Management of lambda paths

by Tiago Fioreze

Supervisor: Aiko Pras

Institution: University of Twente

University of Twente
Enschede - The Netherlands

Outline

You are
here!

- ● Outline
- ○ Background information
- ○ Current management approaches
- ○ Self-management of lambda connections
- ○ Self-management architecture
- ○ Characteristics of flows eligible to lambda connections
- ○ Current challenge
- ○ Final considerations
- ● Q&A

Background information

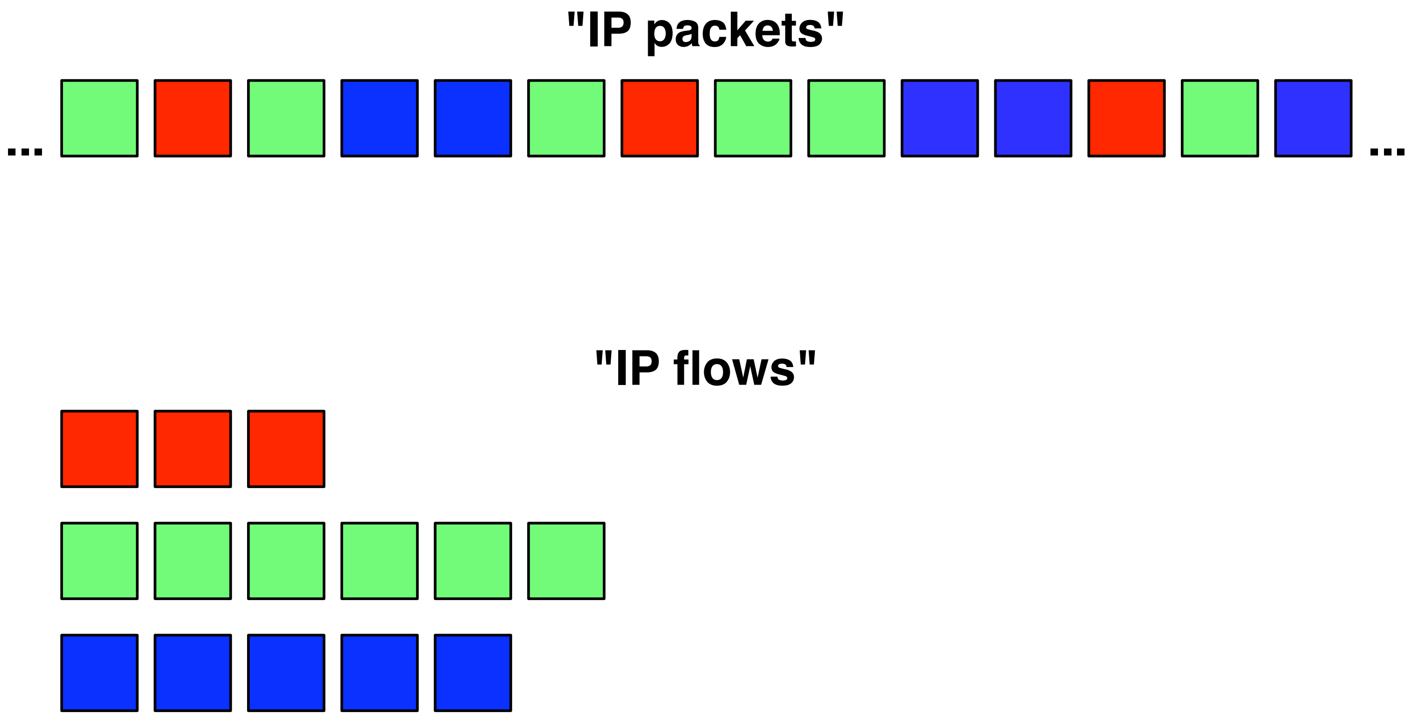
- Hmm... what do you mean with **lambda-connection**?
  - A dedicated light path between two-end points where data (e.g., IP packets) is transferred.
- ok... and can you tell me one good **advantage** of using **lambda-connections**?
  - Big IP flows can be fully switched at optical level, where they get better QoS (e.g., no jitter) and at the same time the network level is relieved (offloaded).

Background information

- **IP flow**: a group of IP packets with the same properties

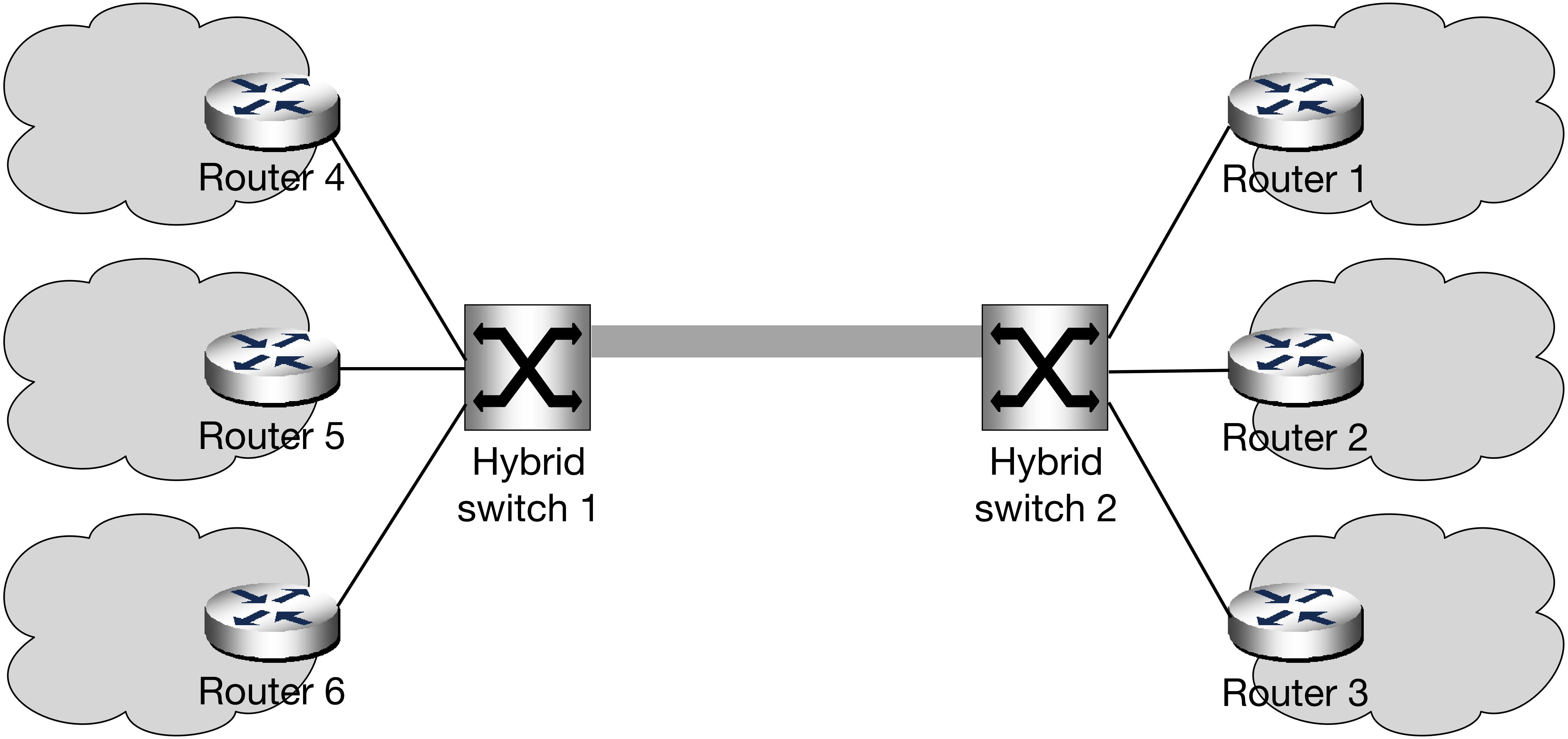
- The 5-tuple flow definition is commonly used:
  - Src/Dst ports
  - Src/Dst IP addresses
  - Protocol

- IP Flows can be defined of many different ways though:
  - Src/Dst autonomous systems

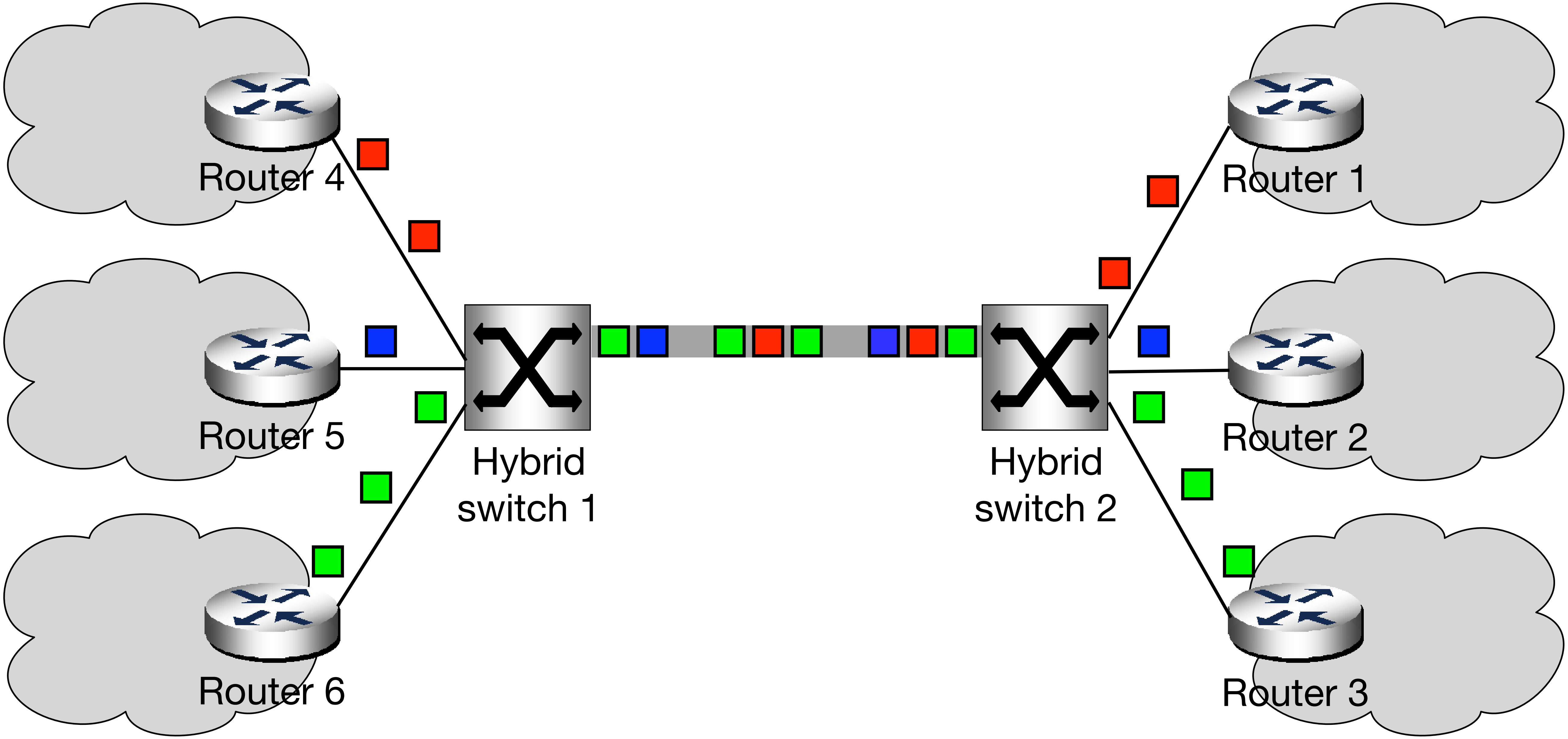


IP flows representation

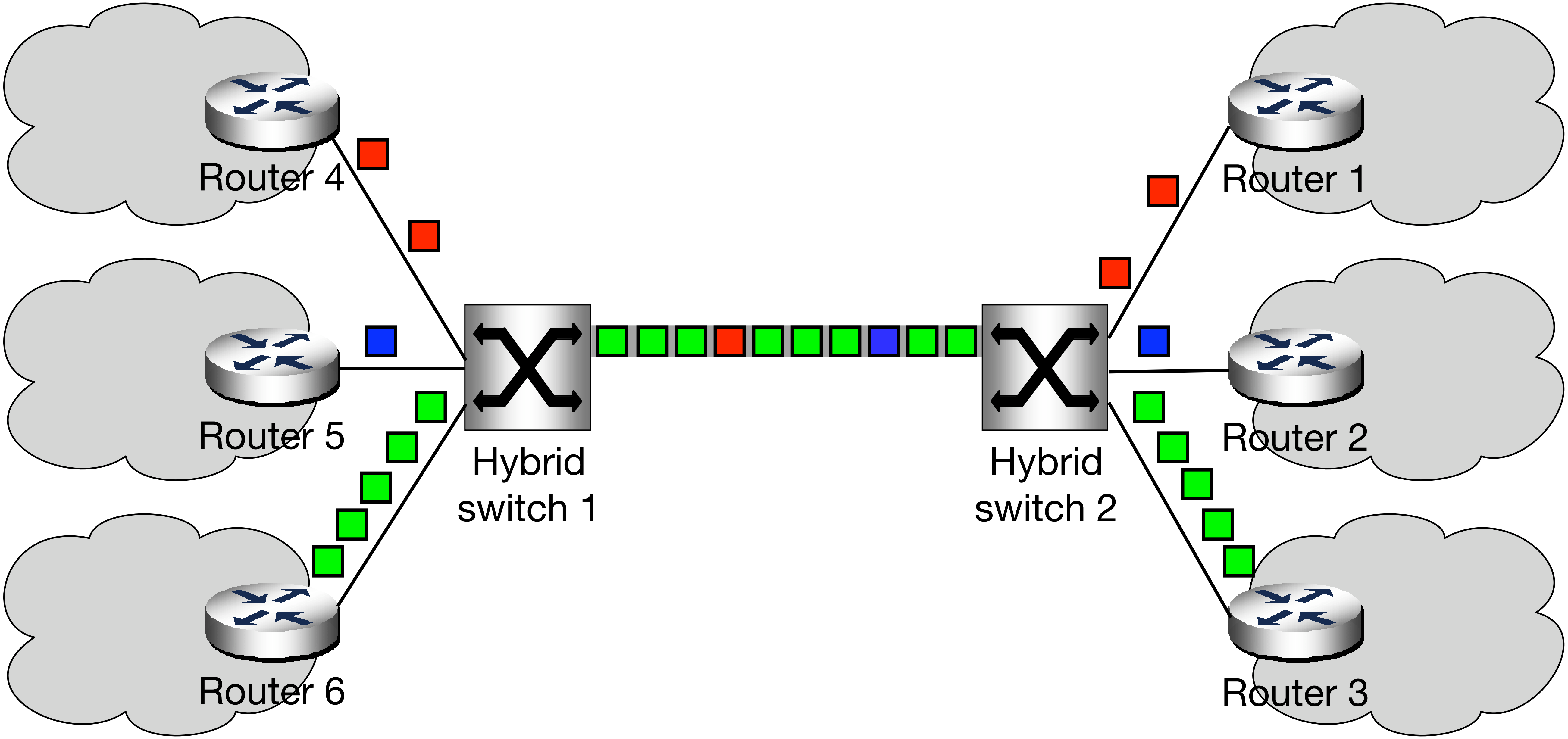
Background information


Router 4
Router 5
Router 6
Hybrid switch 1
Hybrid switch 2
Router 1
Router 2
Router 3

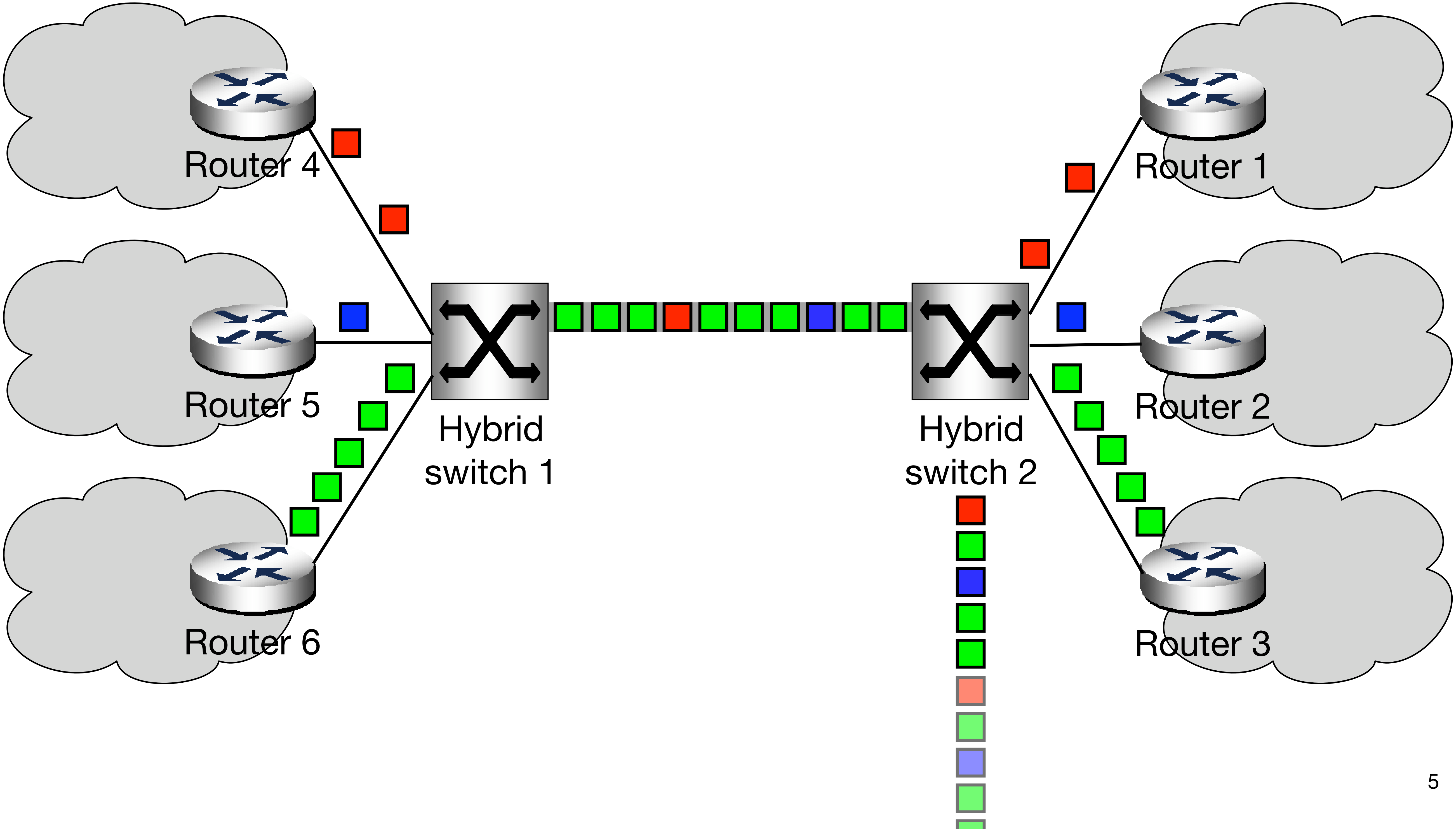
Background information


Router 4
Router 5
Router 6
Hybrid switch 1
Hybrid switch 2
Router 1
Router 2
Router 3

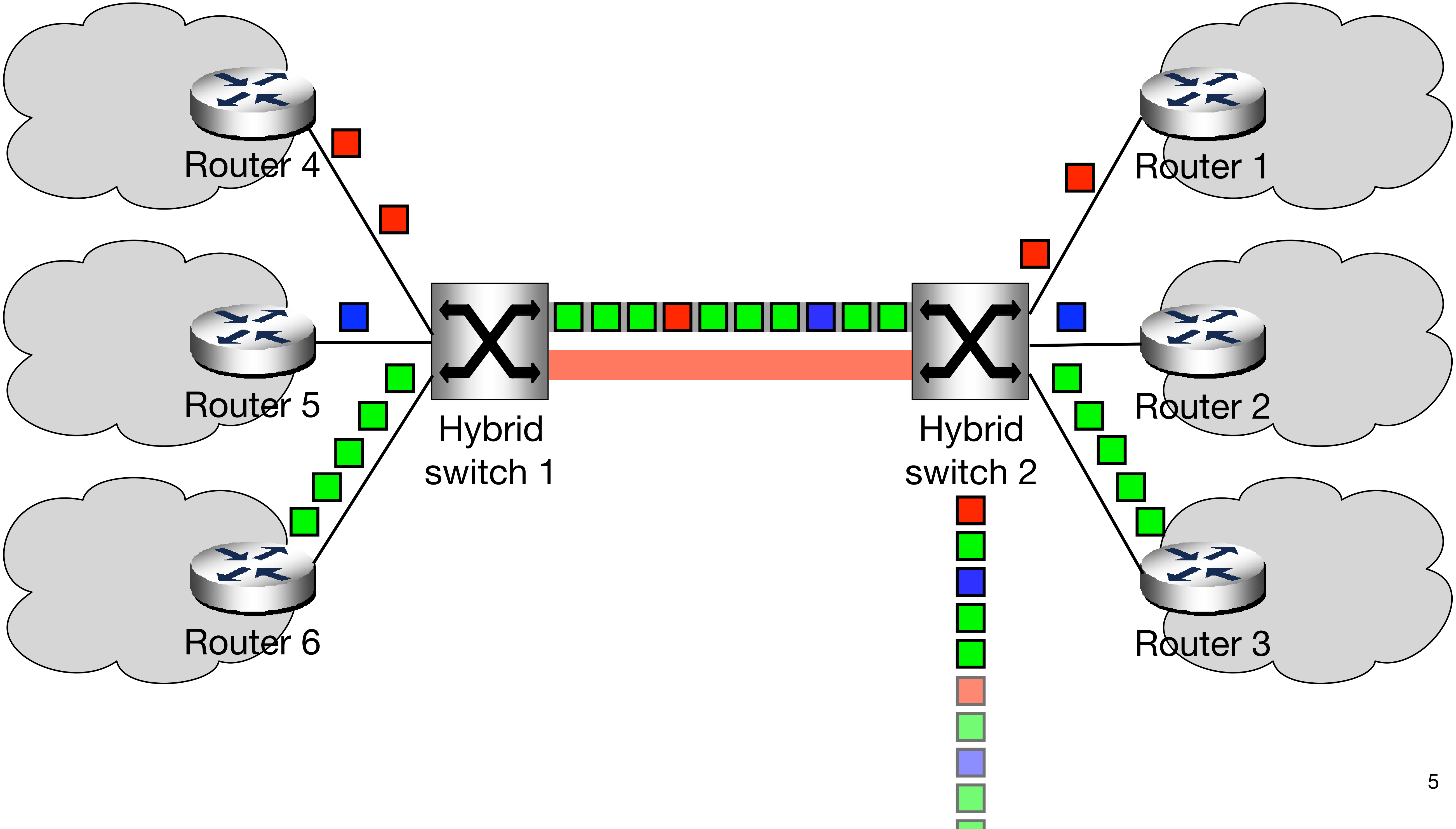
Background information


Router 4
Router 5
Router 6
Hybrid switch 1
Hybrid switch 2
Router 1
Router 2
Router 3

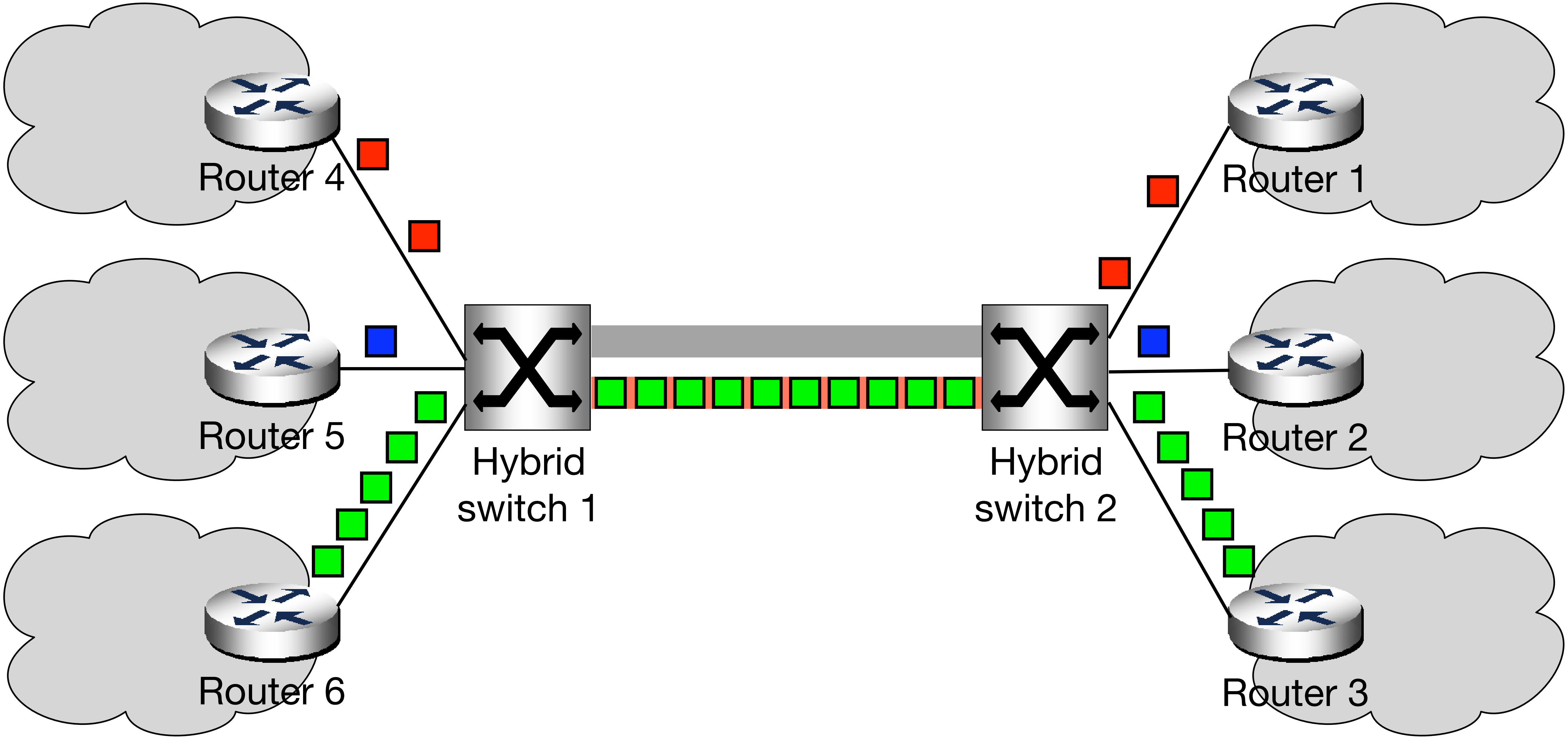
Background information


Router 4
Router 5
Router 6
Hybrid switch 1
Hybrid switch 2
Router 1
Router 2
Router 3

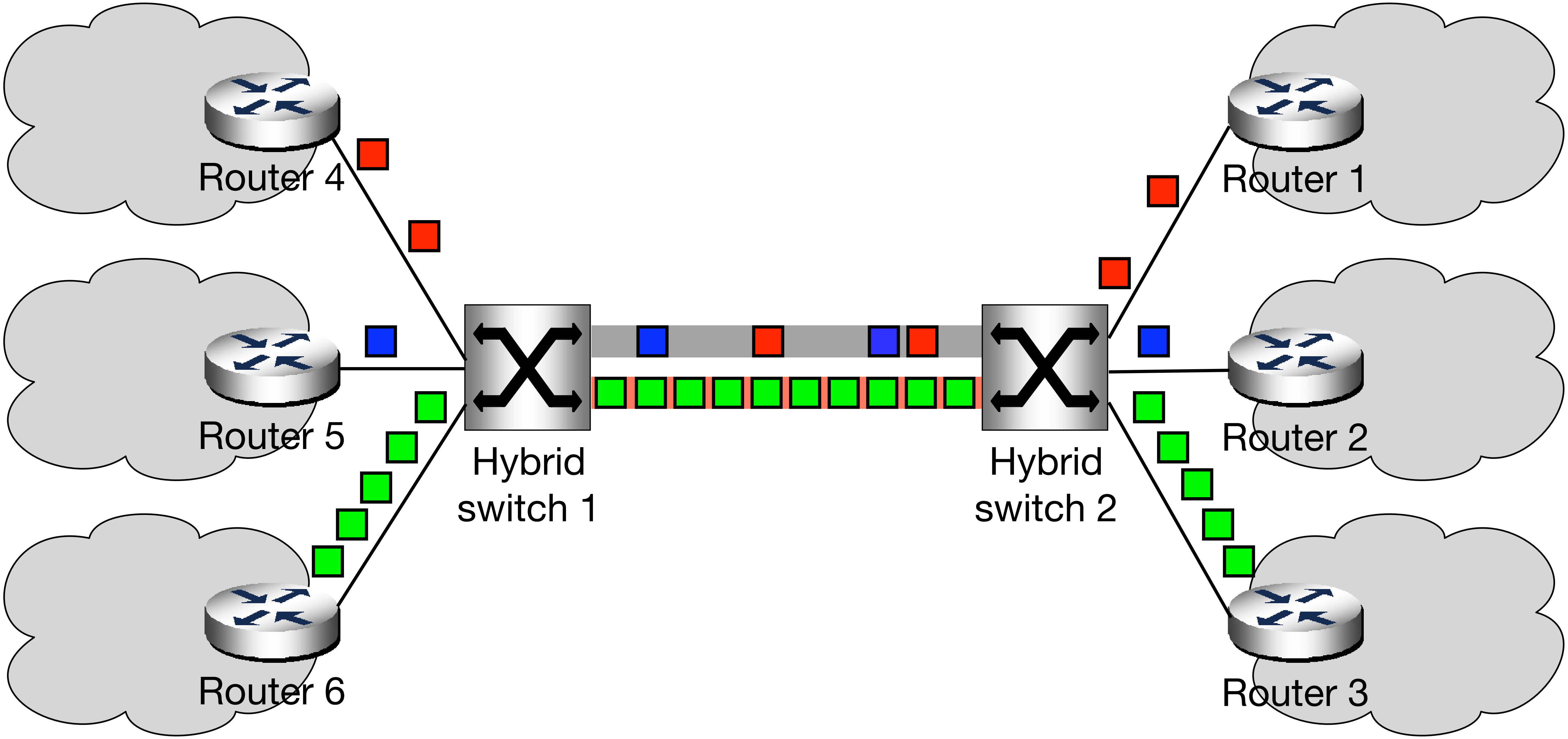
Background information


Router 4
Router 5
Router 6
Hybrid switch 1
Hybrid switch 2
Router 1
Router 2
Router 3

Background information


Router 4
Router 5
Router 6
Hybrid switch 1
Hybrid switch 2
Router 1
Router 2
Router 3

Background information

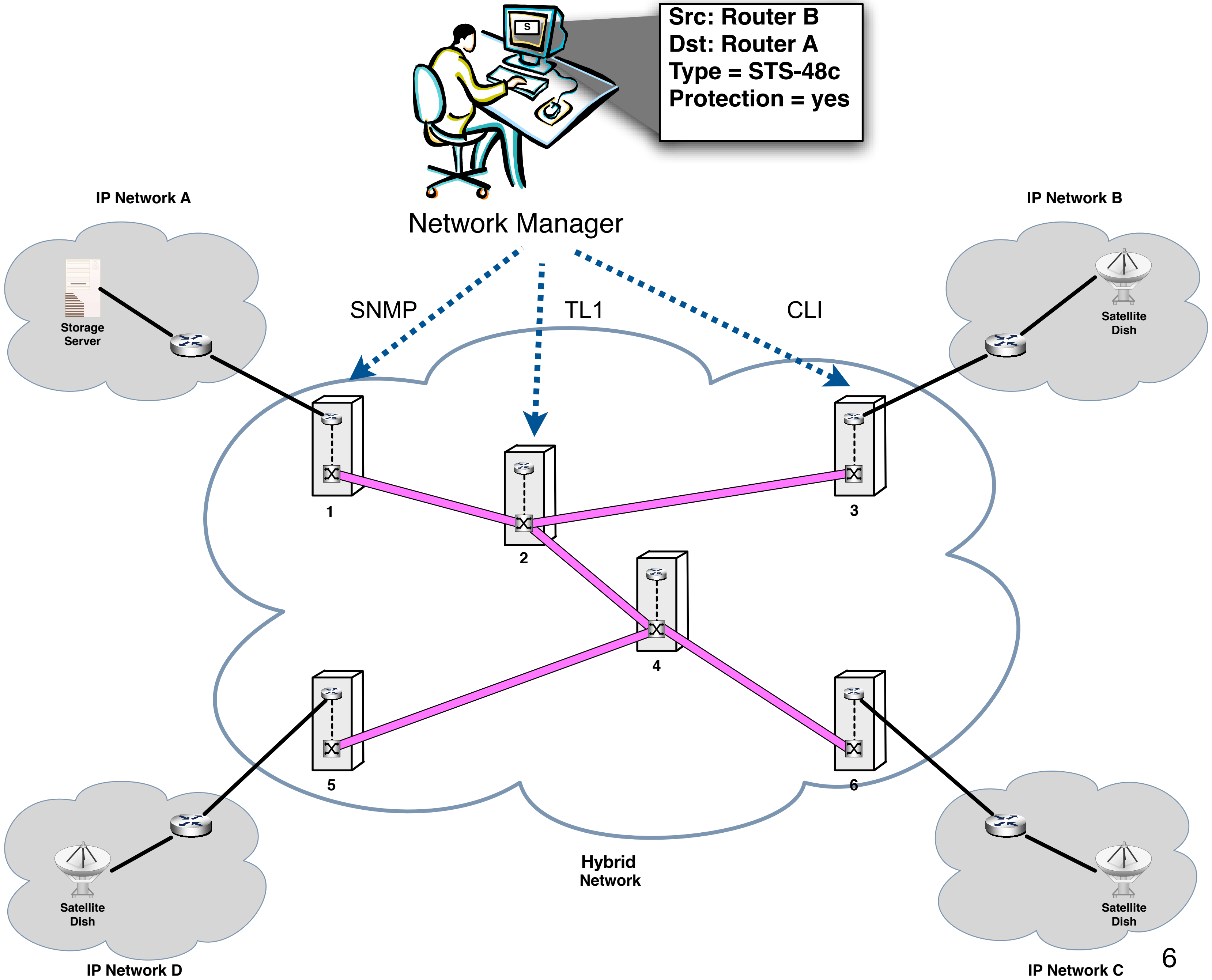

Router 4
Router 5
Router 6
Hybrid switch 1
Hybrid switch 2
Router 1
Router 2
Router 3

Current management approaches

- **Conventional management approach:**

✤ **Protocols:**

- Simple Network Management Protocol (SNMP)
- Command Line Interface (CLI)
- Transaction Language 1 (TL1)



Src: Router B
Dst: Router A
Type = STS-48c
Protection = yes

Network Manager
SNMP
TL1
CLI
IP Network A
Storage Server
IP Network B
Satellite Dish
1
2
3
4
5
6
Hybrid Network
Satellite Dish
IP Network D
Satellite Dish
IP Network C

Current management approaches

- **Conventional management approach:**
  - Who is assigned to:

    1) select IP flows?

      ➡ Human manager

    2) establish and release lambda-connections?

      ➡ Human manager
  - ... and how about the optical switches?

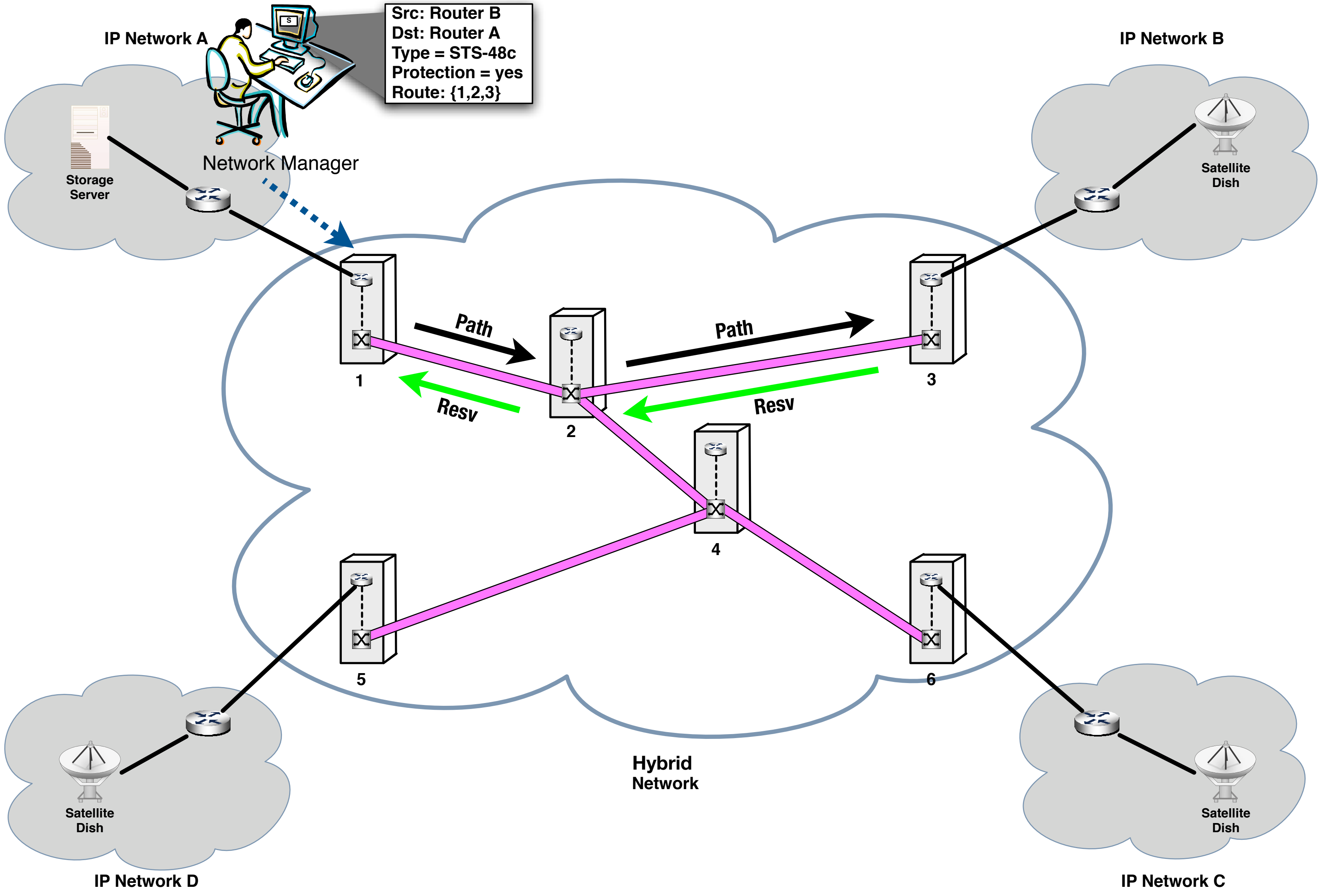
    ➡ They execute orders! No much intelligence in them

Current management approaches

- **Signaling approach: GMPLS**

✤ **GMPLS Protocols:**

- OSPF-TE or ISIS-TE (routing protocols)
- LMP (Link Management Protocol)
- RSVP-TE and CR_LDP (reservation/label distribution protocols)


IP Network A
Storage Server
Network Manager
Src: Router B
Dst: Router A
Type = STS-48c
Protection = yes
Route: {1,2,3}
IP Network B
Satellite Dish
Path
Path
Resv
Resv
1
2
3
4
5
6
Hybrid Network
Satellite Dish
IP Network D
Satellite Dish
IP Network C

Current management approaches

- **Signaling approach:**
  - Who is assigned to:

    1) select IP flows?

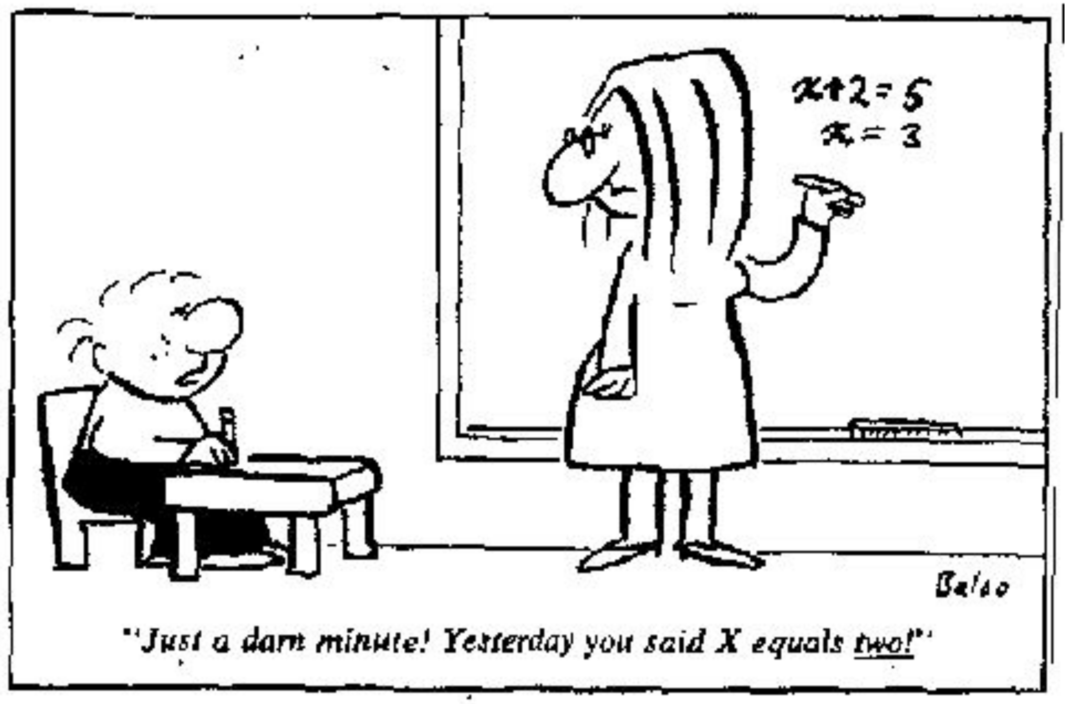
      ➡ Human manager

    2) establish and release lambda-connections?

      ➡ Optical switches, but human managers trigger the action
  - Are the optical switches intelligent in this approach?

    ➡ Sort of... there is some intelligence in the optical switches in order to find a path between end-points (by using routing protocols) as well as create/release the lambda-connections (by using signaling messages)

Problem statement

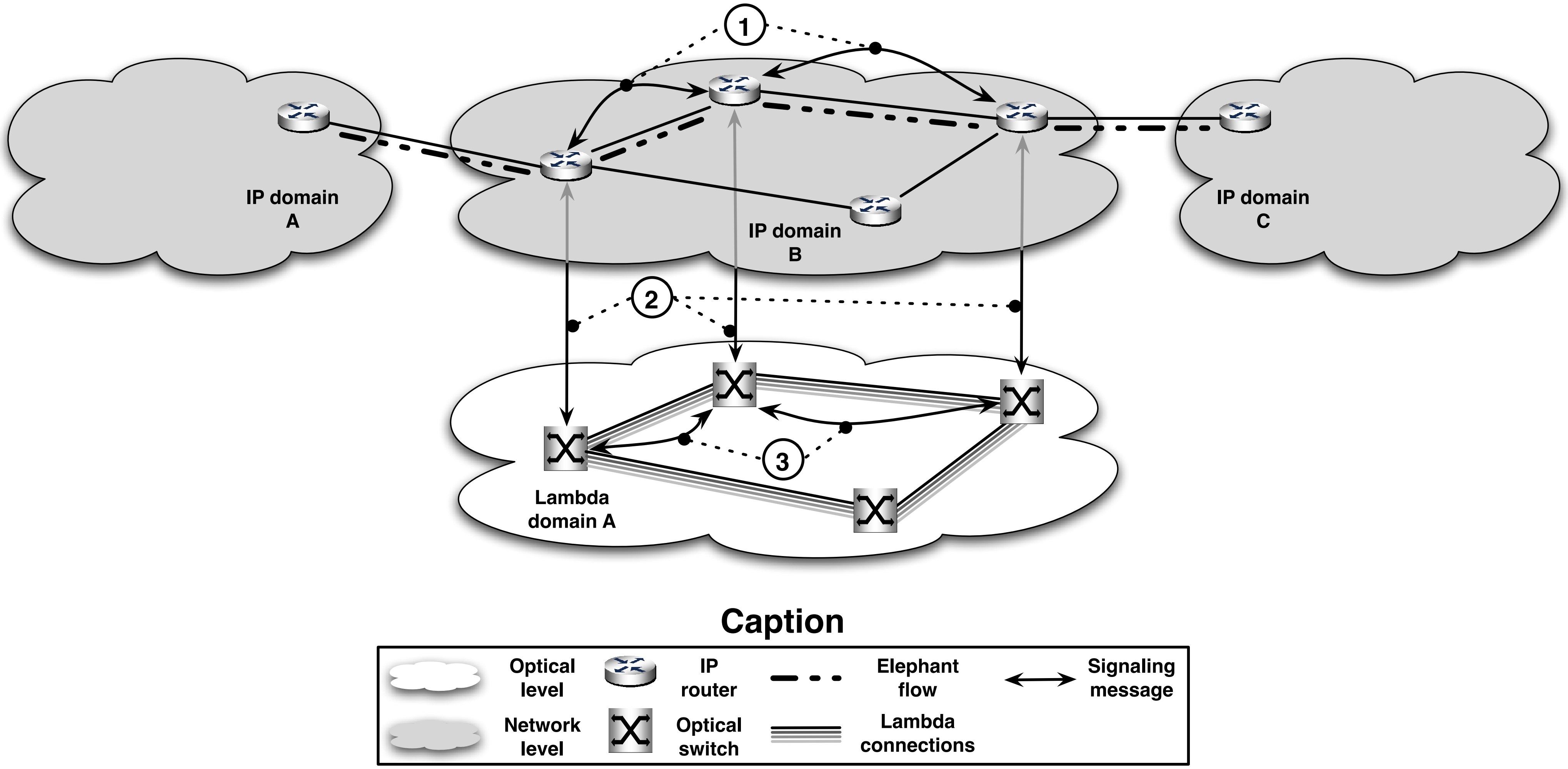


"Just a darn minute! Yesterday you said X equals two!"

- Current approaches mostly depends on human intervention to select IP flows, and create and release lambda-connections
- As a result of that, current approaches can be characterized as:
  - Slow:
    - intra-domain: several hours or even days (flow selection + λ creation)
    - inter-domain: several days or even weeks (flow selection + λ creation)
  - Error prone:
    - Misconfiguration of lambda-connections parameters
    - Some flows may not be detected or they may be eligible for a lambda-connection during the establishment of the connection, but no longer when the connection is established

Self-management of lambda connections

- What is self-management of lambda-connections?
  - Self-management consists of a cooperation between the network and optical layers in order to automatically detect IP flows eligible to the optical level as well as establish/release lambda-connections for them.

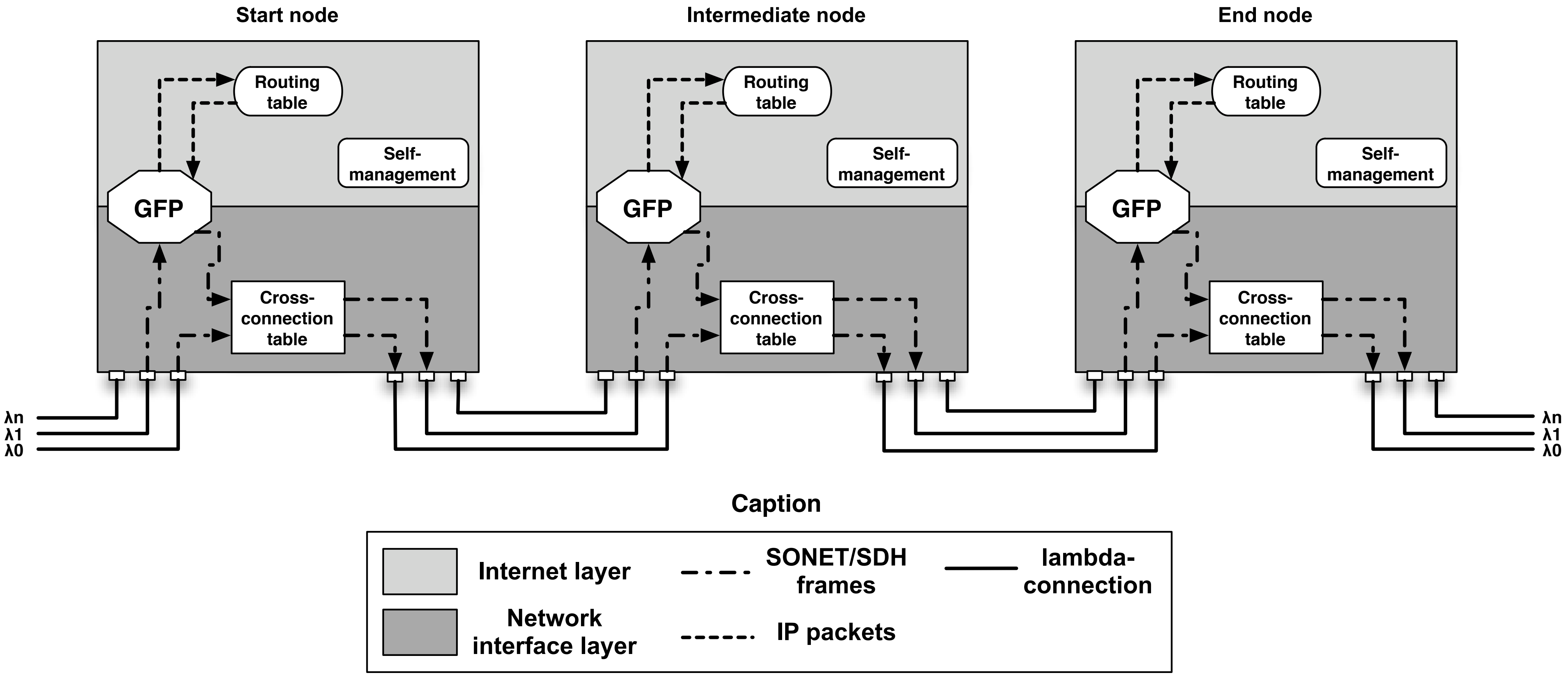

1
IP domain A
IP domain B
IP domain C
2
3
Lambda domain A
Caption
Optical level
Network level
IP router
Optical switch
Elephant flow
Lambda connections
Signaling message

Comparison among management approaches

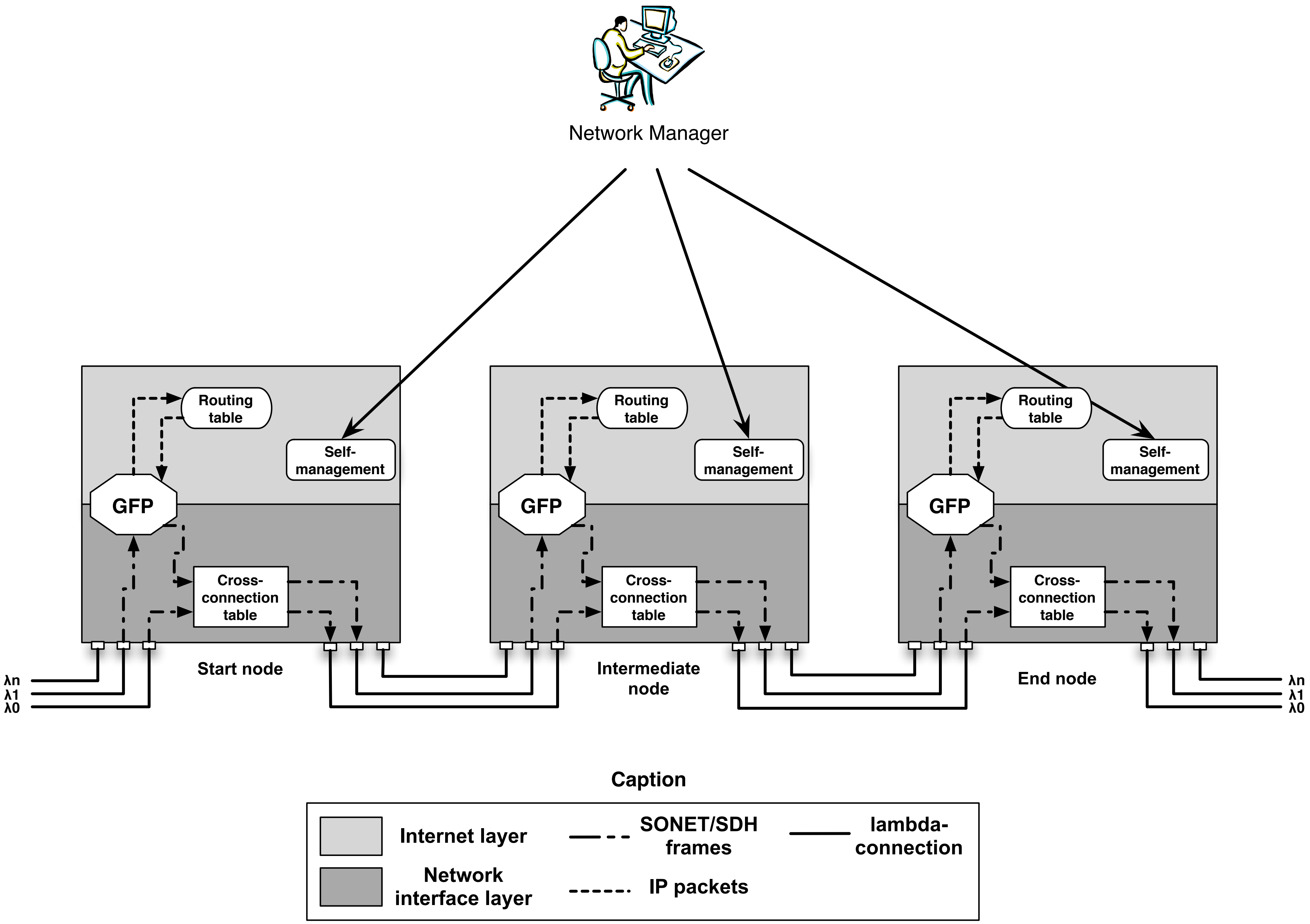
Management approach	Selection of IP flows	Establishment and release of lambda-connections
Conventional	Human manager	Human manager
Signaling	Human manager	Optical switches
Self-management	Optical switches	Optical switches

Functional architecture

Functional architecture


Start node
Intermediate node
End node
Routing table
Self-management
GFP
Cross-connection table
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
IP packets
lambda-connection

Functional architecture



Network Manager

Routing table

Self-management

GFP

Cross-connection table

Start node

Intermediate node

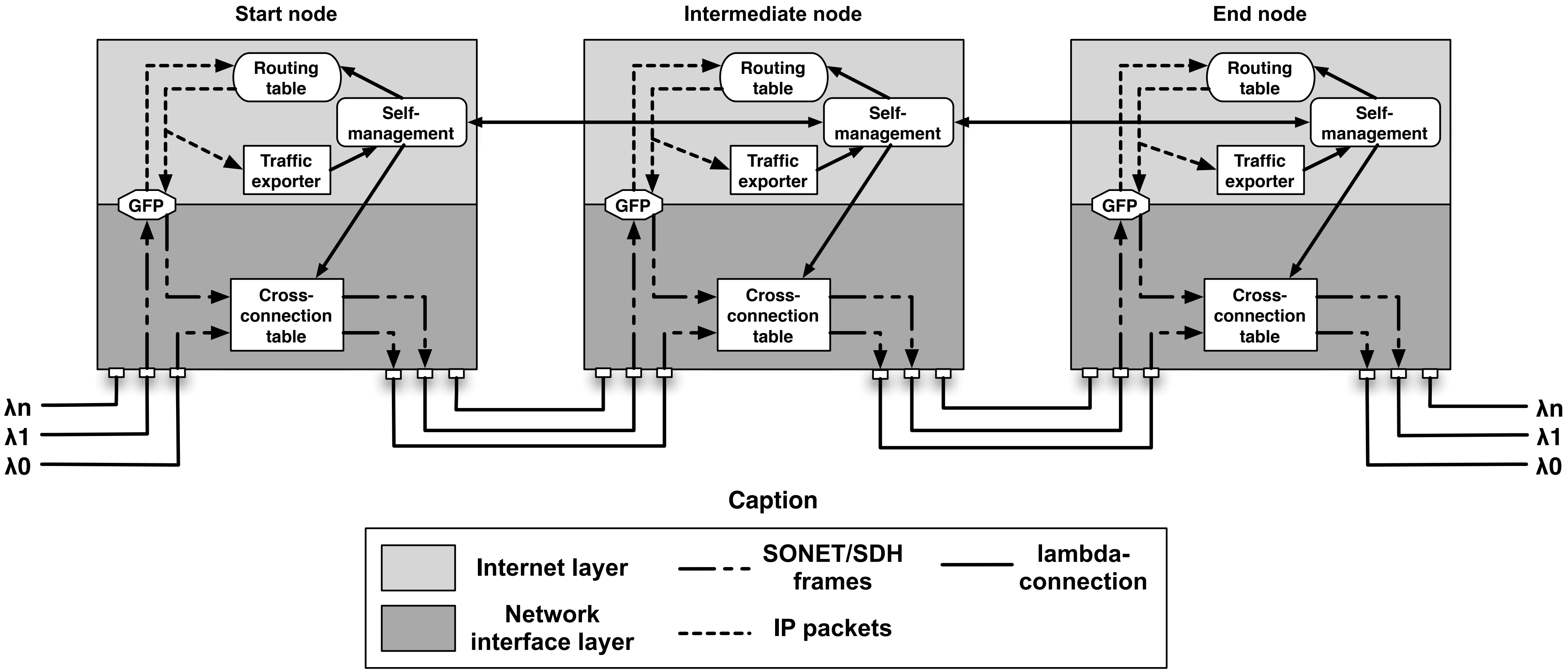
End node

λn
λ1
λ0

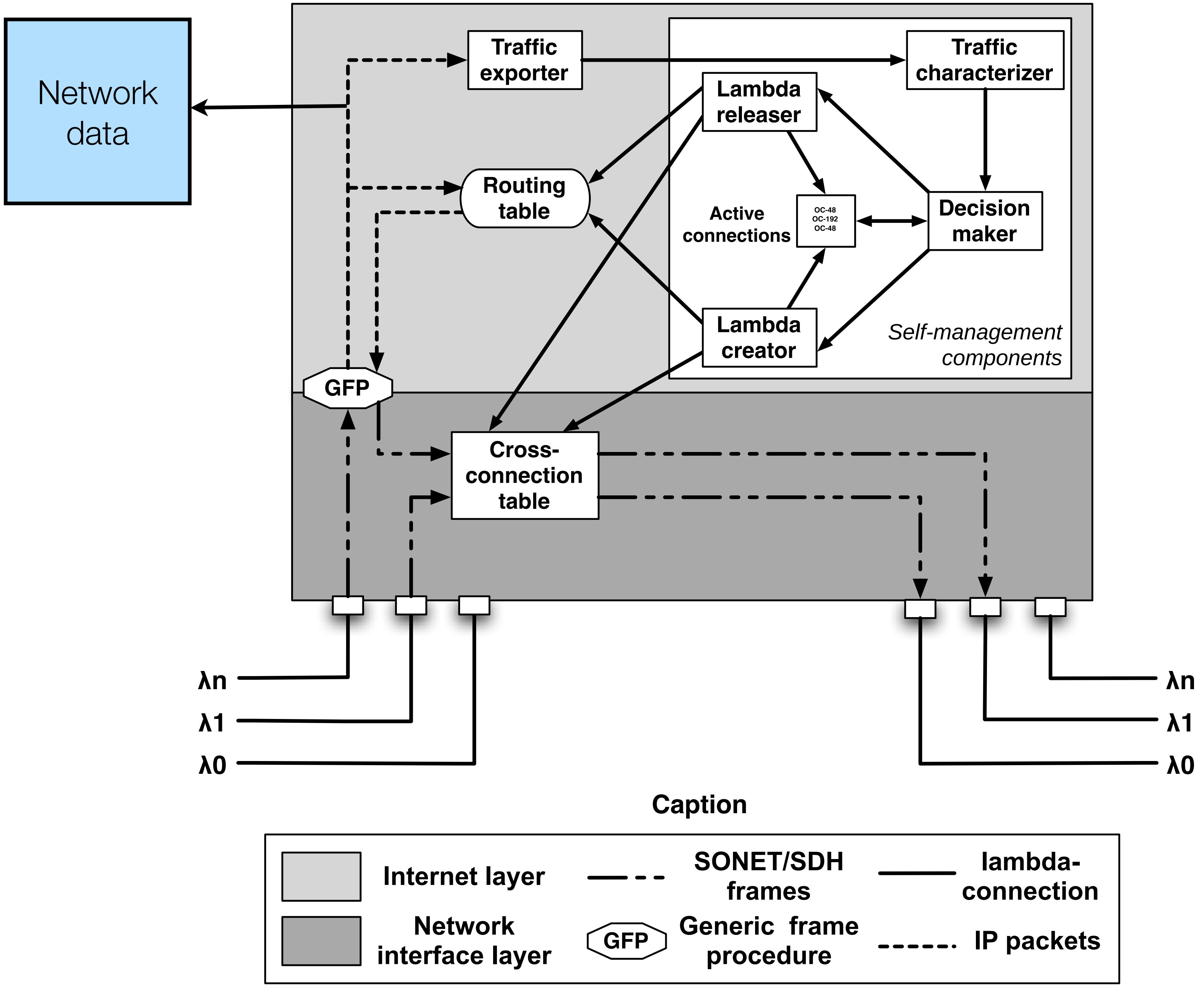
Caption

▨	Internet layer	—--	SONET/SDH frames	——	lambda-connection
▨	Network interface layer	------	IP packets		

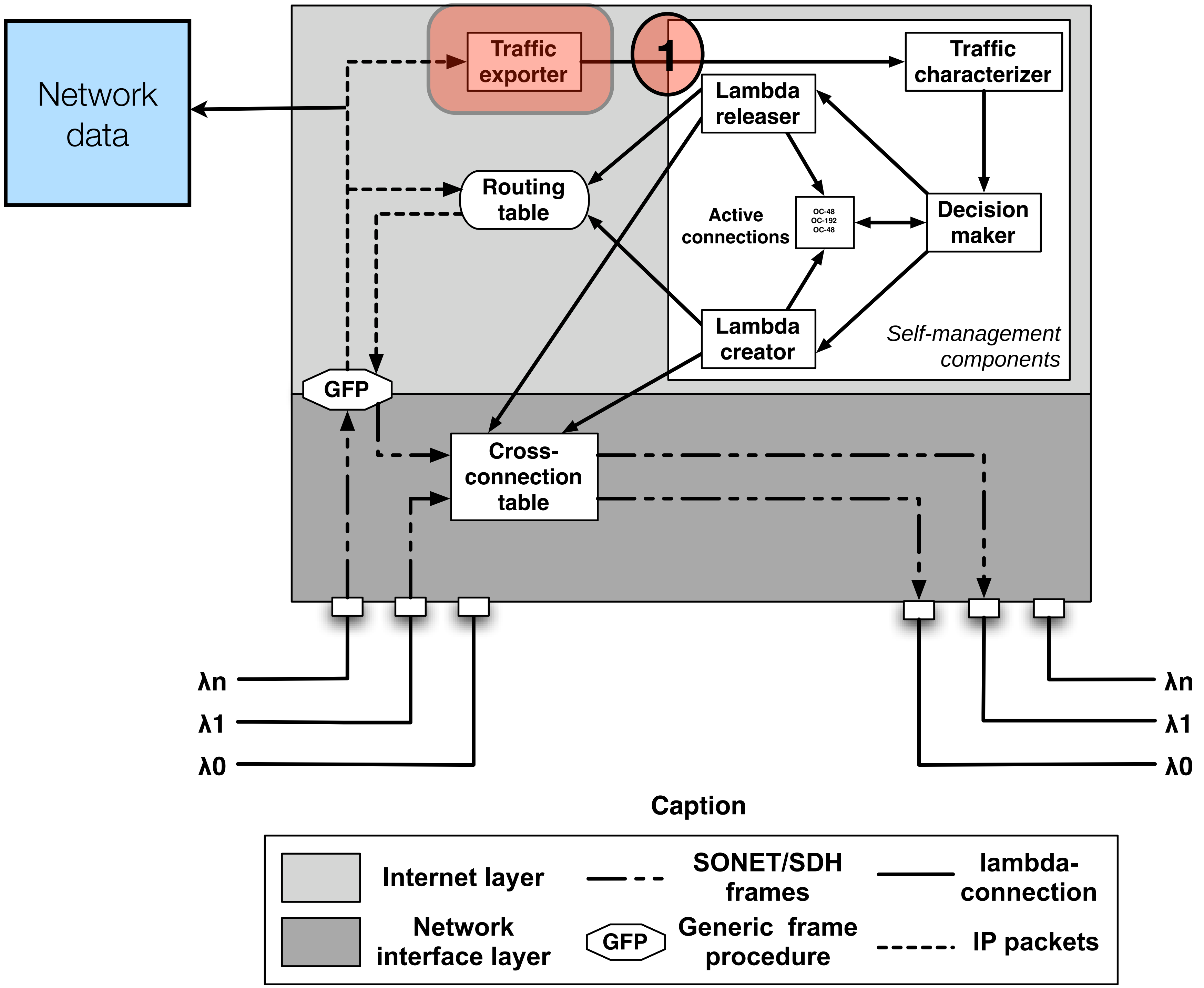
Functional architecture


Start node
Intermediate node
End node
Routing table
Self-management
Traffic exporter
GFP
Cross-connection table
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
IP packets
lambda-connection

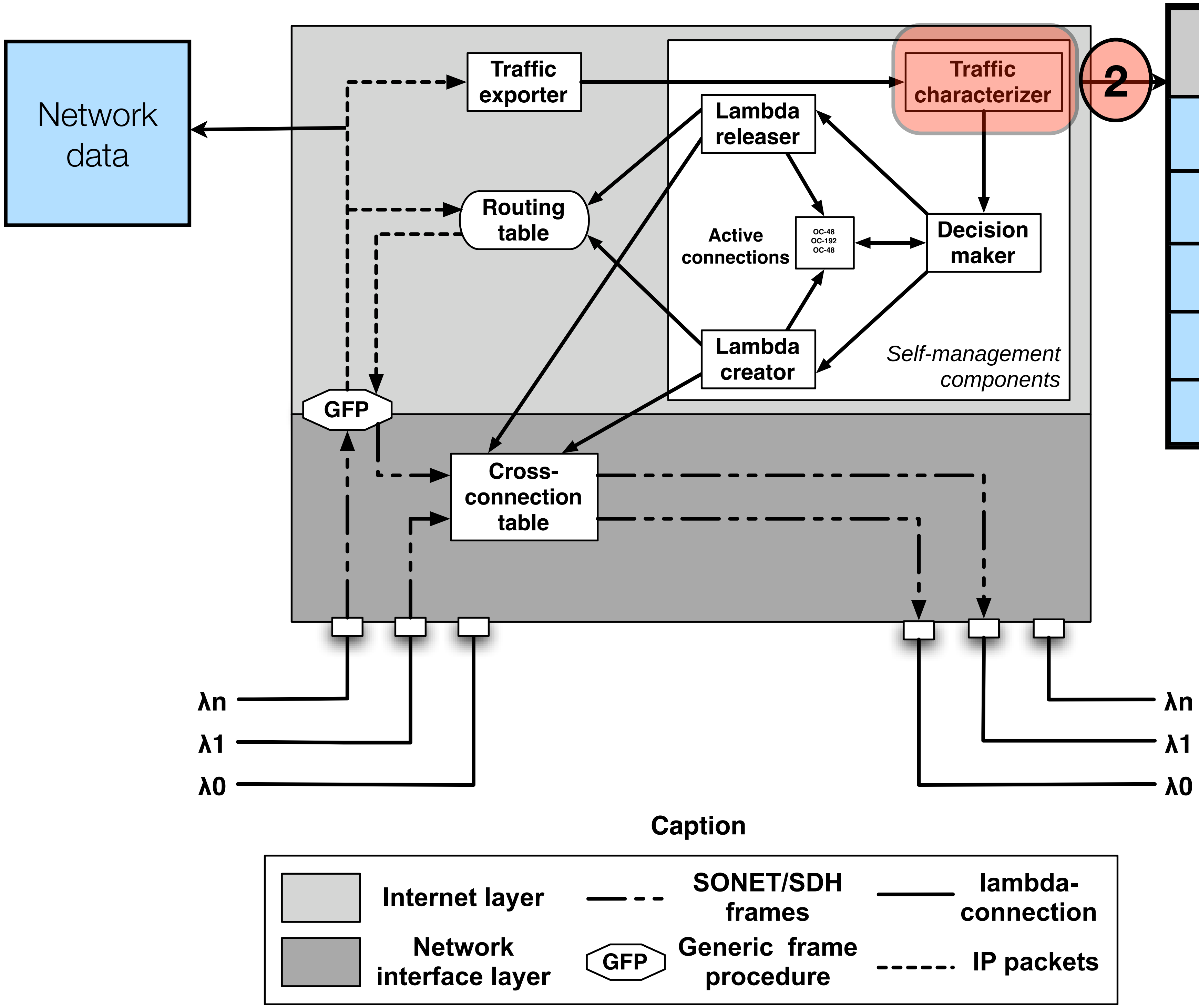
Zooming in into the self-management module


Network data
Traffic exporter
Traffic characterizer
Lambda releaser
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
Lambda creator
Self-management components
GFP
Cross-connection table
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
SONET/SDH frames
lambda-connection
Network interface layer
GFP
Generic frame procedure
IP packets

Zooming in into the self-management module

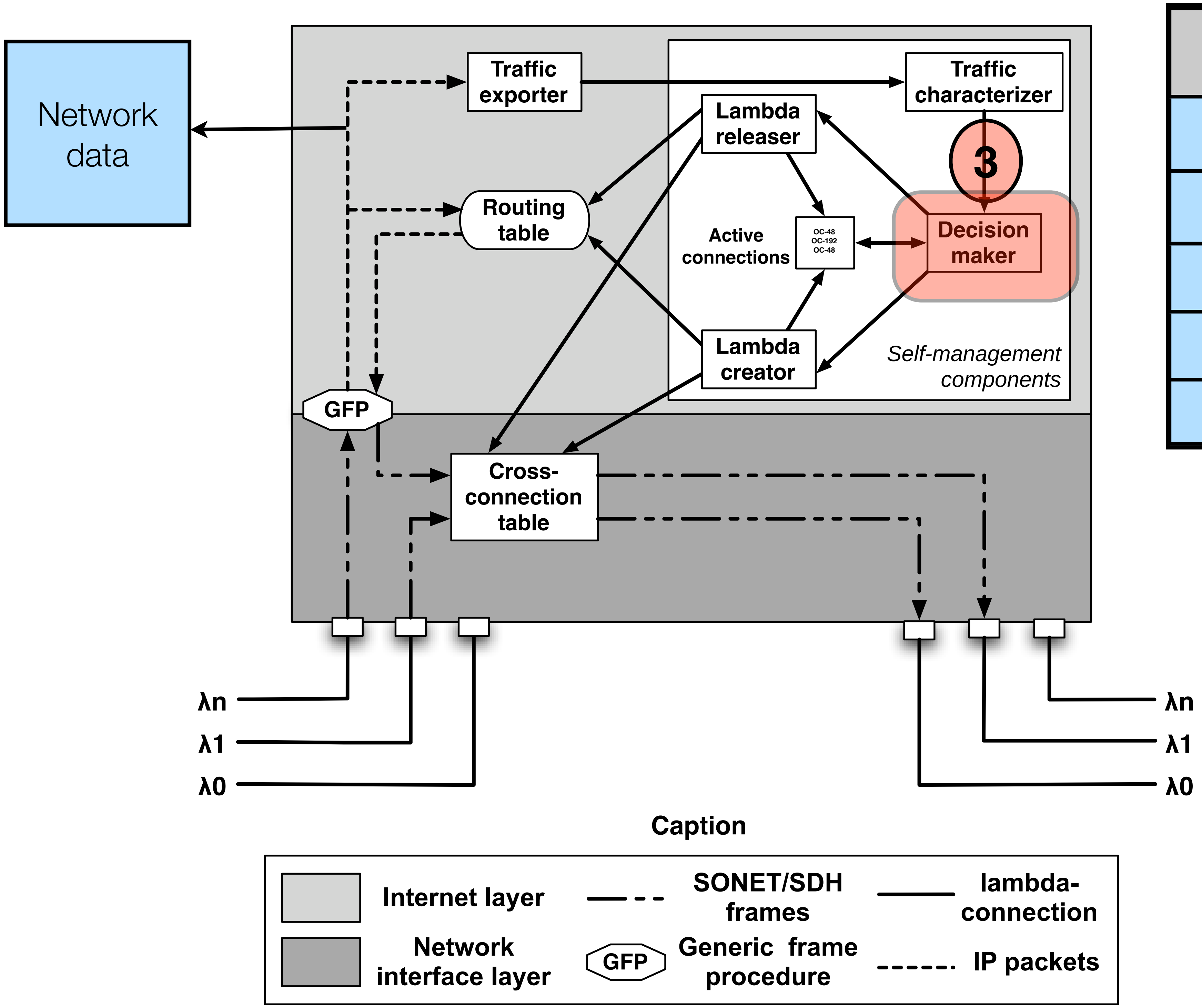

Network data
Traffic exporter
1
Traffic characterizer
Lambda releaser
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
Lambda creator
Self-management components
GFP
Cross-connection table
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
GFP
Generic frame procedure
lambda-connection
IP packets

Zooming in into the self-management module


Network data
Traffic exporter
Traffic characterizer
2
Lambda releaser
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
Lambda creator
Self-management components
GFP
Cross-connection table
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
GFP
Generic frame procedure
lambda-connection
IP packets

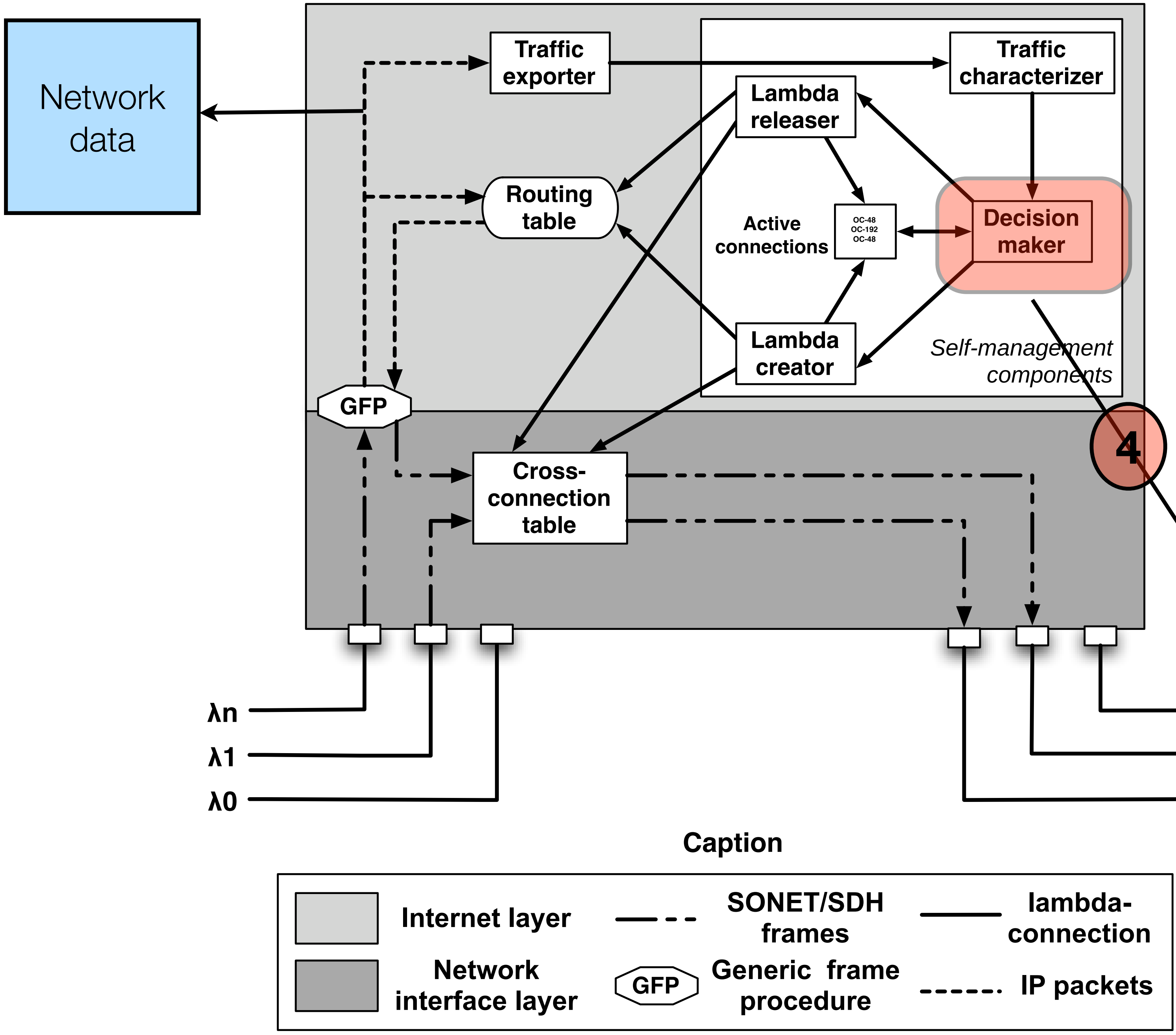
IP Flow	Throughput
1	350 Mbps
2	170 Mbps
3	54 Mbps
4	45 Mbps
5	17 Mbps

Zooming in into the self-management module


Network data
Traffic exporter
Traffic characterizer
Lambda releaser
3
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
Lambda creator
Self-management components
GFP
Cross-connection table
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
GFP
Generic frame procedure
lambda-connection
IP packets

IP Flow	Throughput
1	350 Mbps
2	170 Mbps
3	54 Mbps
4	45 Mbps
5	17 Mbps

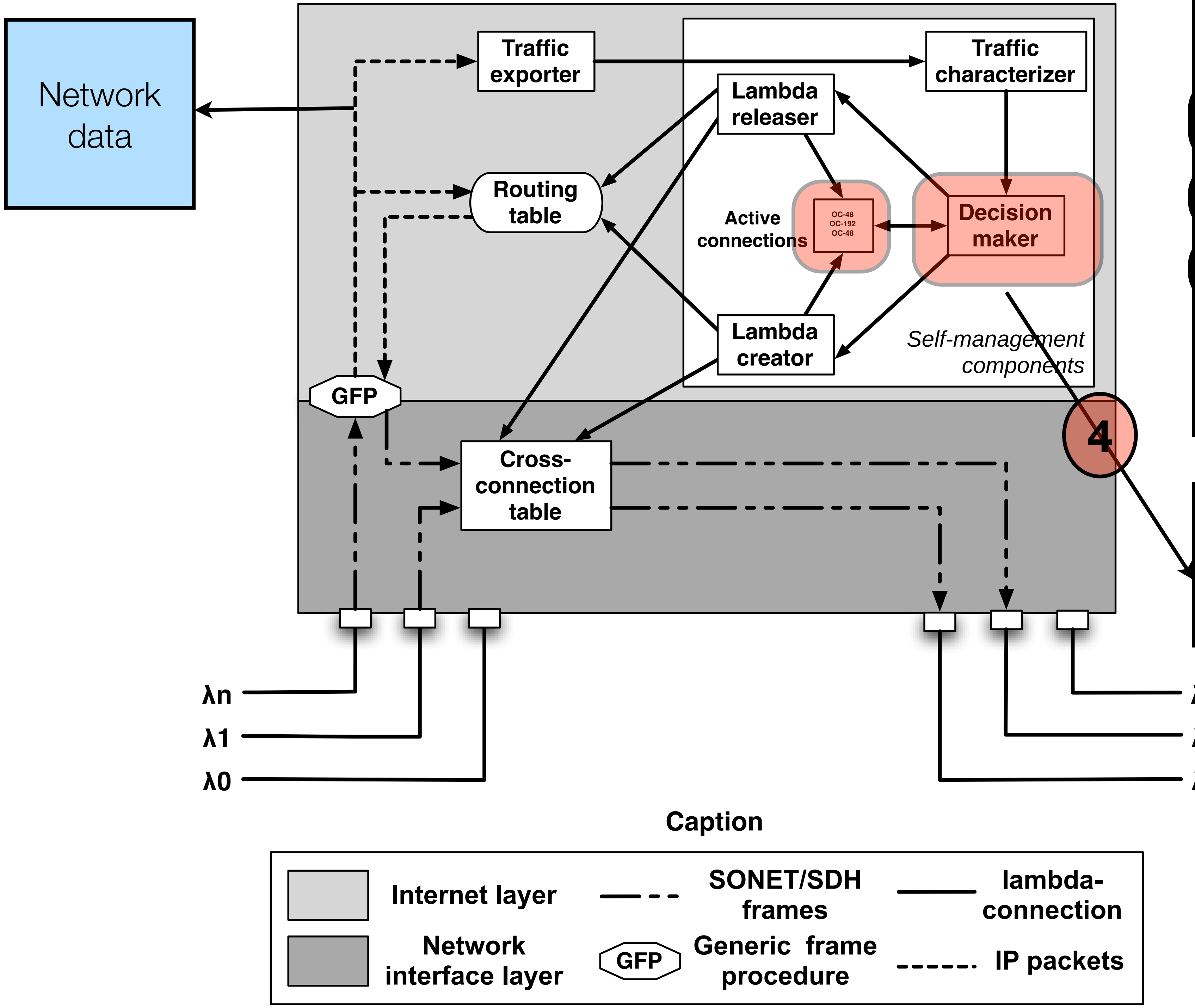
Zooming in into the self-management module


Network data
Traffic exporter
Traffic characterizer
Lambda releaser
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
Lambda creator
Self-management components
GFP
Cross-connection table
4
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
SONET/SDH frames
lambda-connection
Network interface layer
GFP
Generic frame procedure
IP packets

IP Flow	Throughput
1	350 Mbps
2	170 Mbps
3	54 Mbps
4	45 Mbps
5	17 Mbps

Any IP flows equal or bigger than 50 Mbps (OC-1)?
Yeap... flows 1, 2, and 3

Zooming in into the self-management module

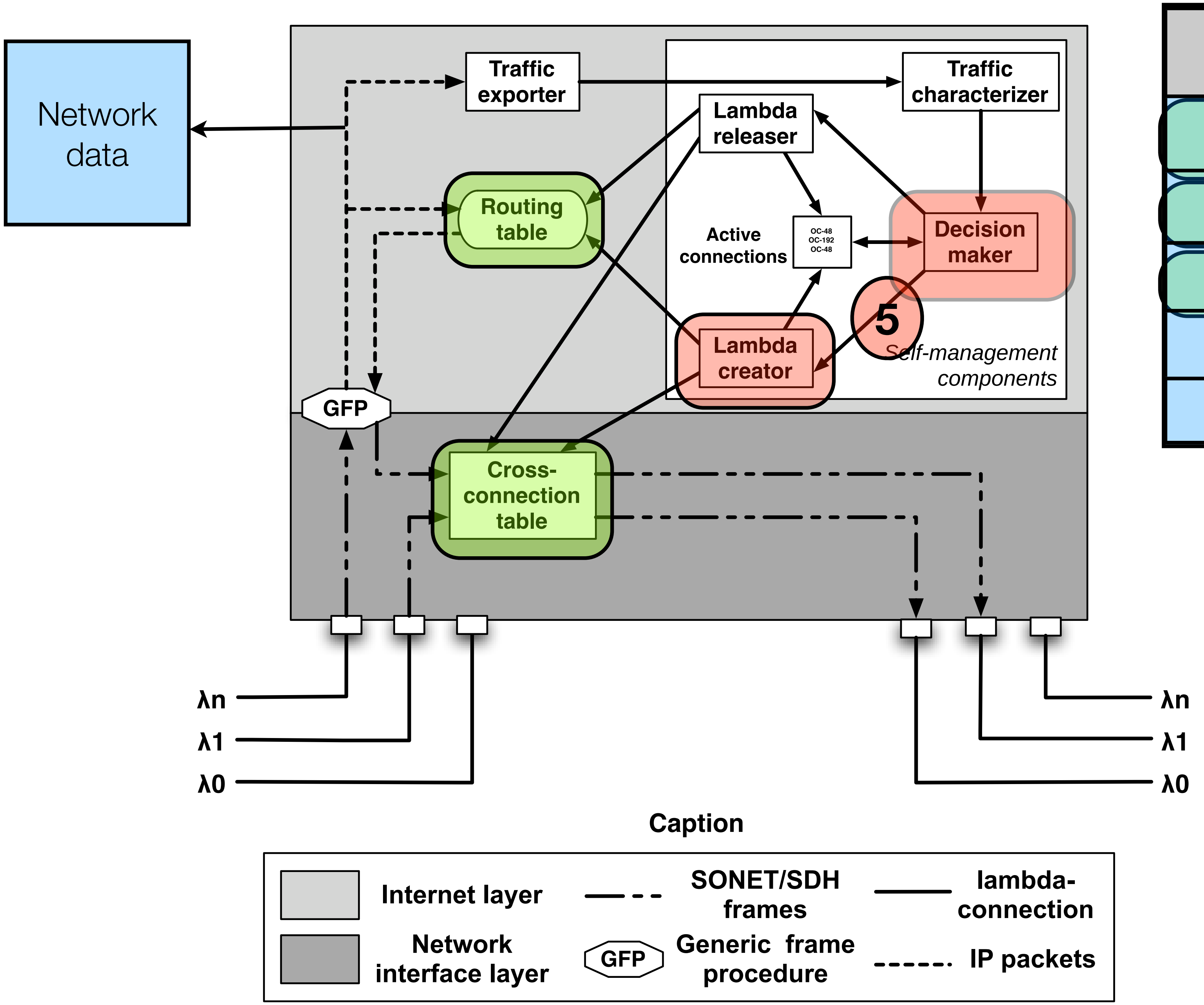

Network data
Traffic exporter
Traffic characterizer
Lambda releaser
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
Lambda creator
Self-management components
GFP
Cross-connection table
4
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
GFP
Generic frame procedure
lambda-connection
IP packets

IP Flow	Throughput
1	350 Mbps
2	170 Mbps
3	54 Mbps
4	45 Mbps
5	17 Mbps

Any IP flows equal or bigger than 50 Mbps (OC-1)?
Yeap... flows 1, 2, and 3

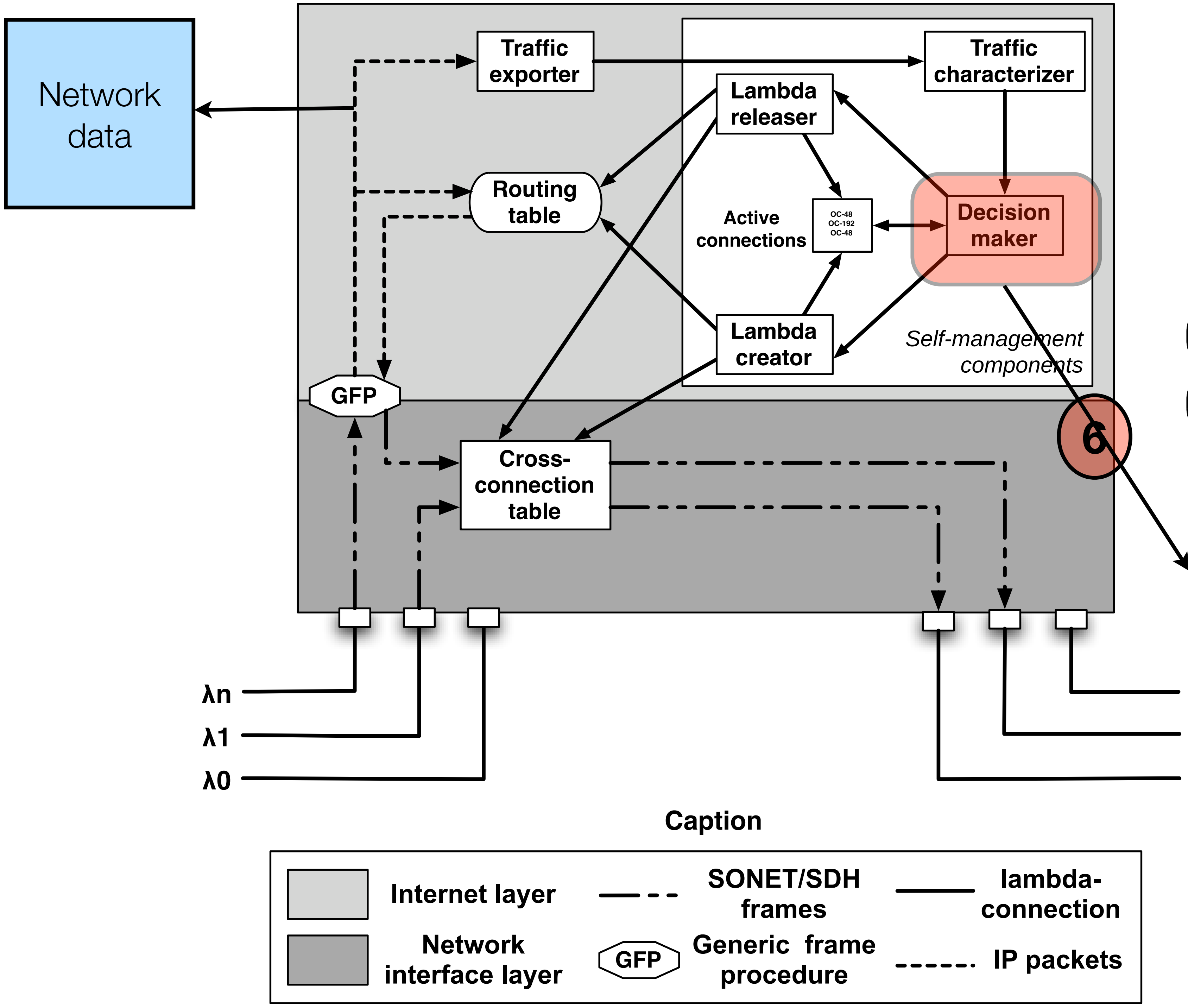
Are these flows already at the optical level?
Not yet!
Create the connection then

Zooming in into the self-management module


Network data
Traffic exporter
Traffic characterizer
Lambda releaser
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
5
Lambda creator
Self-management components
GFP
Cross-connection table
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
GFP
Generic frame procedure
lambda-connection
IP packets

IP Flow	Throughput
1	350 Mbps
2	170 Mbps
3	54 Mbps
4	45 Mbps
5	17 Mbps

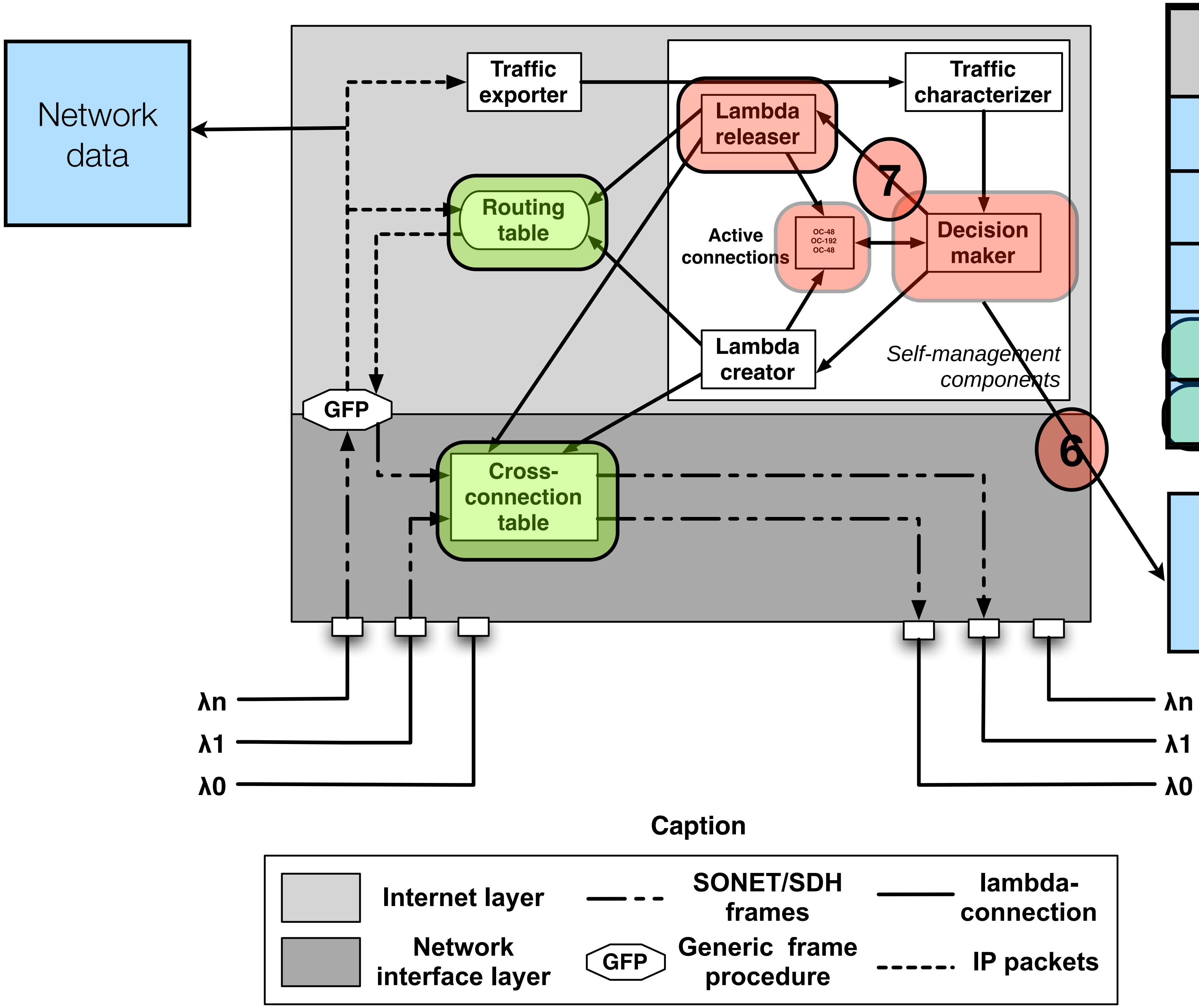
Zooming in into the self-management module


Network data
Traffic exporter
Traffic characterizer
Lambda releaser
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
Lambda creator
Self-management components
GFP
Cross-connection table
6
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
GFP
Generic frame procedure
lambda-connection
IP packets

IP Flow	Throughput
1	350 Mbps
2	170 Mbps
3	54 Mbps
4	45 Mbps
5	17 Mbps

Any IP flows smaller than 50 Mbps?
Yeap... flows 4, and 5

Zooming in into the self-management module


Network data
Traffic exporter
Traffic characterizer
Lambda releaser
Routing table
Active connections
OC-48
OC-192
OC-48
Decision maker
7
Lambda creator
Self-management components
GFP
6
Cross-connection table
λn
λ1
λ0
λn
λ1
λ0
Caption
Internet layer
Network interface layer
SONET/SDH frames
GFP
Generic frame procedure
lambda-connection
IP packets

IP Flow	Throughput
1	350 Mbps
2	170 Mbps
3	54 Mbps
4	45 Mbps
5	17 Mbps

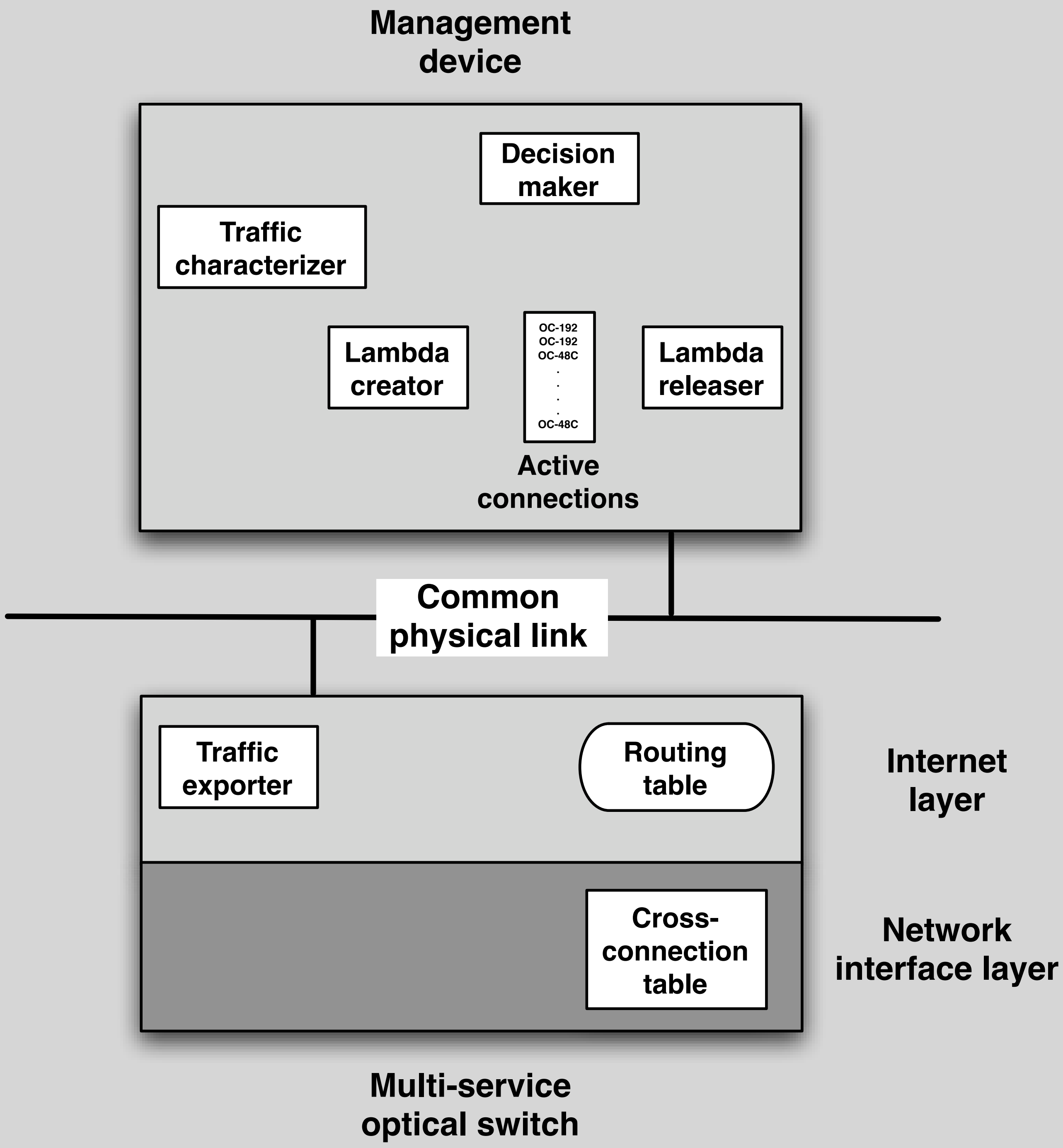
Any IP flows smaller than 50 Mbps?
Yeap... flows 4, and 5

Are these flows already at the optical level?
Yes, they are!
Release the connection then

Physical architecture

- What is physical architecture?
    - Our physical architecture consists of showing the physical location of the functional blocks

- Why is the self-management module outside?
    - Vendors may not be willing to change the implementation of the optical switches operating systems


Management device
Decision maker
Traffic characterizer
Lambda creator
OC-192
OC-192
OC-48C
OC-48C
Lambda releaser
Active connections
Common physical link
Traffic exporter
Routing table
Internet layer
Cross-connection table
Network interface layer
Multi-service optical switch

Analyzing flow characteristics

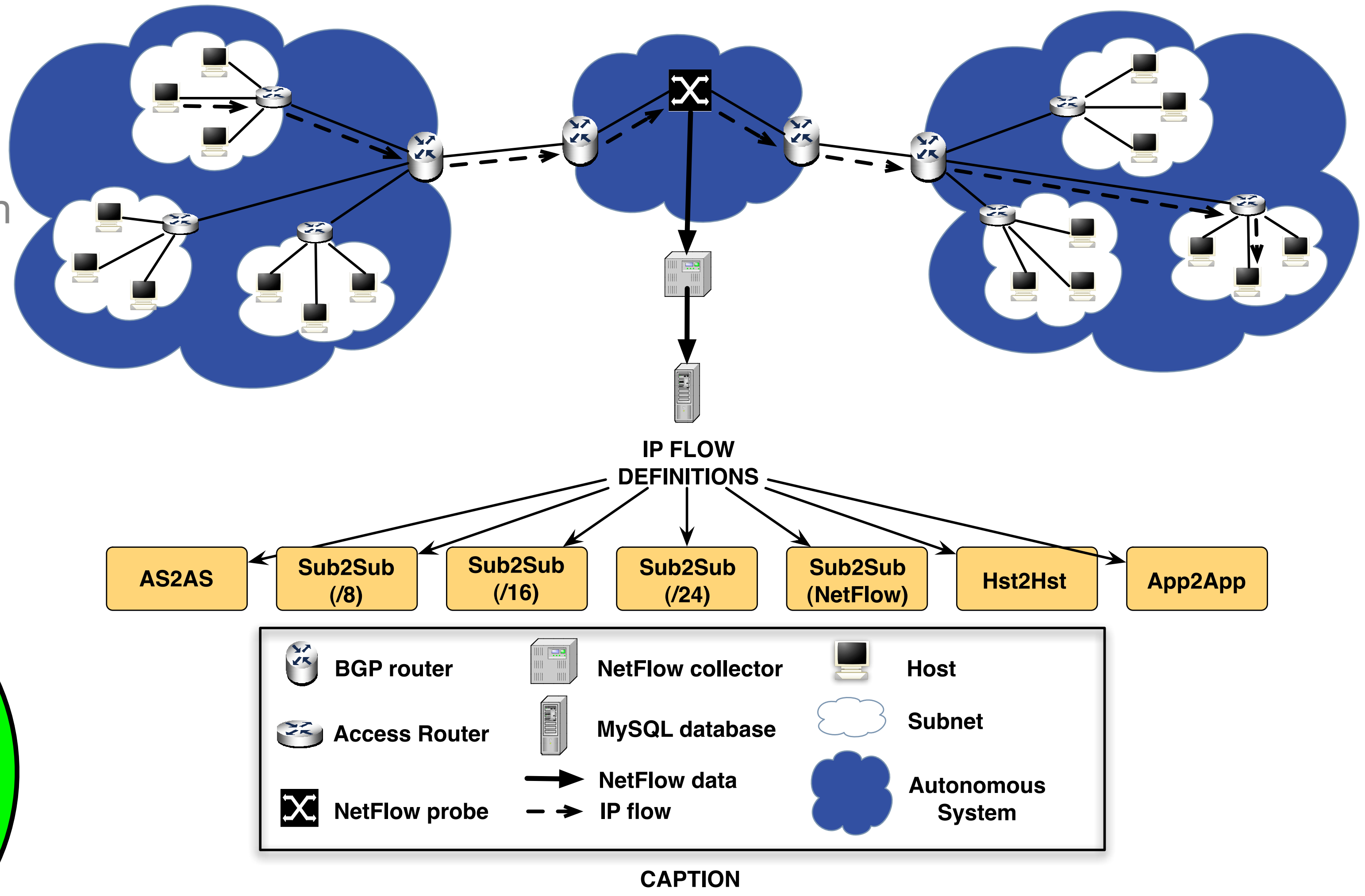
- NetFlow analysis was performed by using different definitions for a flow
- 2 weeks of NetFlow data were divided in 5 and 30 minutes intervals
- **Criterion**: An IP flow is eligible to the optical level if its total consumed bandwidth is equal or bigger than the minimal unit of transmission in SONET networks in a certain time interval: average throughput >= 50.112 Mbit/s.

OC-1 x 30 minutes
↓
((50.112 Mbps/1024) x 1800 seconds) / 8 bits
↓
11 GBytes

Criterion 1

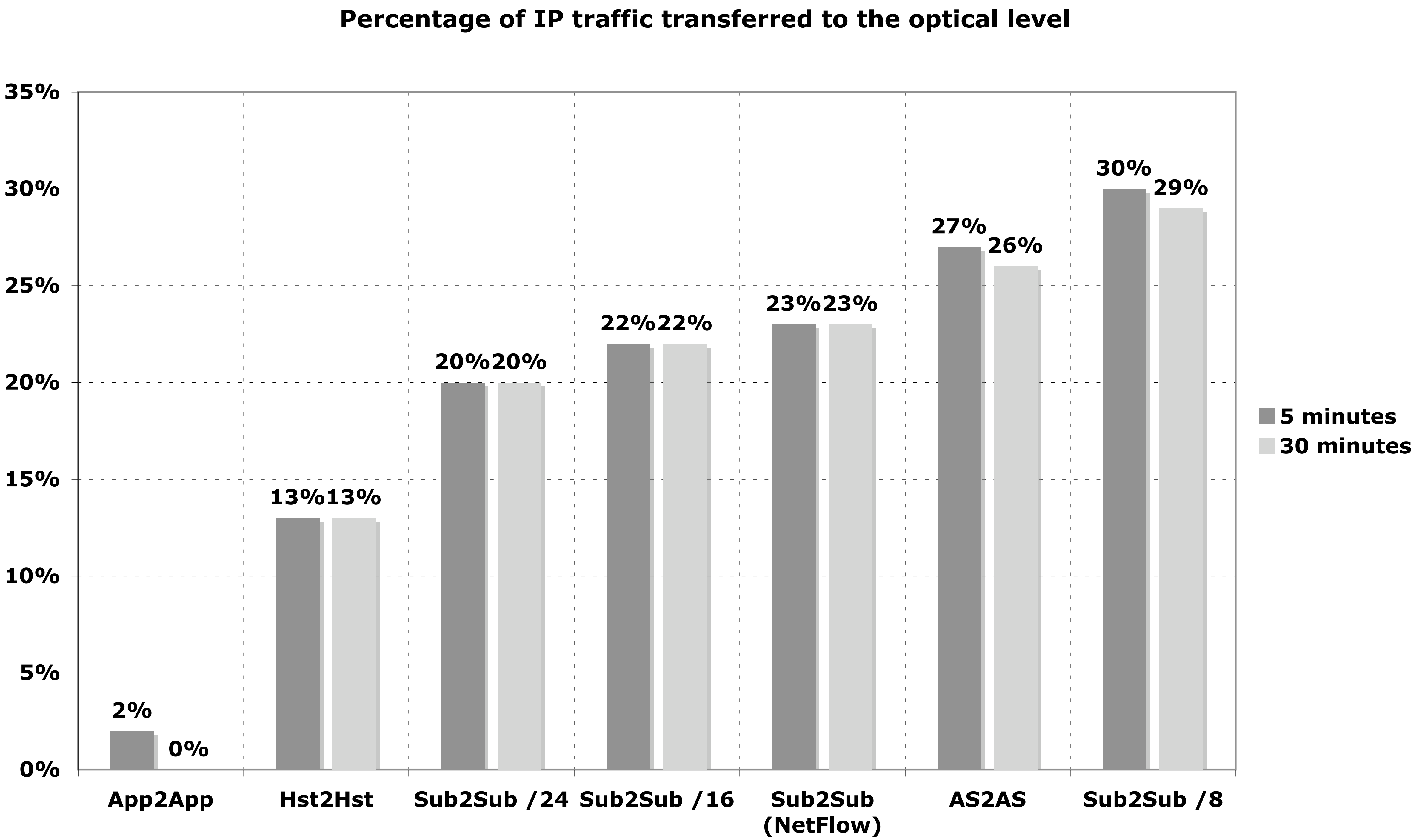
OC-1 x 5 minutes
↓
((50.112 Mbps/1024)x 300 seconds) / 8 bits
↓
1.8 GBytes

Criterion 2

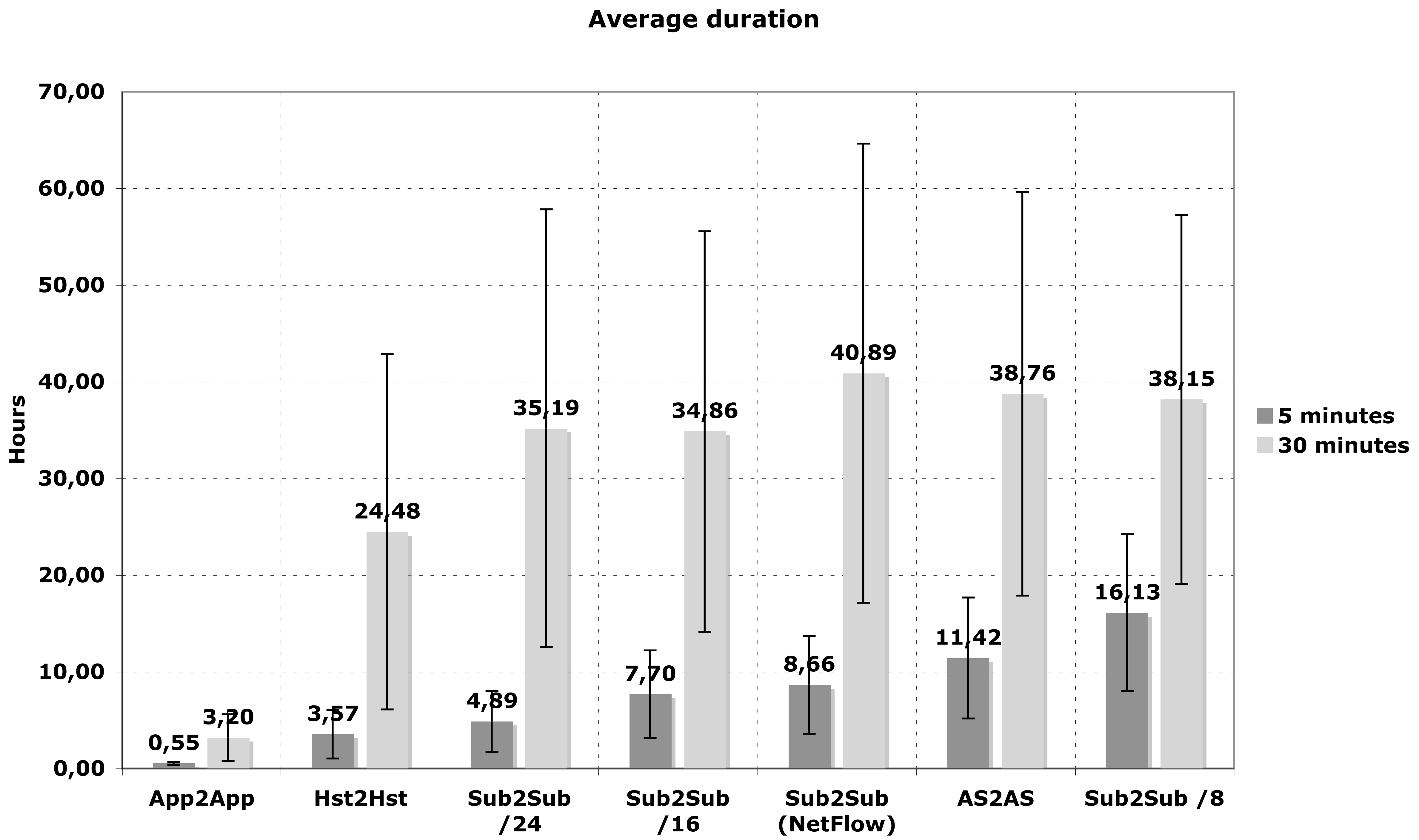

IP FLOW DEFINITIONS
AS2AS
Sub2Sub (/8)
Sub2Sub (/16)
Sub2Sub (/24)
Sub2Sub (NetFlow)
Hst2Hst
App2App
BGP router
Access Router
NetFlow probe
NetFlow collector
MySQL database
NetFlow data
IP flow
Host
Subnet
Autonomous System
CAPTION

NetFlow data analysis scenario

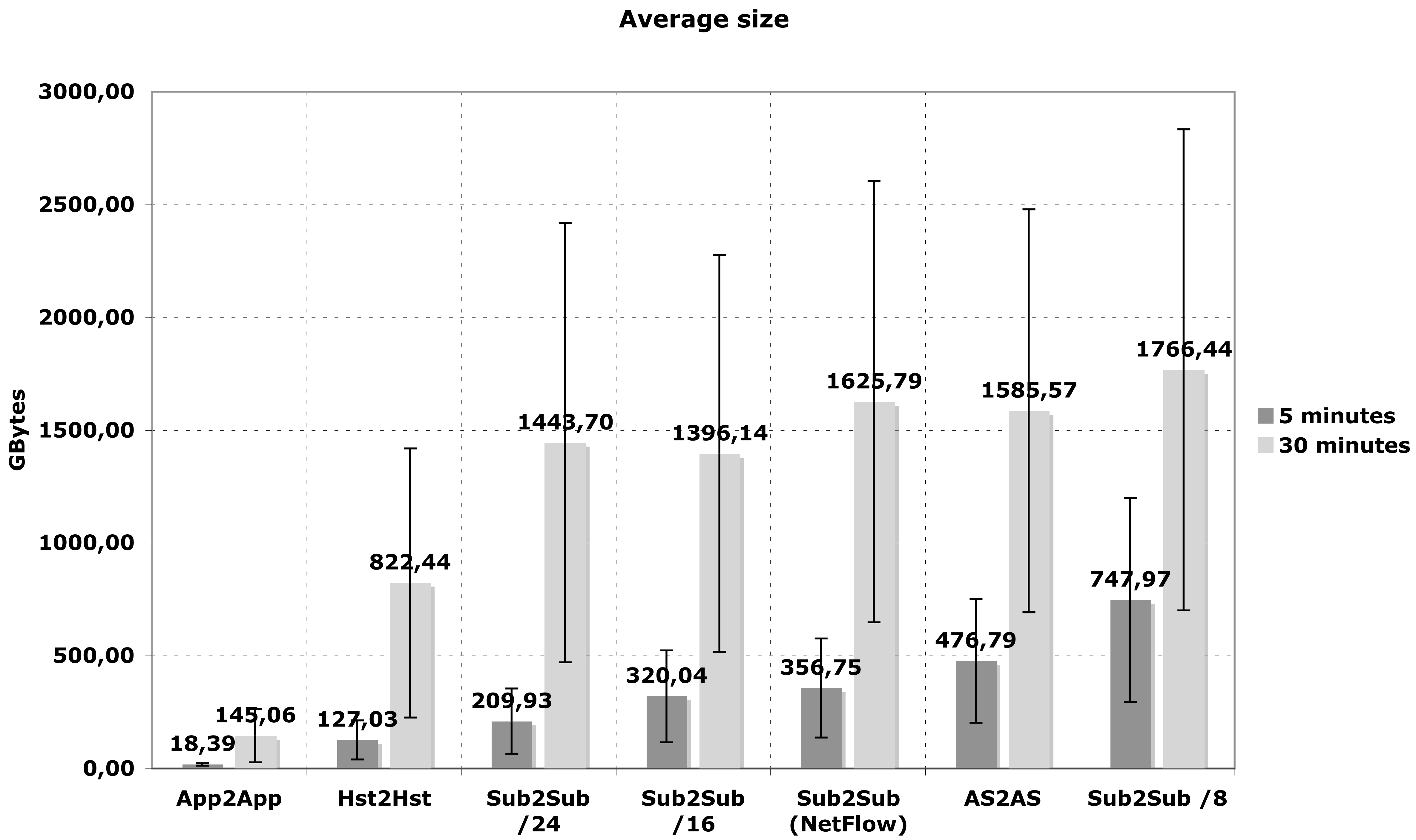
Characteristics of IP flows eligible to lambda-connections



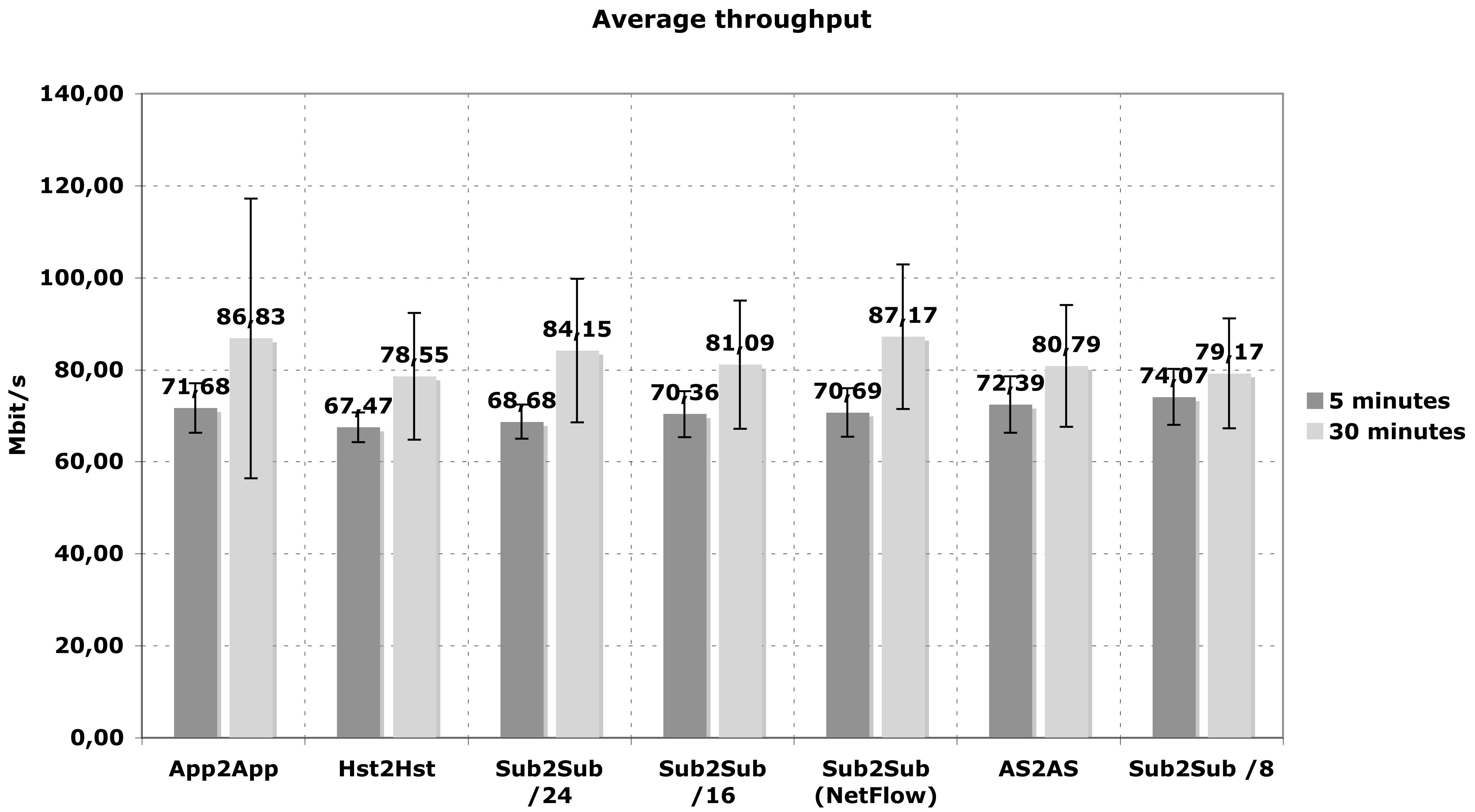
Characteristics of IP flows eligible to lambda-connections



Characteristics of IP flows eligible to lambda-connections



Characteristics of IP flows eligible to lambda-connections



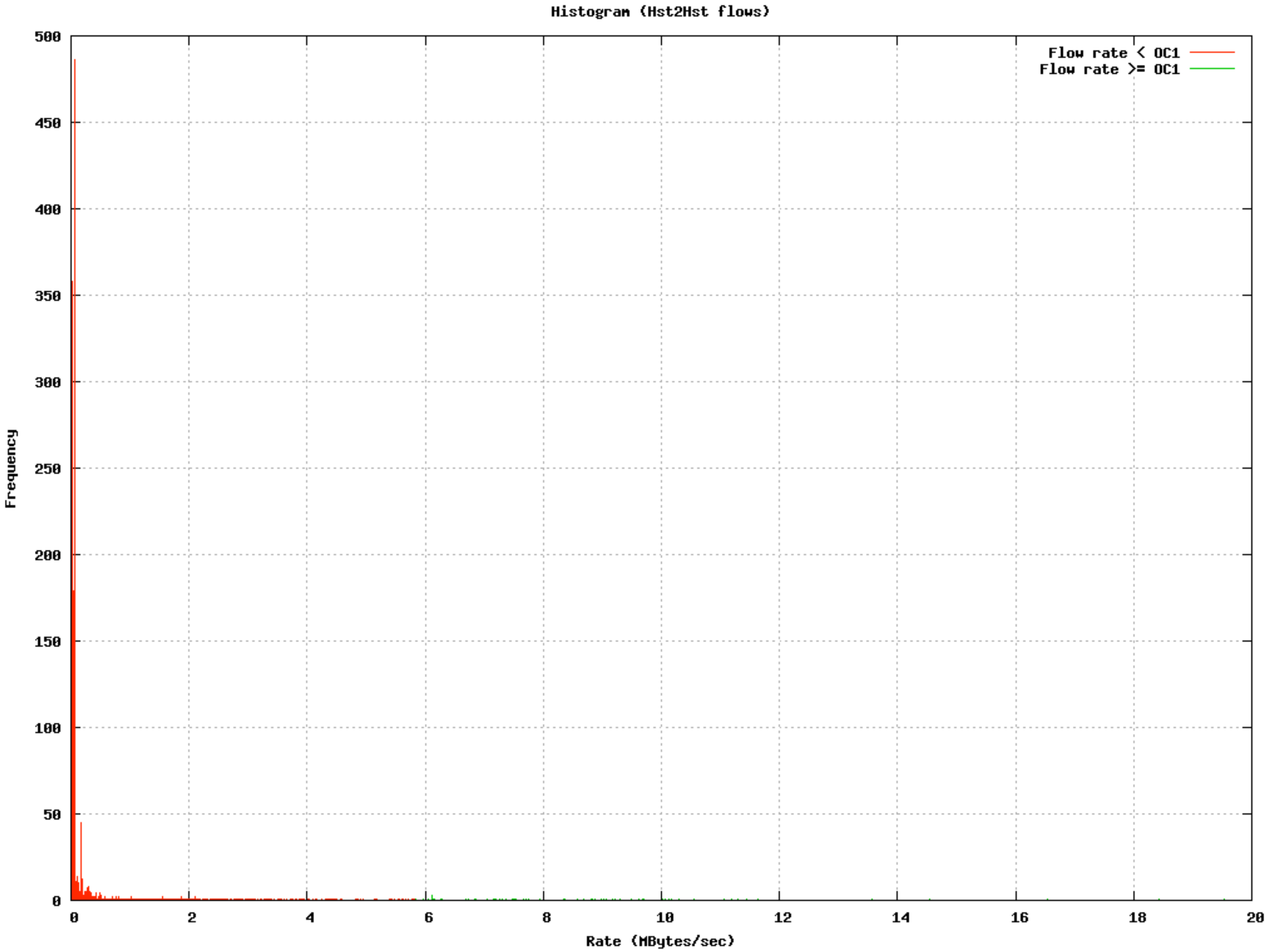
Current challenge

- **Current challenge:** given the flow throughput, is it possible to estimate its duration and volume?

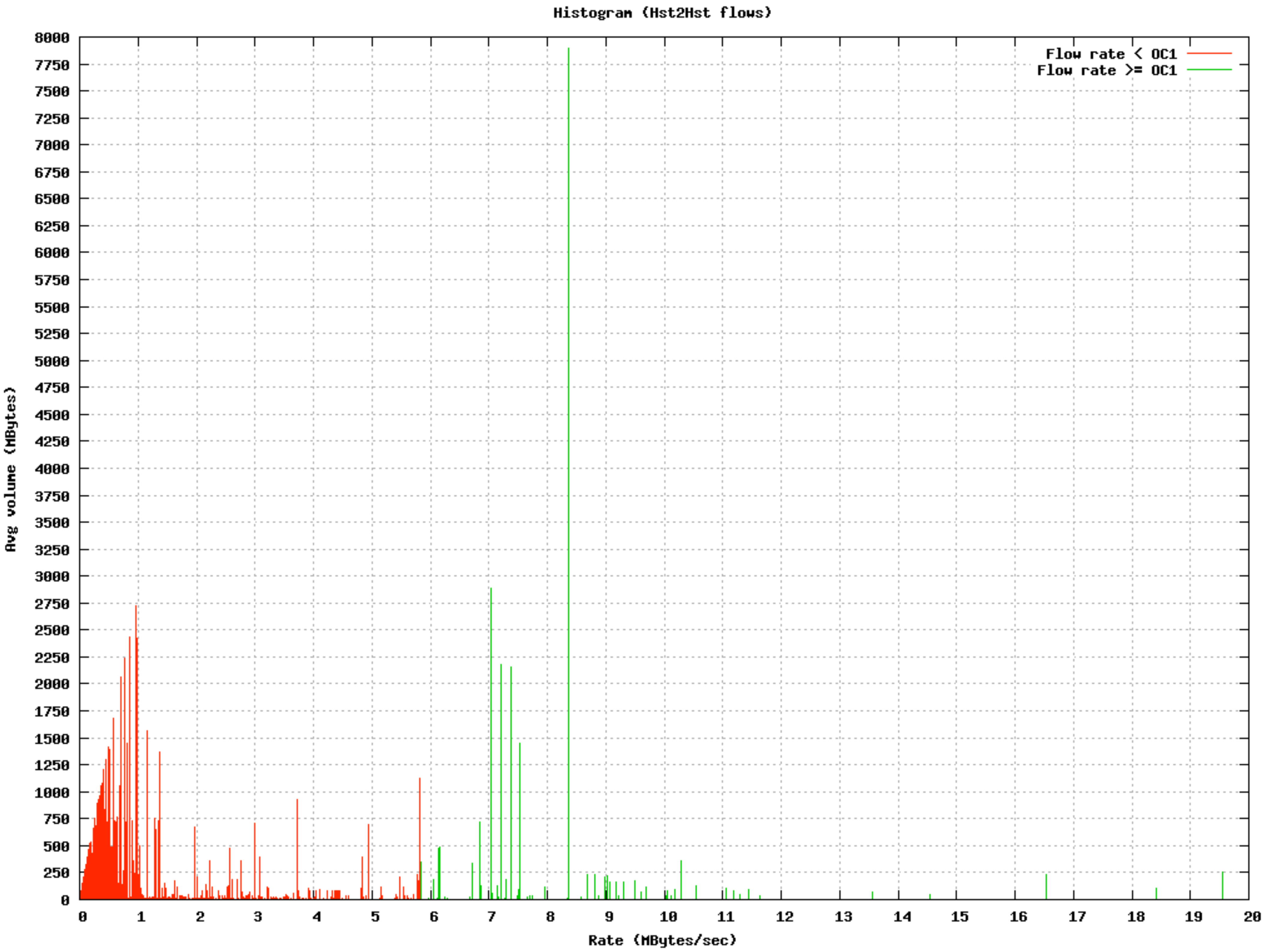
- **Purpose**: in order to help deciding when a lambda-connection should be allocated to a certain flow as well as what the required link capacity should be used

- **Approach used**: 45 minutes of non-sampled NetFlow data was collected from the UT network and stored into a MySQL database for analysis

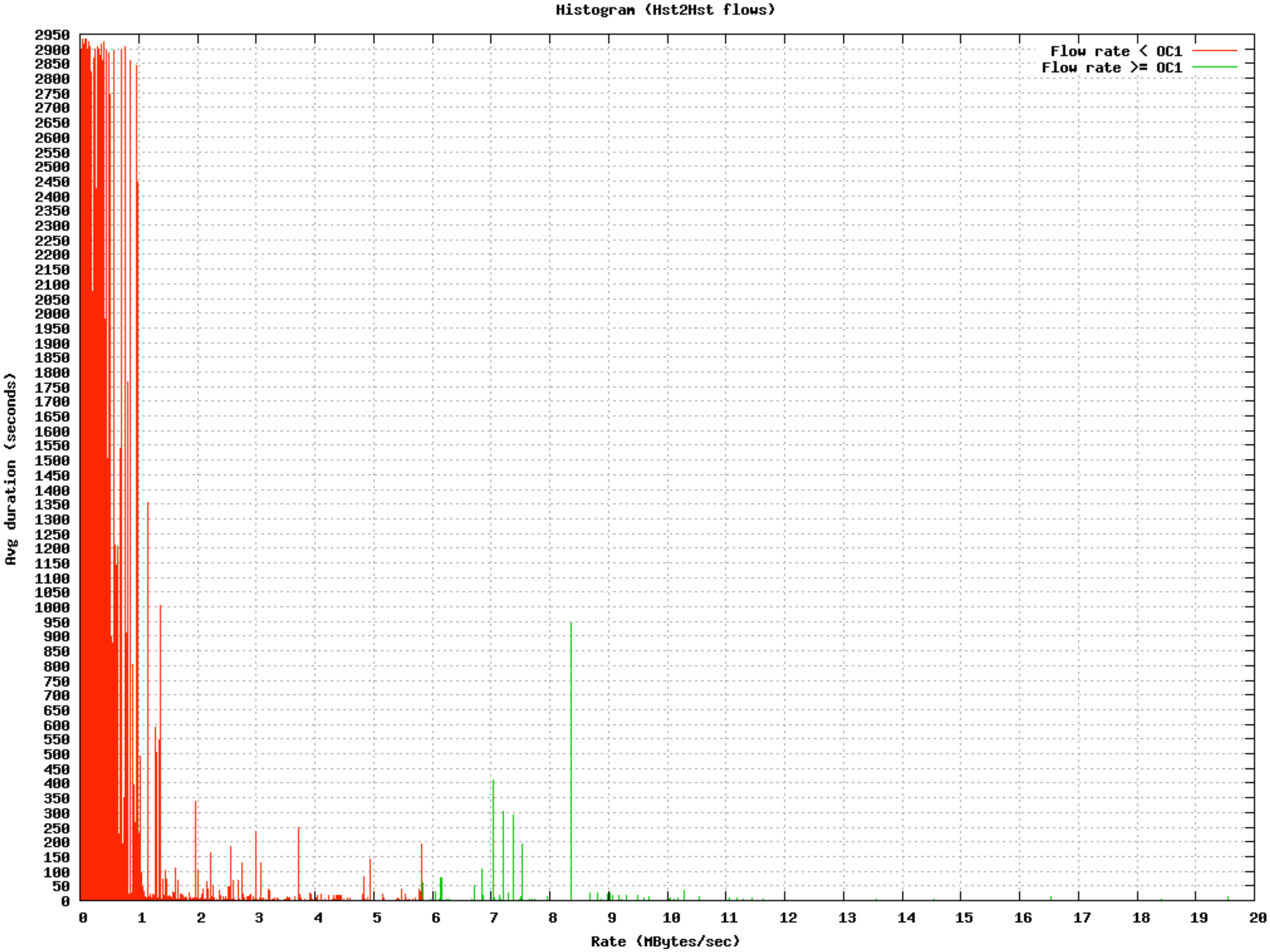
Flow rate vs frequency



Flow rate vs volume



Flow rate vs duration



Final considerations

- Error proneness and slowness are inherent in current management approaches of lambda-connections
- The self-management approach aims at reducing human interaction by automatizing:
    - the detection of IP flows
    - management (establishment/release) of lambda-connections
- Preliminary results show that IP flows present considerable variability in their behavior, which makes the search for patterns a difficult task

Final considerations

- Open issues:
  - How to deal with the splitting of data between the optical and network levels?
  - How to accurately estimate the flow variance?

Thanks for you attention!

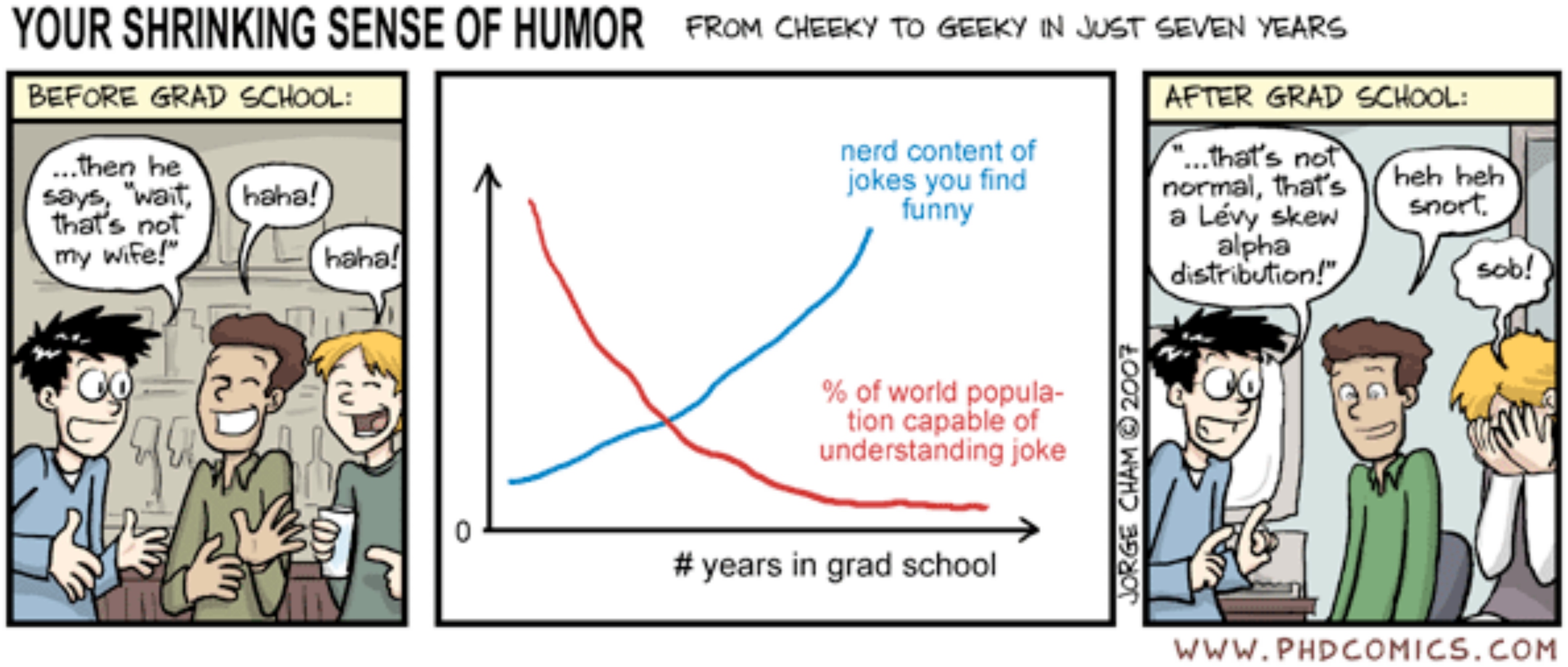
- Special thanks to SURFnet and EMANICS for their support with this research work
- Contact information:

Tiago Fioreze

t.fioreze@utwente.nl

Aiko Pras

a.pras@utwente.nl


YOUR SHRINKING SENSE OF HUMOR
FROM CHEEKY TO GEEKY IN JUST SEVEN YEARS
BEFORE GRAD SCHOOL:
...then he says, "wait, that's not my wife!"
haha!
haha!
nerd content of jokes you find funny
% of world population capable of understanding joke
0
# years in grad school
JORGE CHAM © 2007
AFTER GRAD SCHOOL:
"...that's not normal, that's a Lévy skew alpha distribution!"
heh heh snort.
sob!
WWW.PHDCOMICS.COM