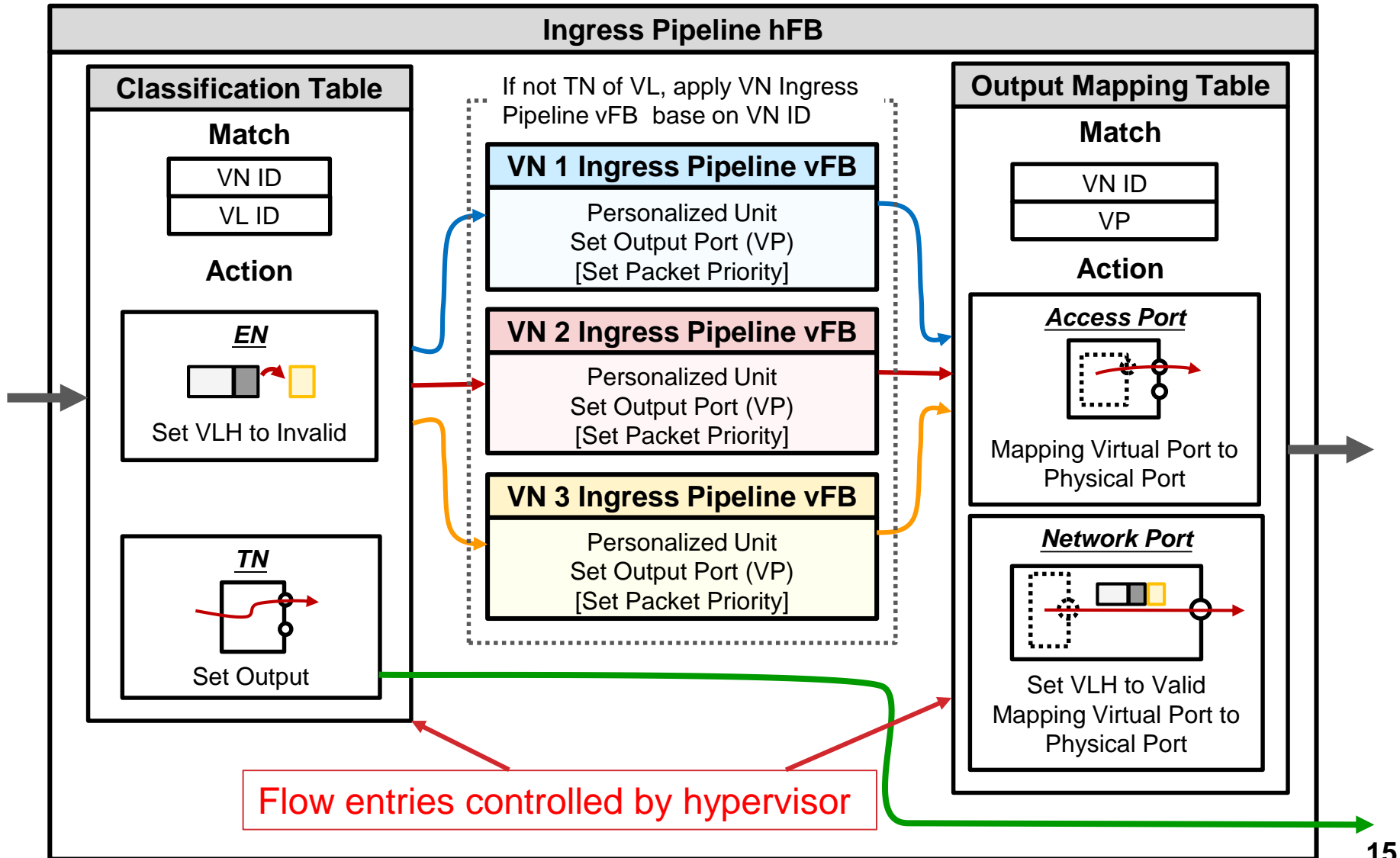
Header and Metadata



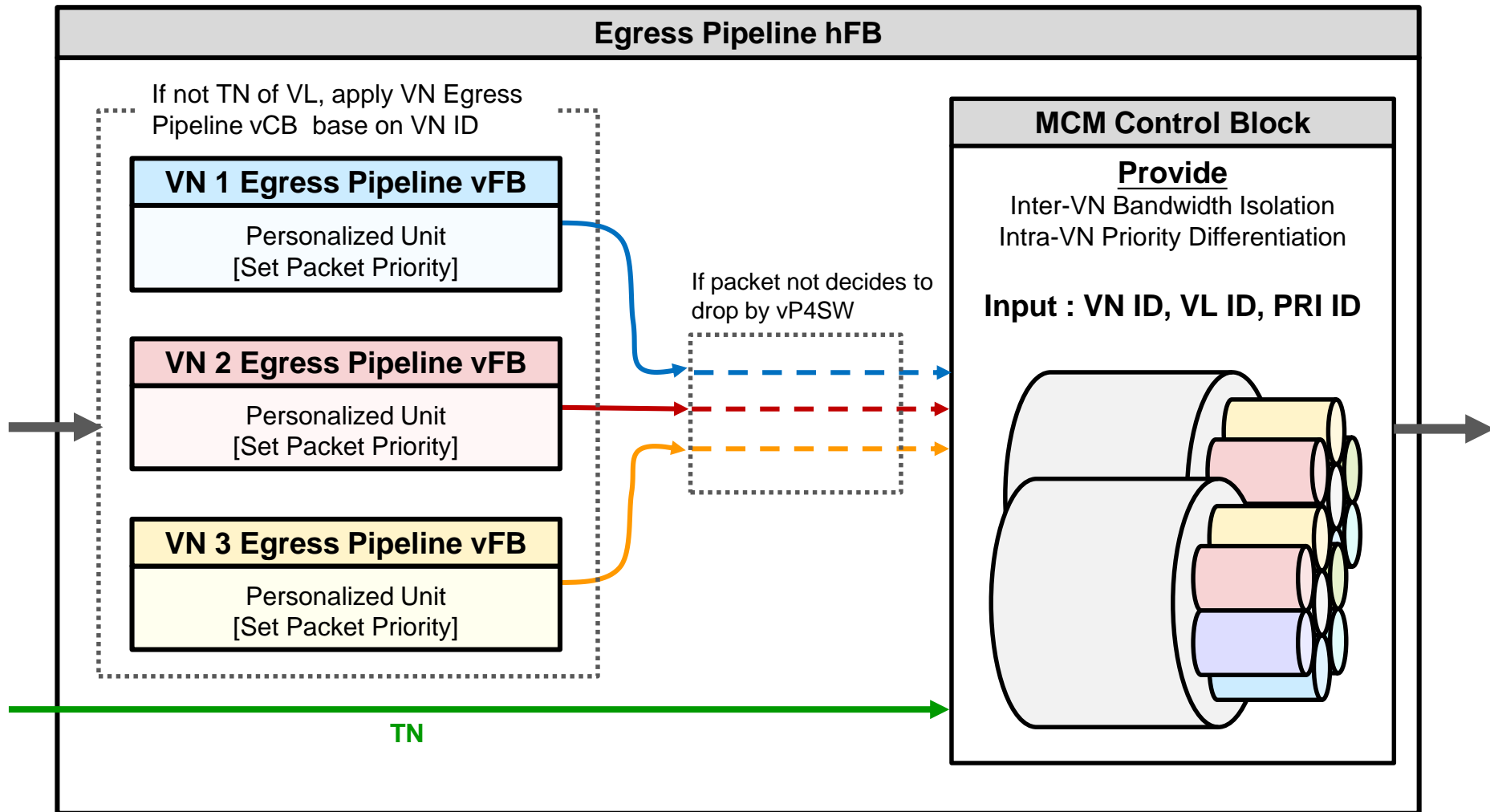
Parser Functional Block



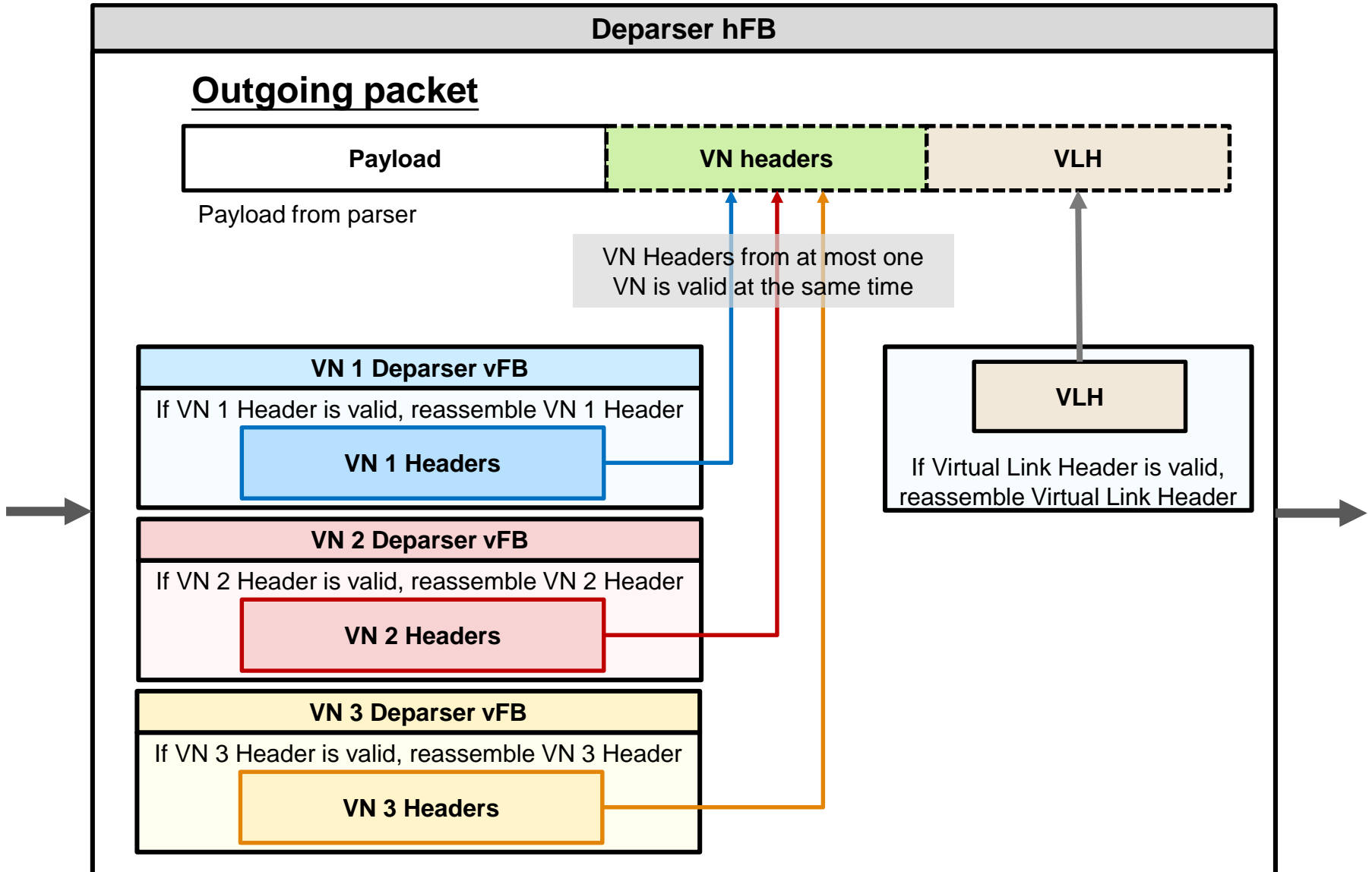
Ingress Pipeline Functional Block



Egress Pipeline Functional Block

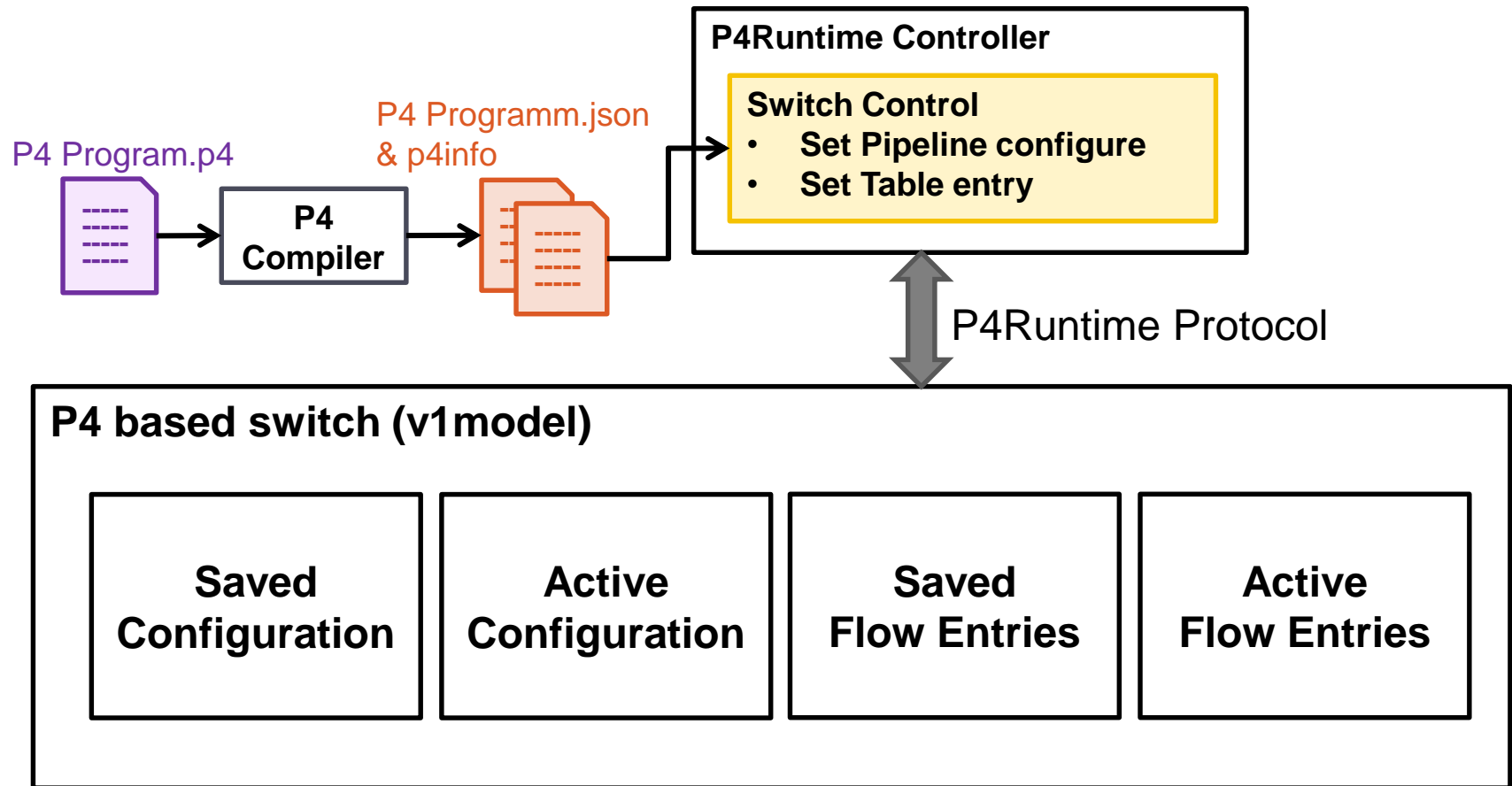


Deparser Functional Block



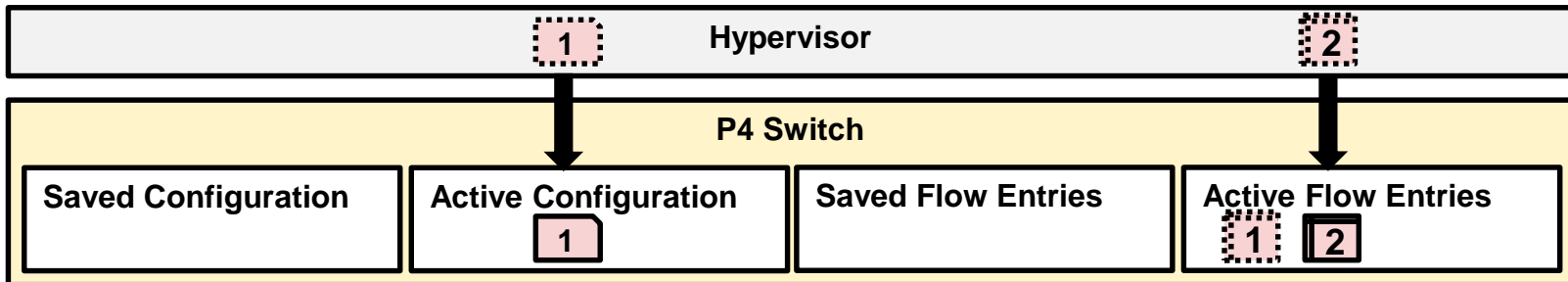
P4 Switch Configuration

- P4 = Programming Protocol-Independent Packet Processors

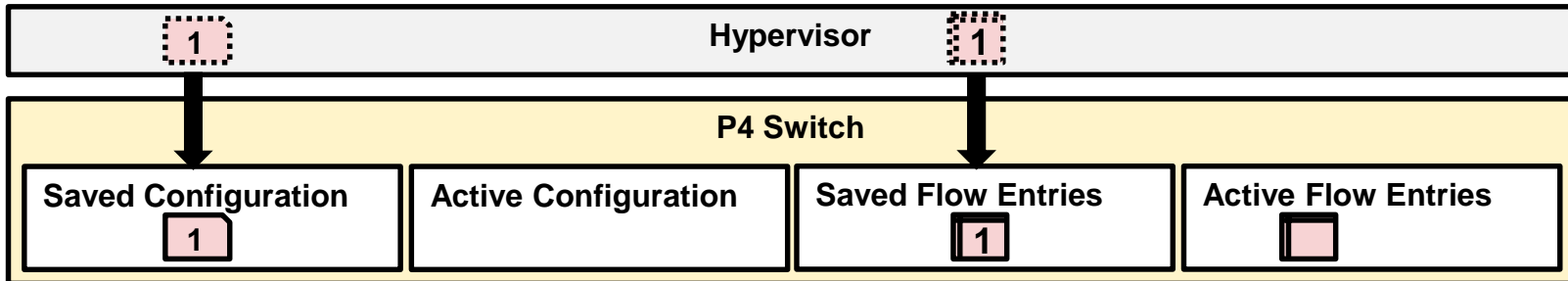


P4 Switch Configuration

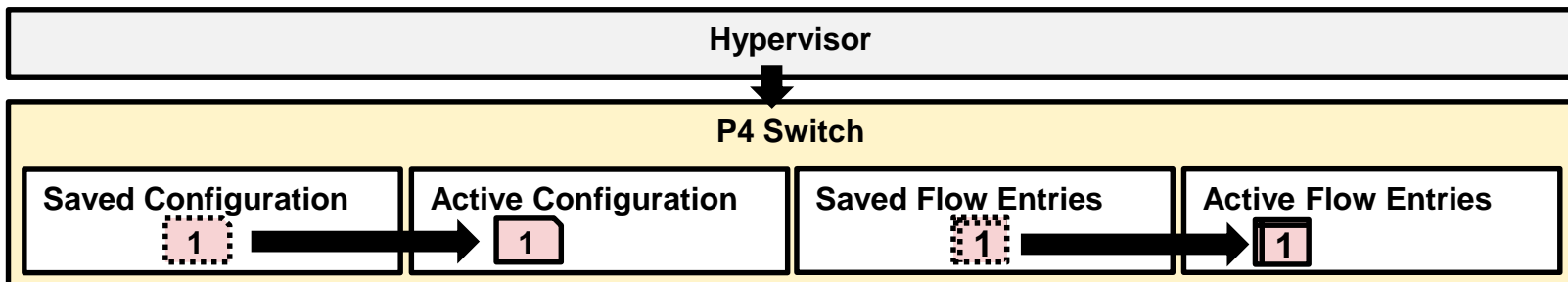
VERIFY_AND_COMMIT



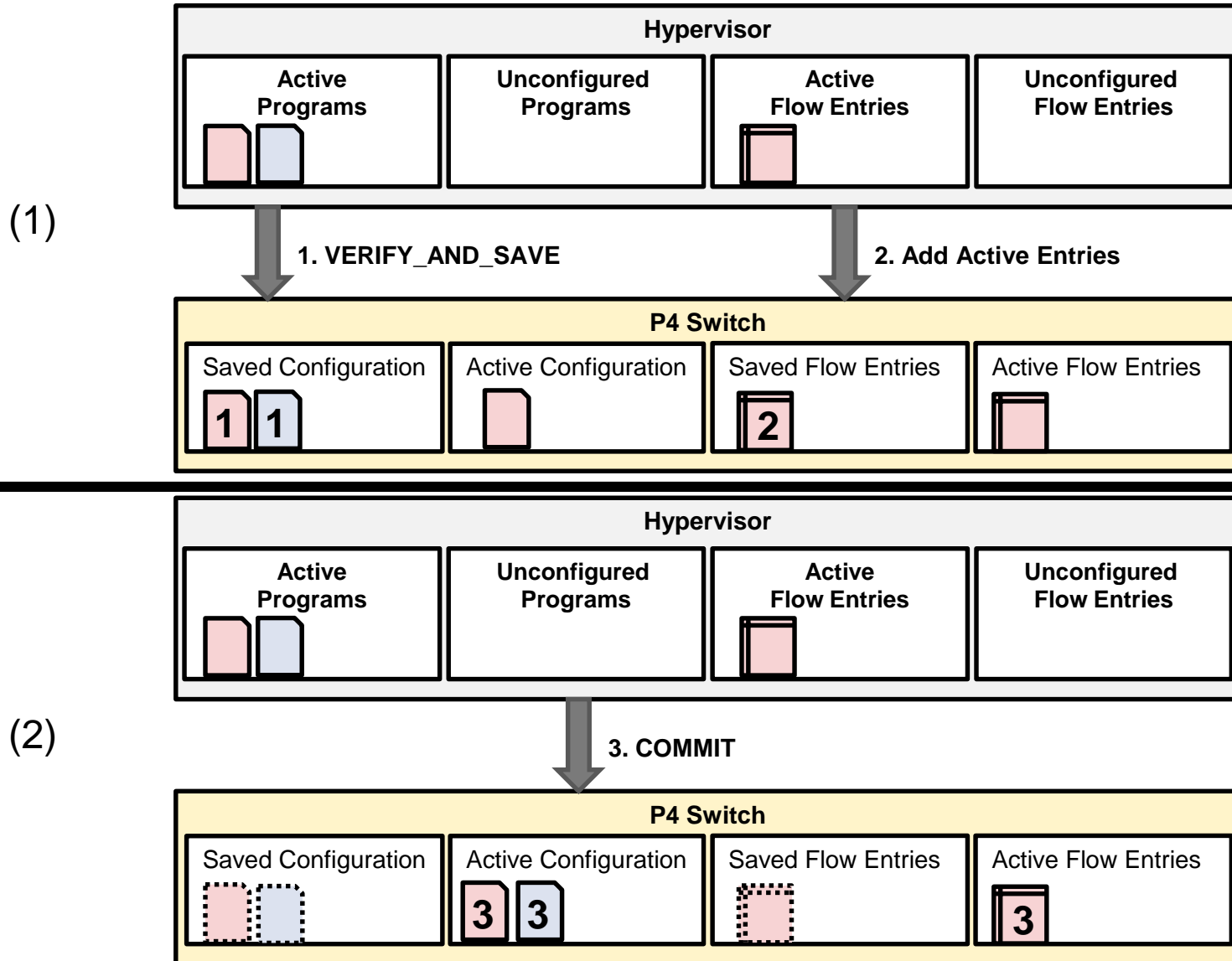
VERIFY_AND_SAVE



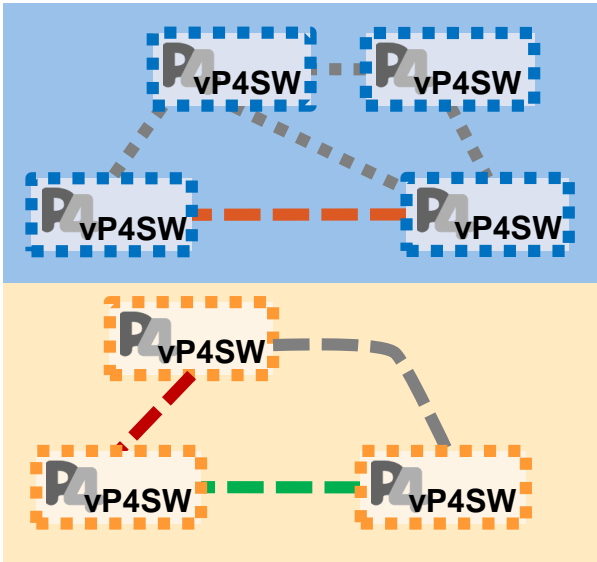
COMMIT



Live Reconfiguration



Multicolor Marker (MCM) based Meter



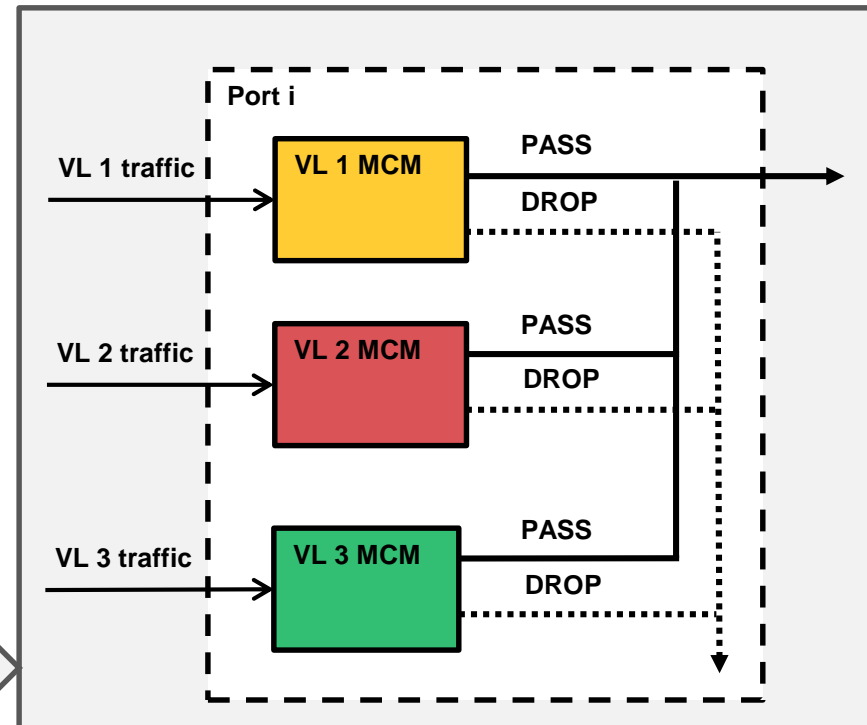
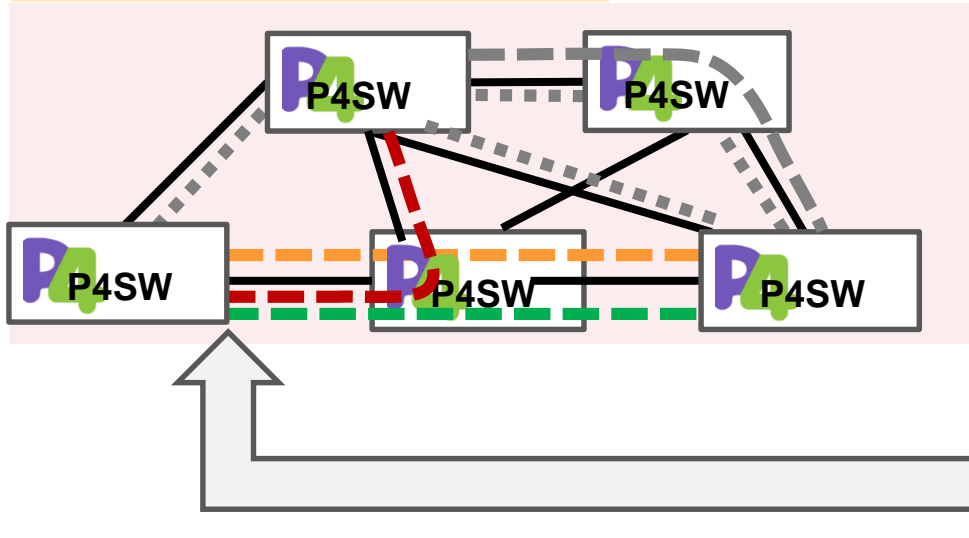
Inter-VN (Inter-VL) : Bandwidth Guarantee
 Intra-VN (Intra-VL) : Priority Differentiation

Tenants define the MCM mode for each VL

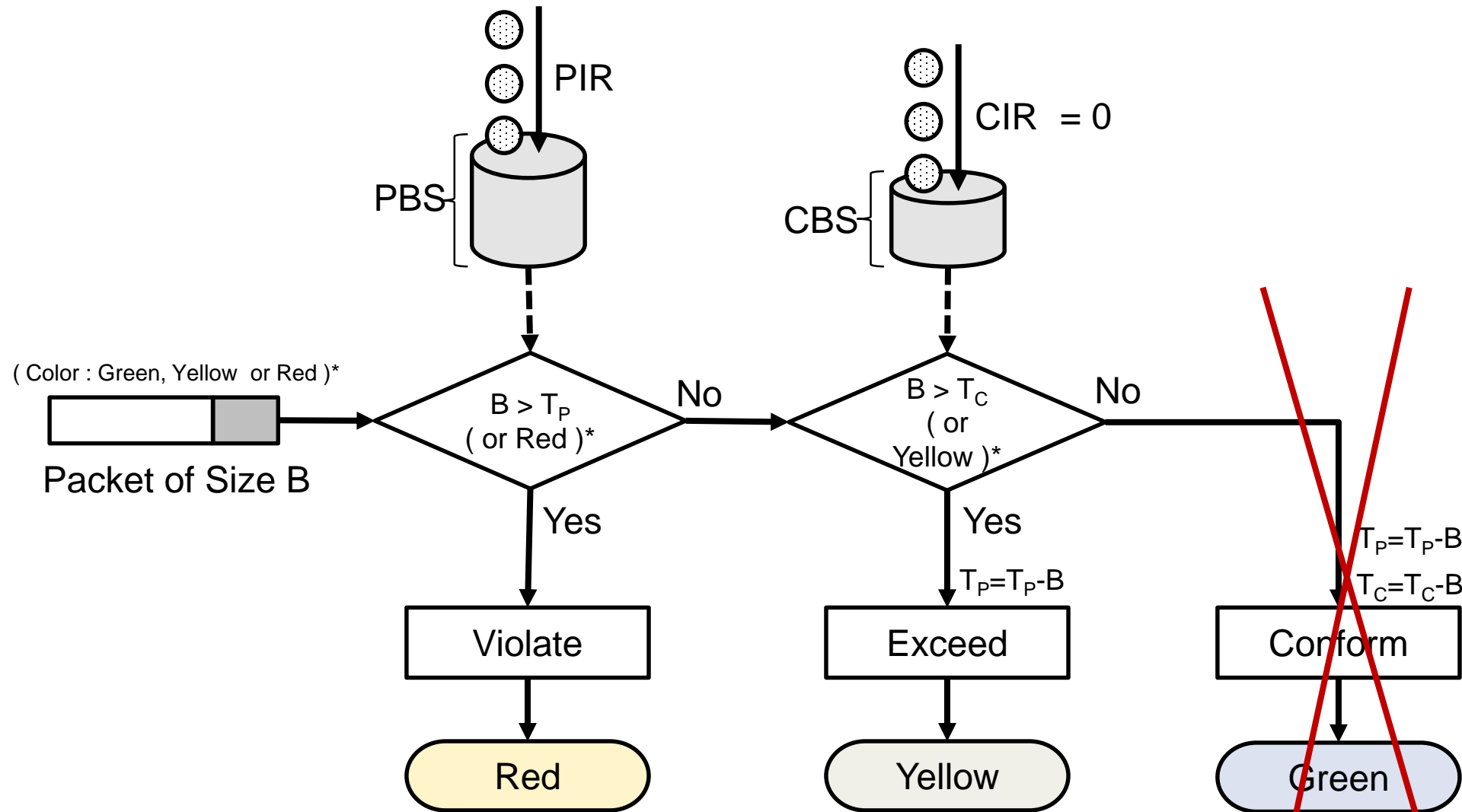
RBNS : Remaining Bandwidth Nonsharing

RBSNP : Remaining Bandwidth Sharing without Prioritization

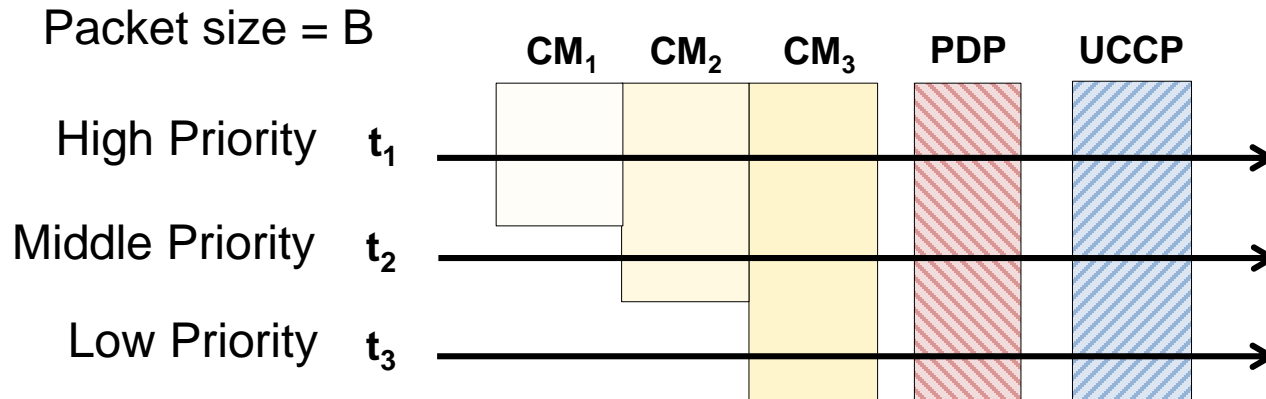
RBSP : Remaining Bandwidth Sharing with Prioritization



P4 Meter (trTCM)



MCM Meter Introduction (1)



PDP

High Priority t_1

- **PASS** : CM_1 color = **Green**
- **DROP** : CM_1 color = **Red**

Middle Priority t_2

- **PASS** : CM_2 color = **Green**
- **DROP** : CM_2 color = **Red**

Low Priority t_3

- **PASS** : CM_3 color = **Green**
- **DROP** : CM_3 color = **Red**

UCCP

t_i : **PASS**

- $CM_{(i+1)\%3}$ color = **Red**, Token -= B
- $CM_{(i+2)\%3}$ color = **Red**, Token -= B

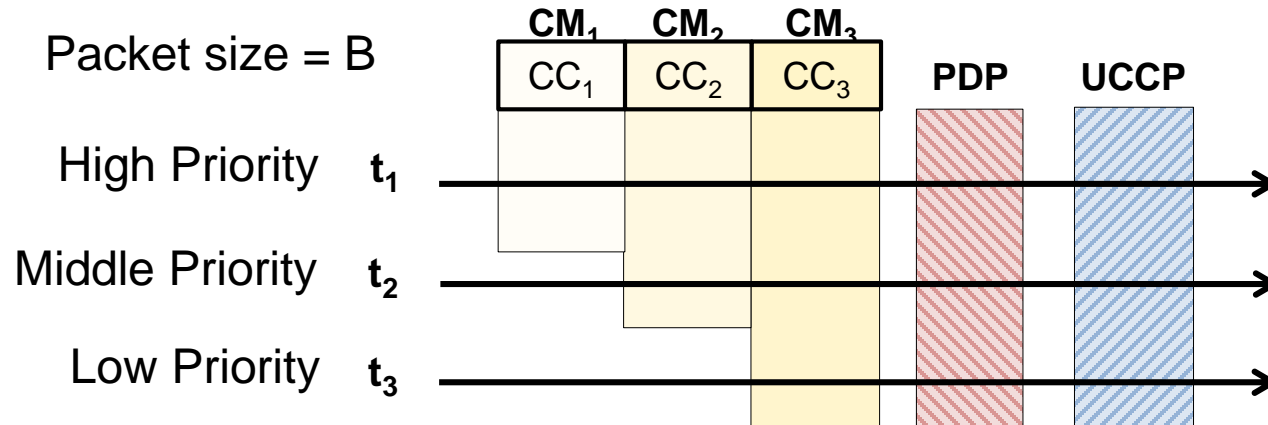
t_i : **DROP**

- $CM_{(i+1)\%3}$ color = **Green**, Token += B
- $CM_{(i+2)\%3}$ color = **Green**, Token += B

P4

Token cannot be modified

MCM Meter Introduction (2)



PDP

High Priority t_i

• PASS :

- CM_i color = Green && CC_i + B > 0
- CM_i color = Red && CC_i ≥ B

• DROP

- CM_i color = Green && CC_i + B ≤ 0
- CM_i color = Red && CC_i < B

UCCP

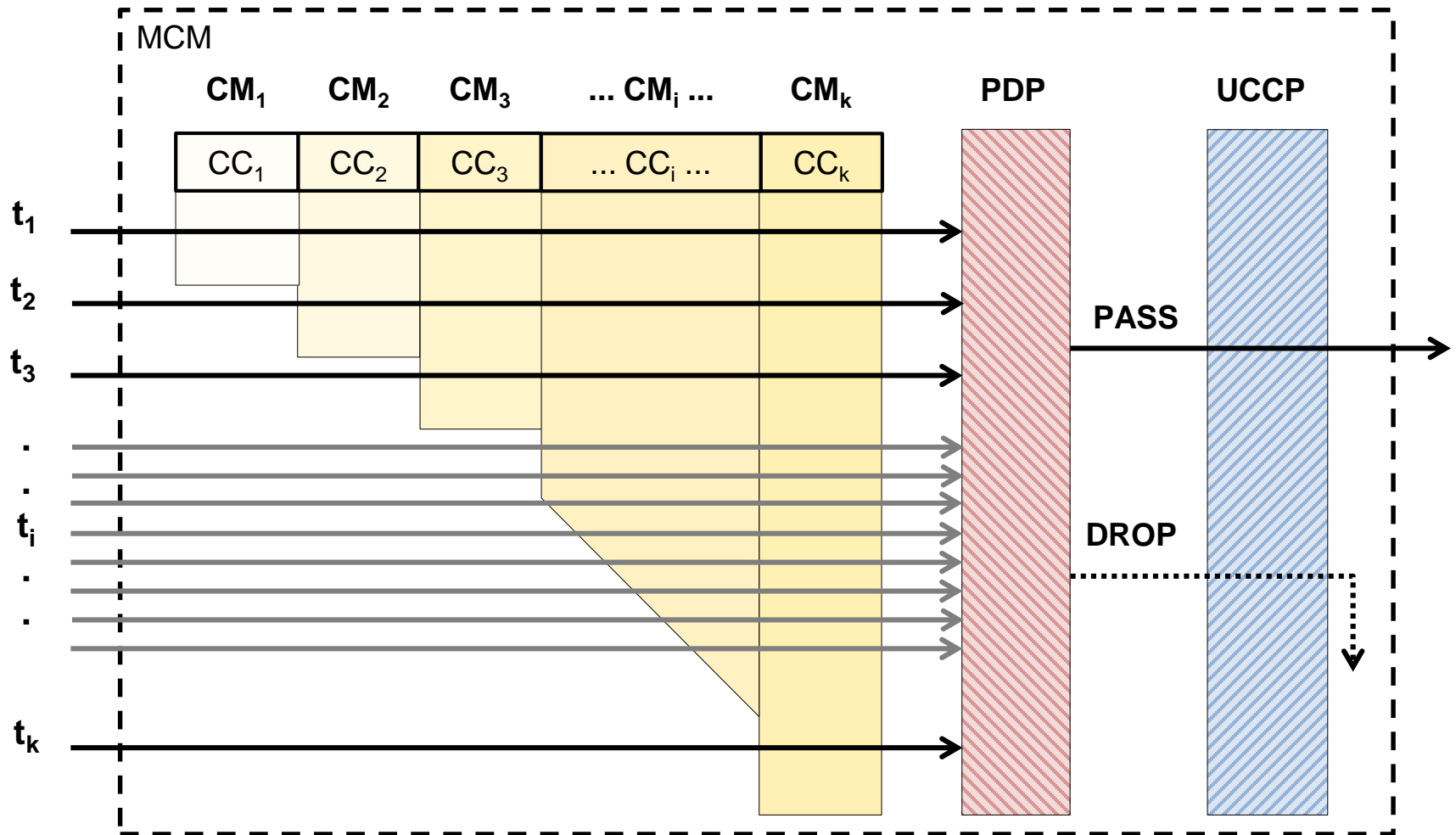
t_i : PASS

- CM_{(i+1)%3} color = Red, CC_{(i+1)%3} -= B
- CM_{(i+2)%3} color = Red, CC_{(i+2)%3} -= B

t_i : DROP

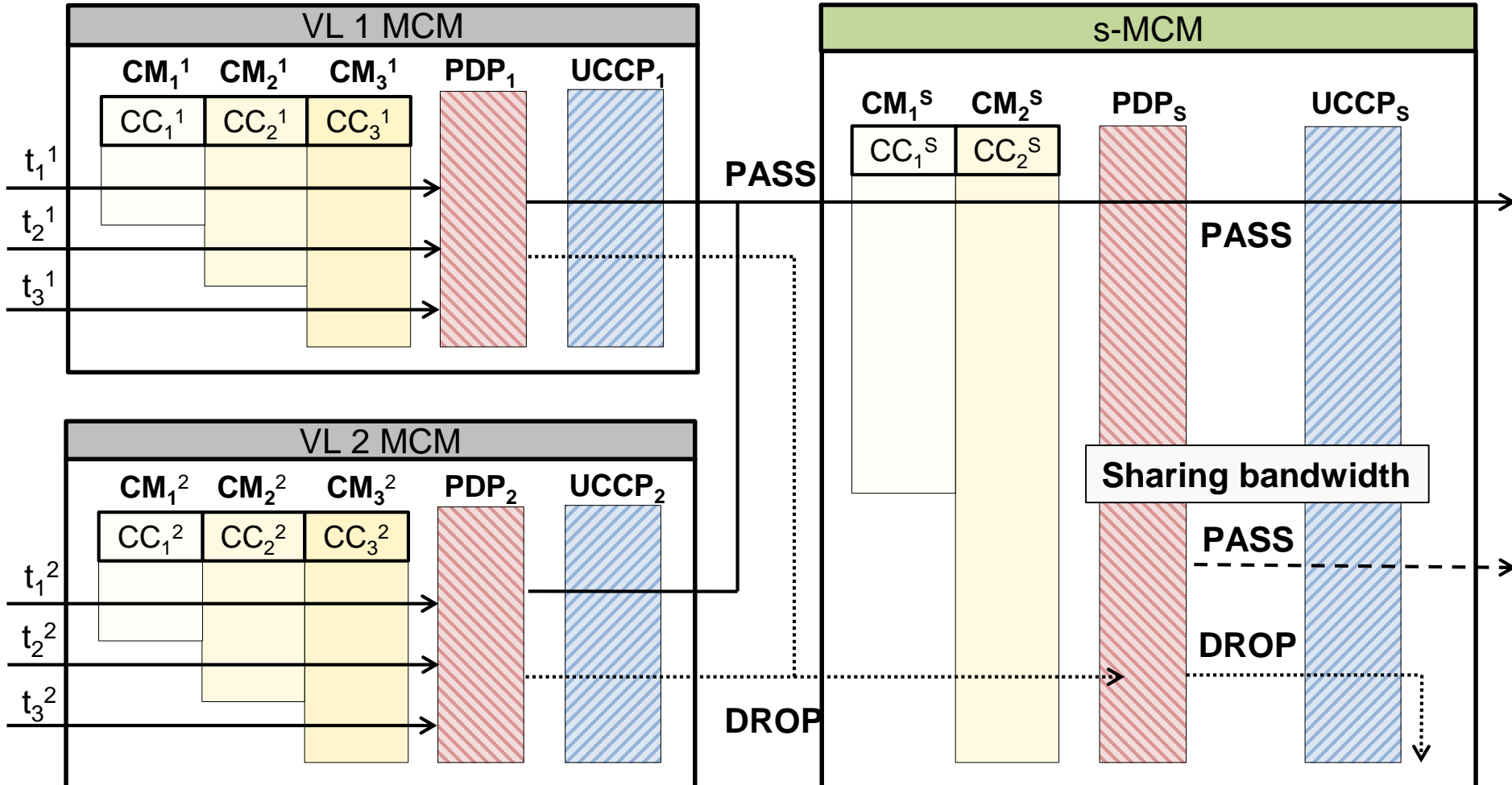
- CM_{(i+1)%3} color = Green, CC_{(i+1)%3} += B
- CM_{(i+2)%3} color = Green, CC_{(i+2)%3} += B

RBNS MCM



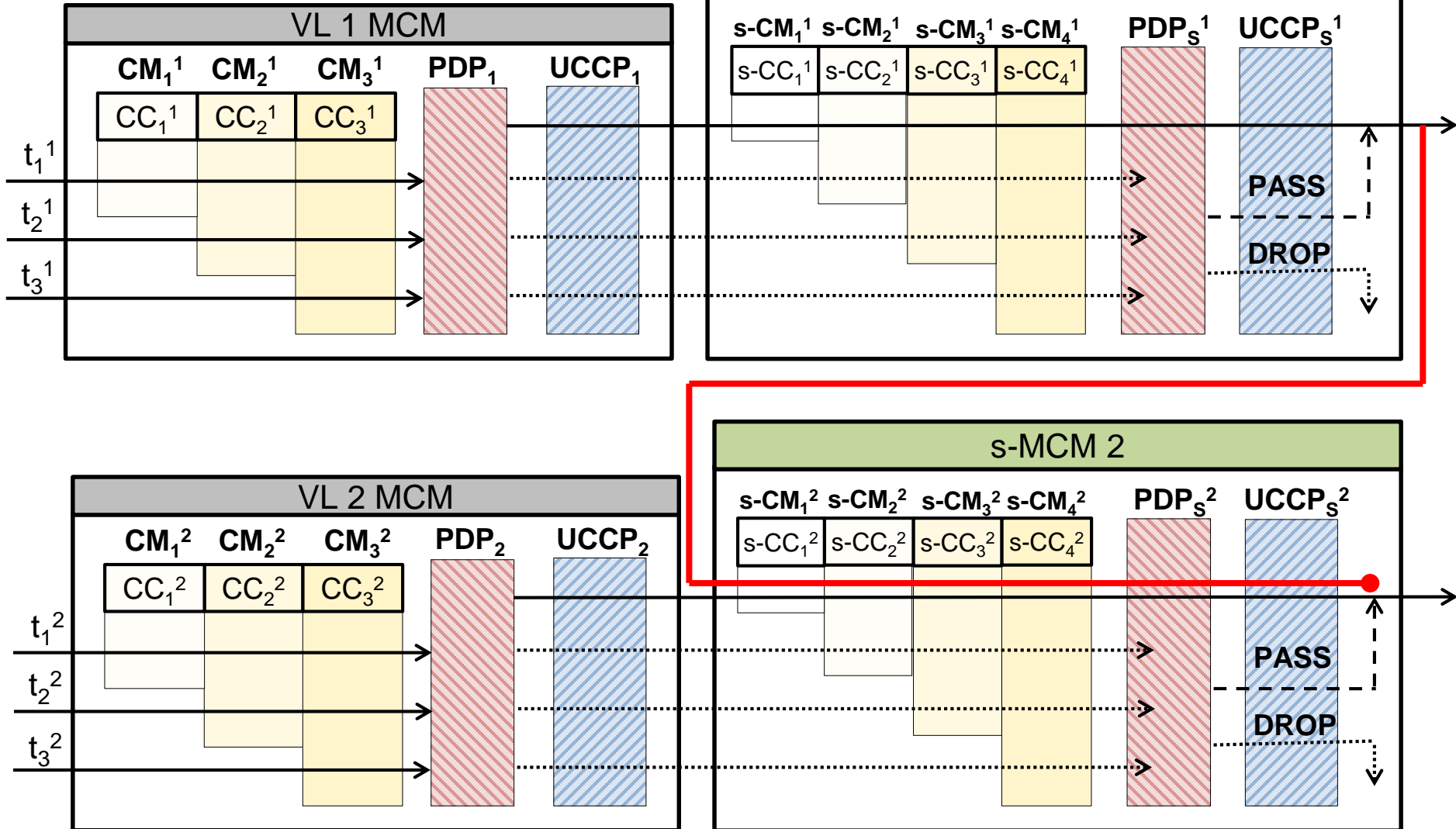
RBSNP MCM

PIR = Link Rate

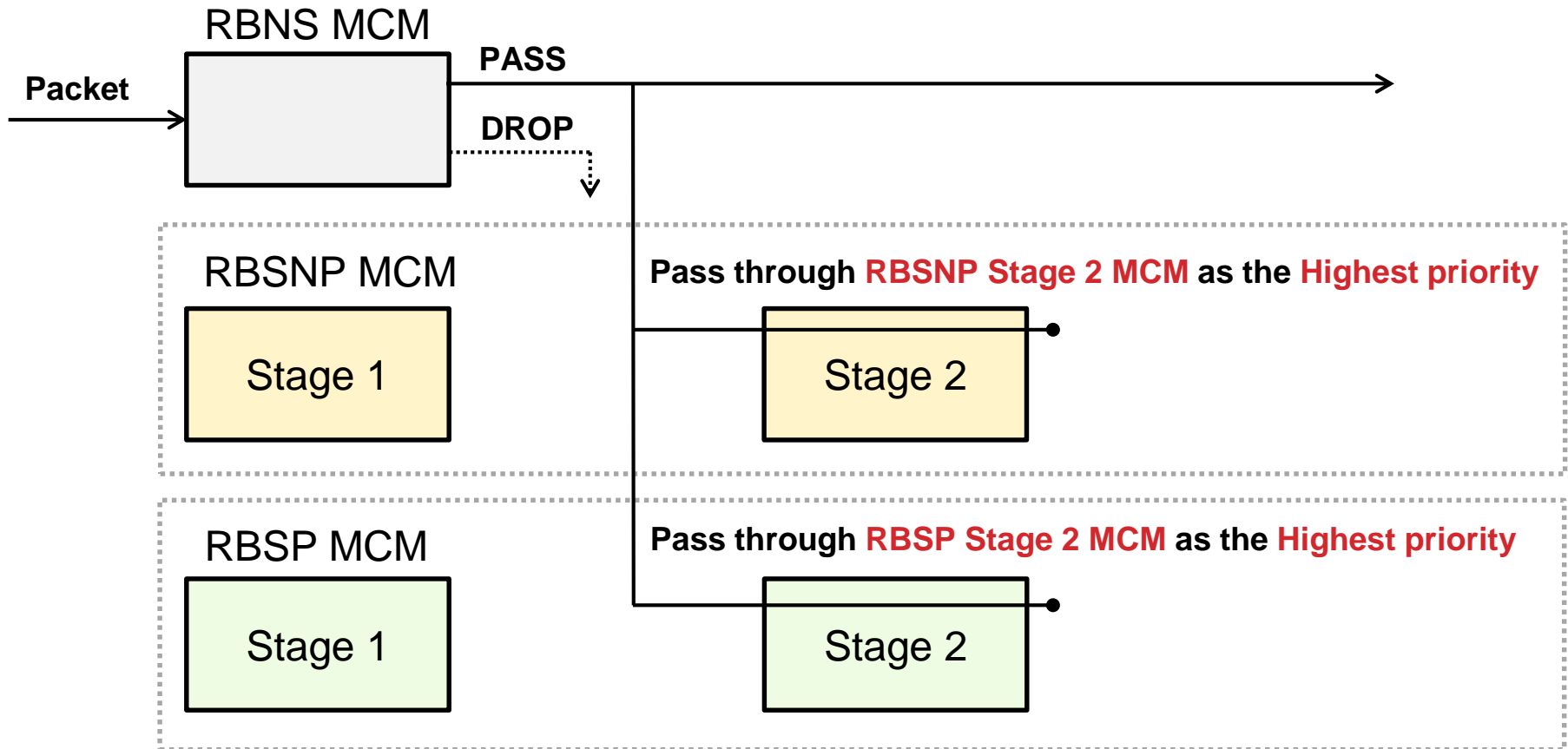


RBSP MCM

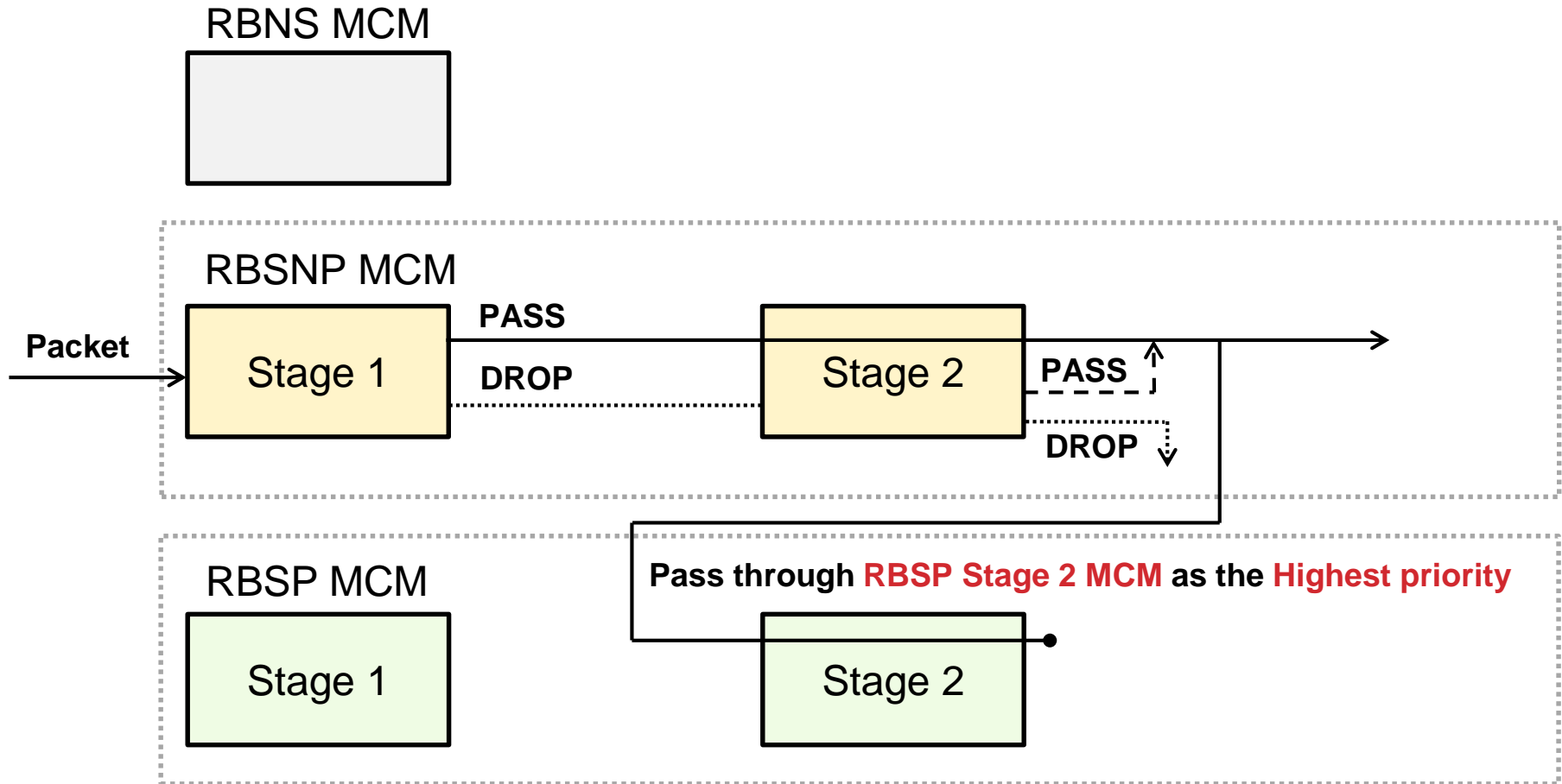
PIR = Link Rate



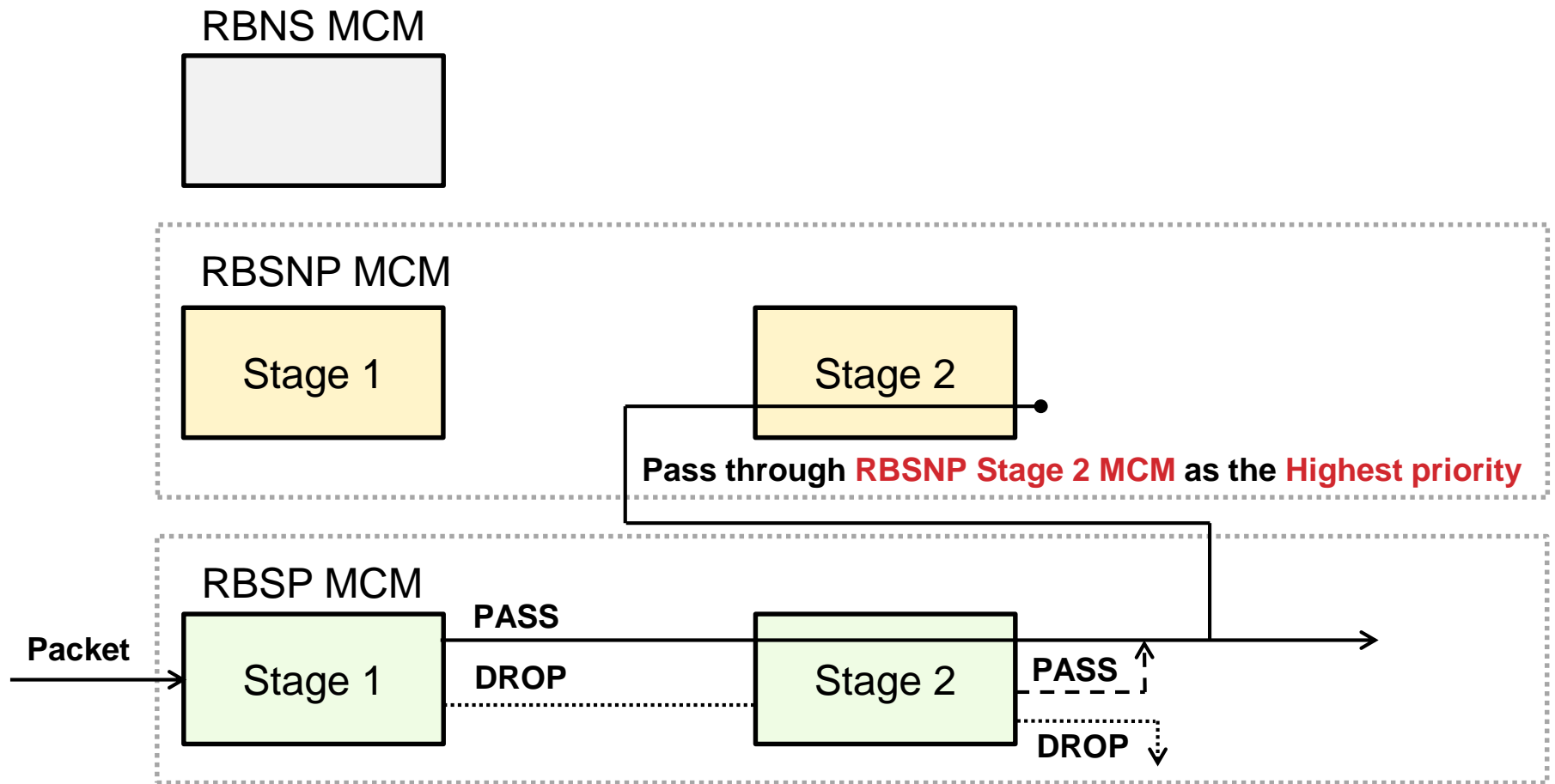
Combined Processing of Multiple MCM Modes



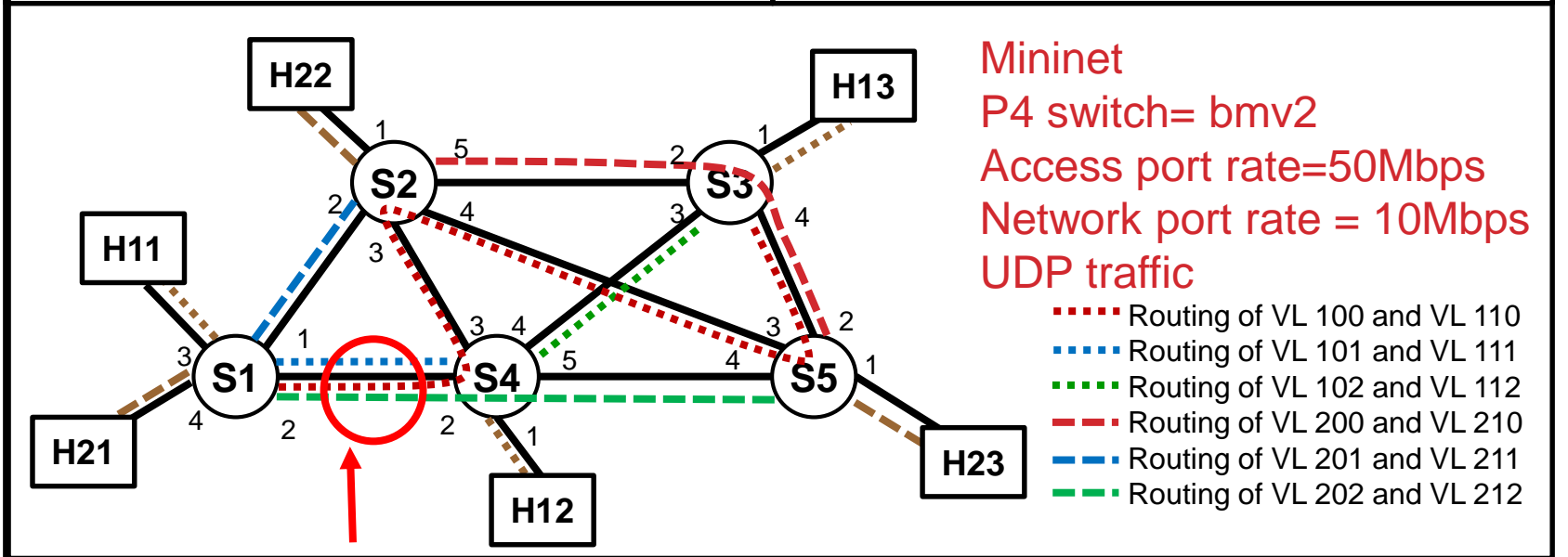
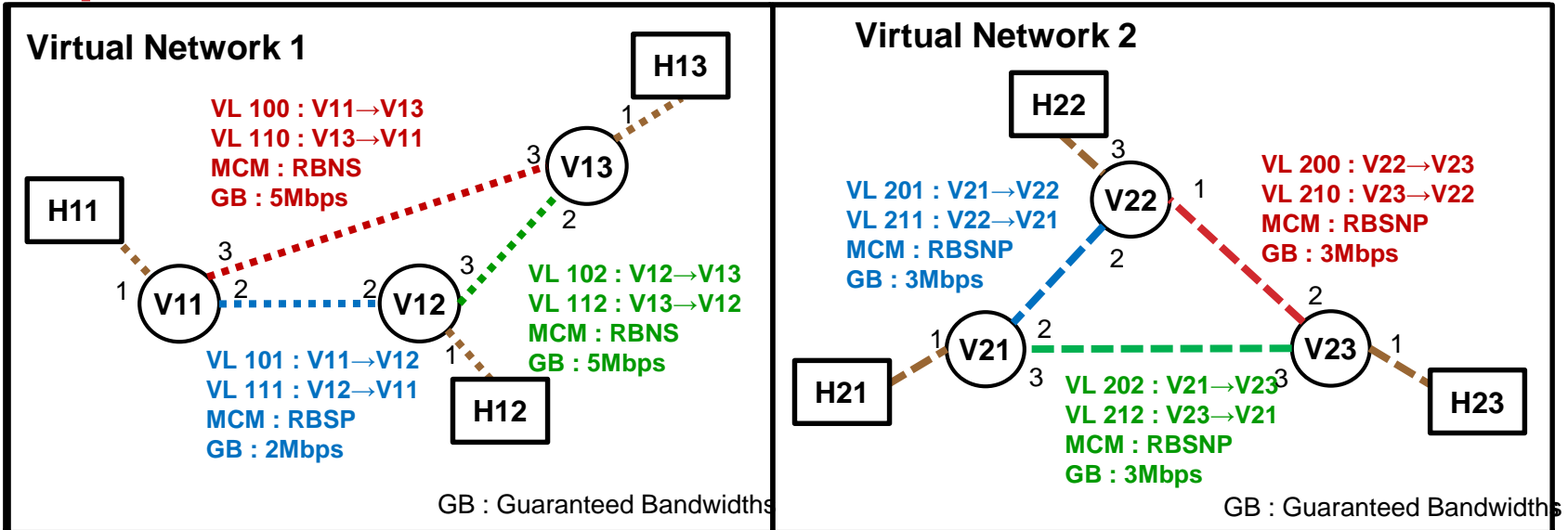
Combined Processing of Multiple MCM Modes



Combined Processing of Multiple MCM Modes



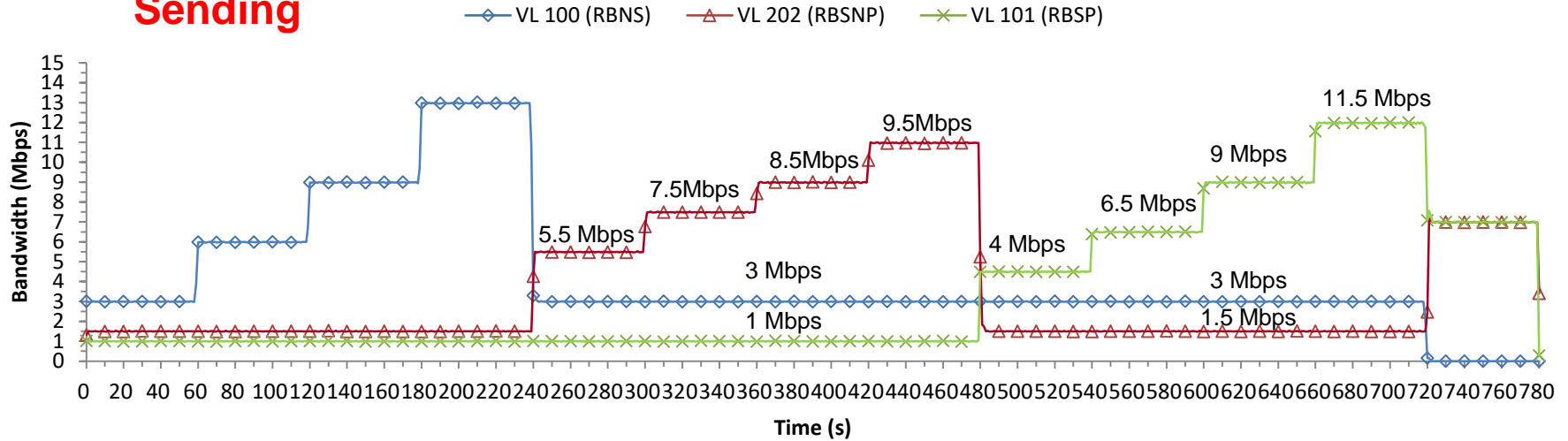
Experimental Environment



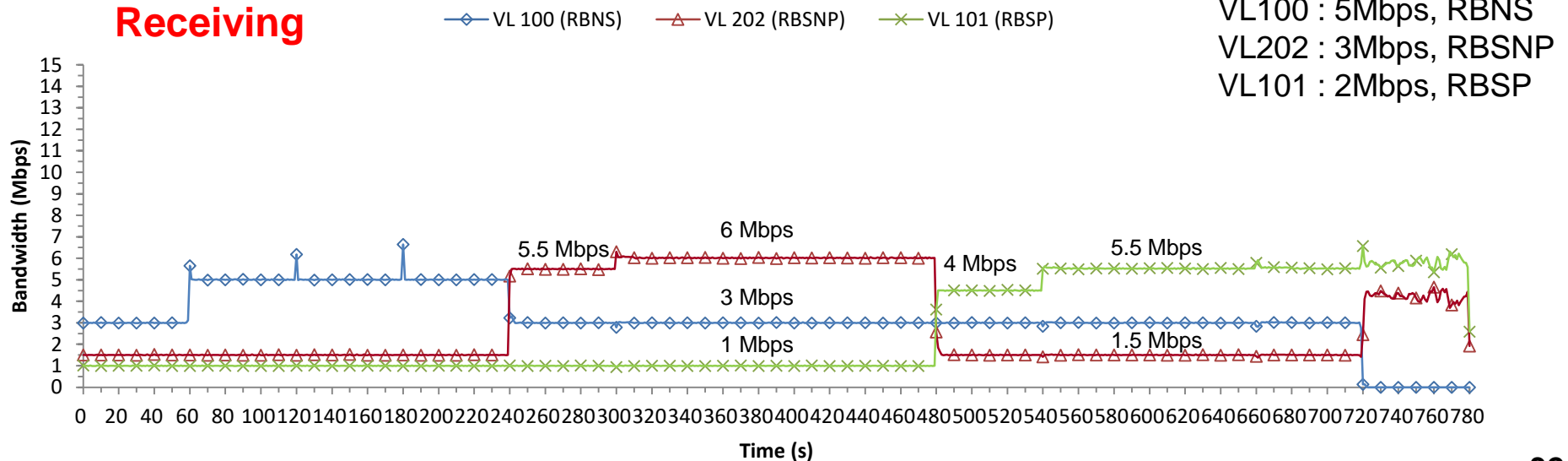
VL Bandwidth Guarantee and Sharing

Bandwidth Usage

Sending



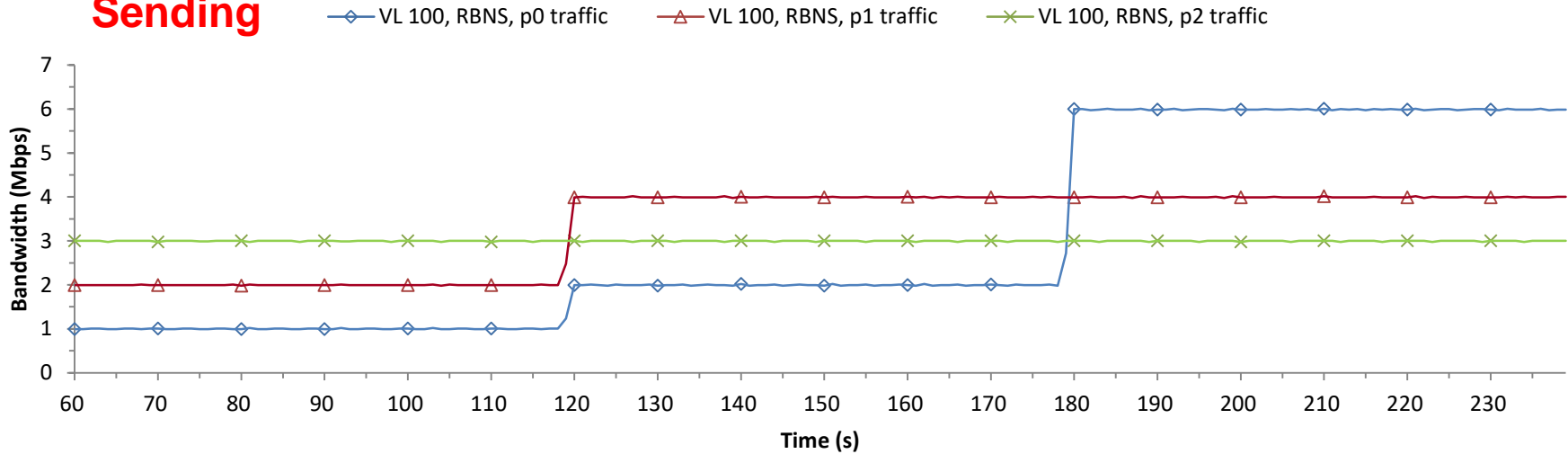
Receiving



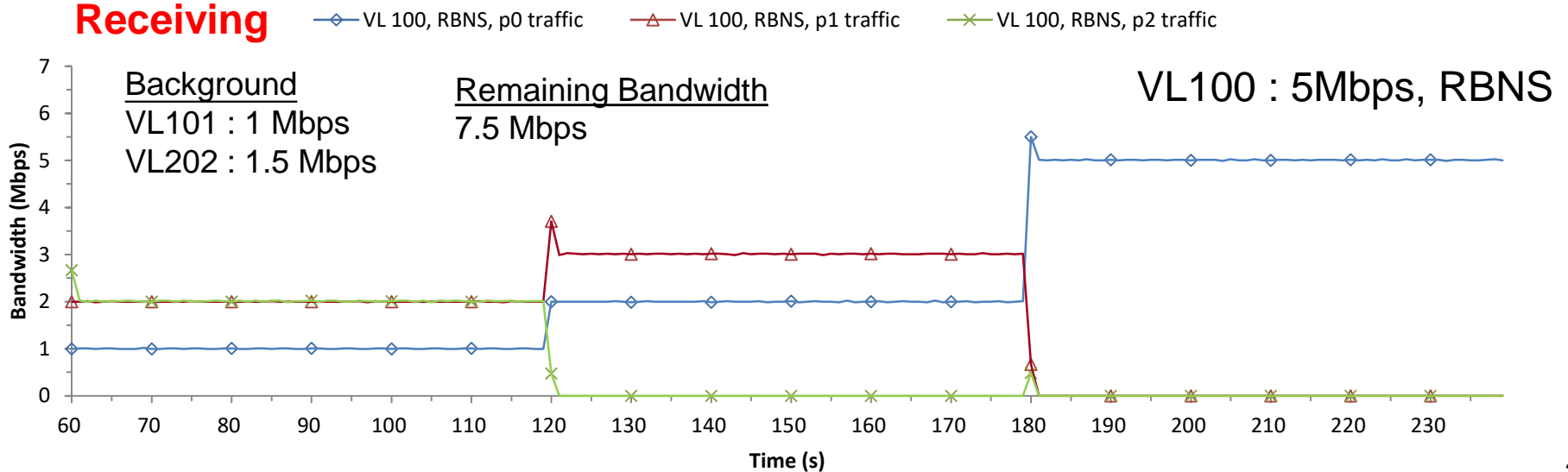
VL100 : 5Mbps, RBNS
VL202 : 3Mbps, RBSNP
VL101 : 2Mbps, RBSP

Using RBNS MCM Meters

Sending

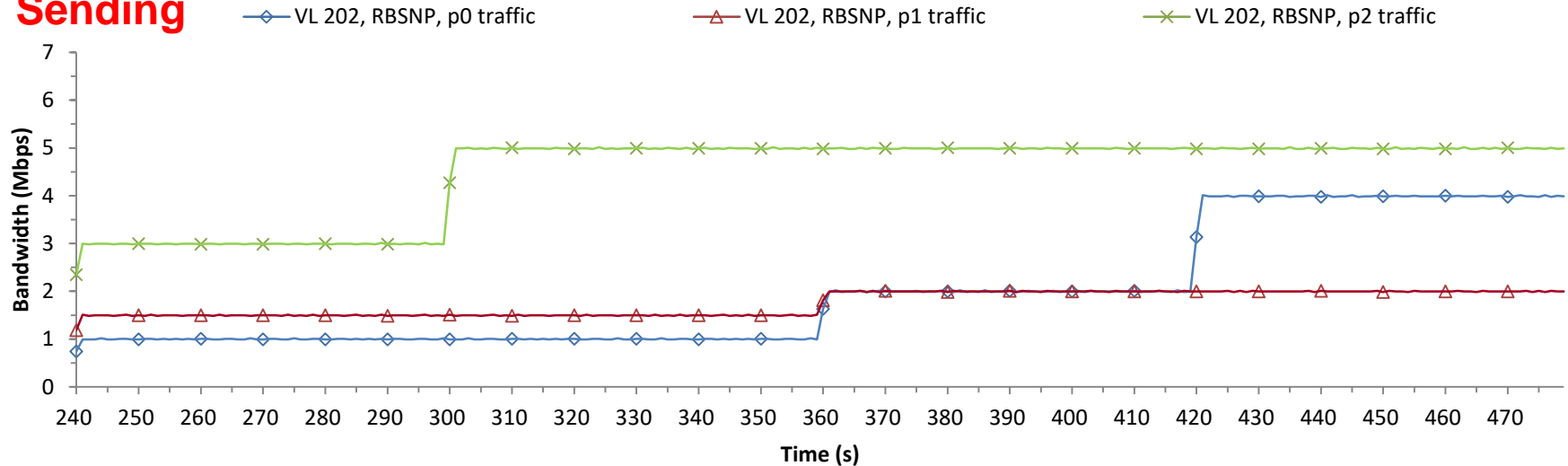


Receiving

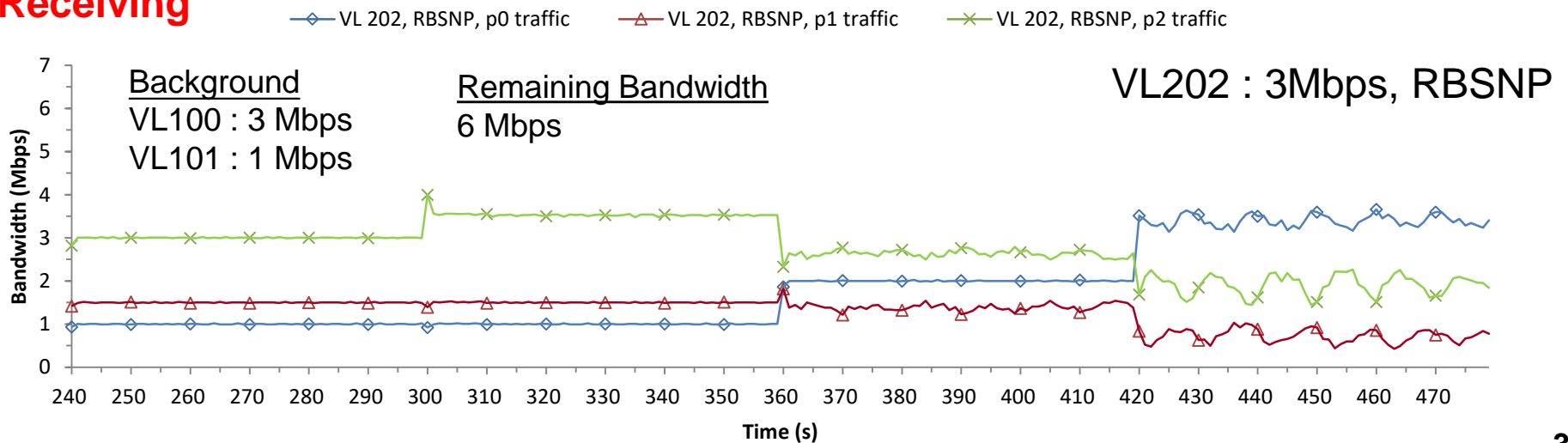


Using RBSNP MCM Meters

Sending

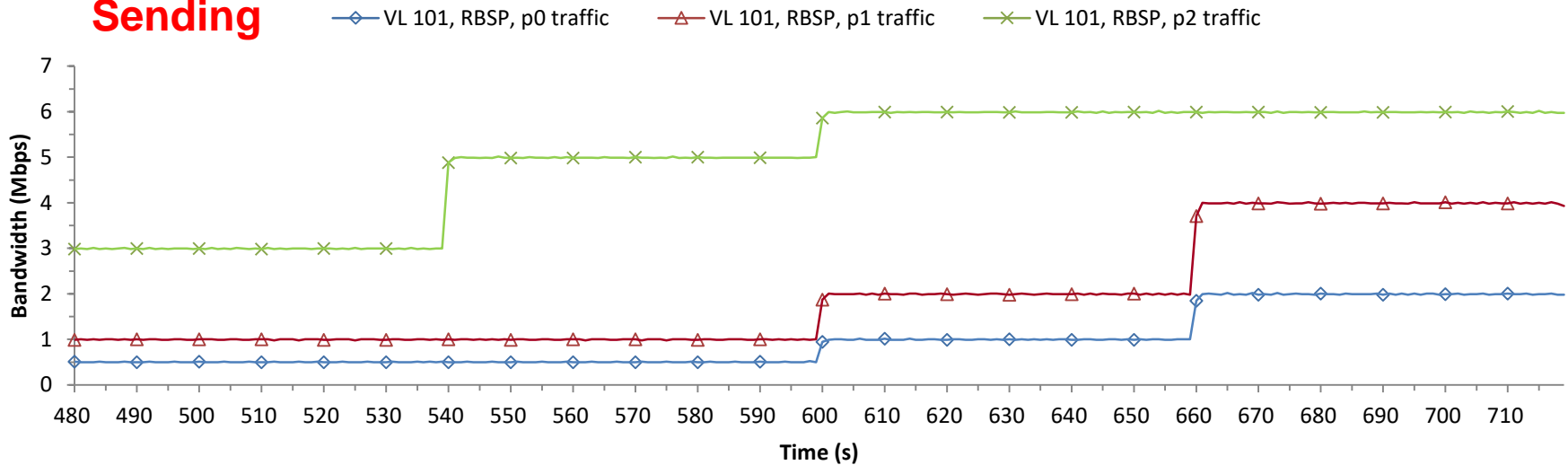


Receiving

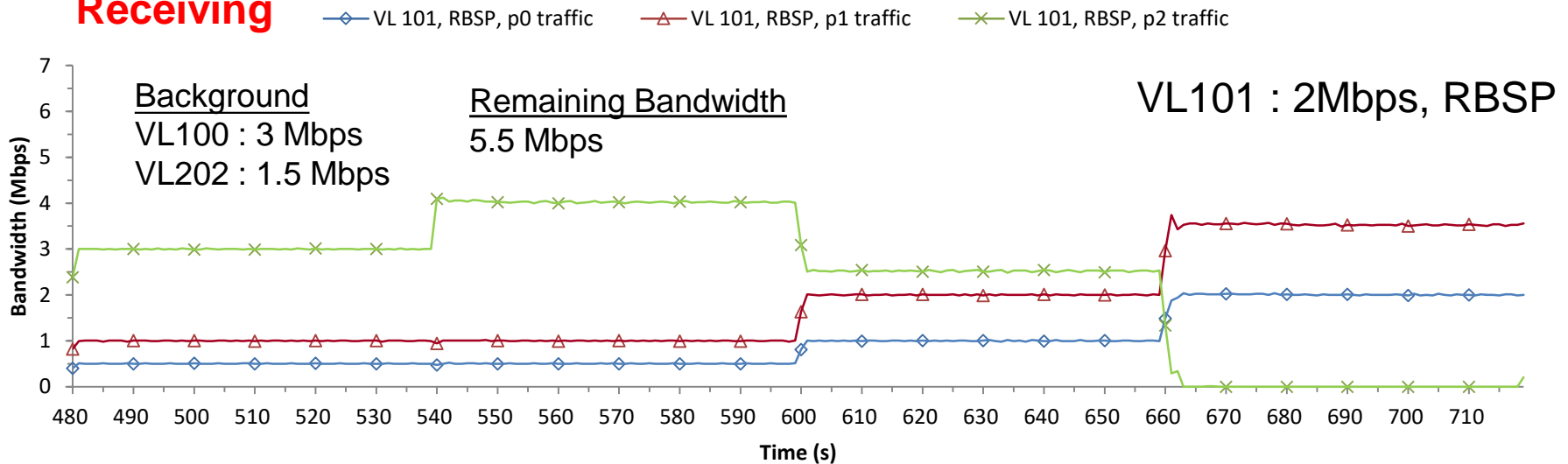


Using RBSP MCM Meters

Sending



Receiving



Conclusion

- Virtual P4 Network
 - Virtual Links, Virtual Port, Virtual P4 Switch
 - Virtual P4 Switch
 - Dynamical Control
 - Dynamical Reconfiguration
- P4 Network Virtualization
 - Traffic Isolation
 - Virtual Link and Virtual Port Mapping
 - P4 Switch Virtualization
 - Data Plane Virtualization
 - Live Reconfiguration
 - Multicolor marker (MCM) Meter
 - Inter-VN : Bandwidth Guarantee
 - Intra-VN : Priority Differentiation