ACCORDANCE

“A Converged Copper-Optical-Radio OFDMA-based Access Network with high Capacity and flexibility”

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Resource Allocation Issues in the ACCORDANCE OFDMA-PON Network

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Outline

1. Introduction

2. Dynamic Bandwidth Allocation (DBA)

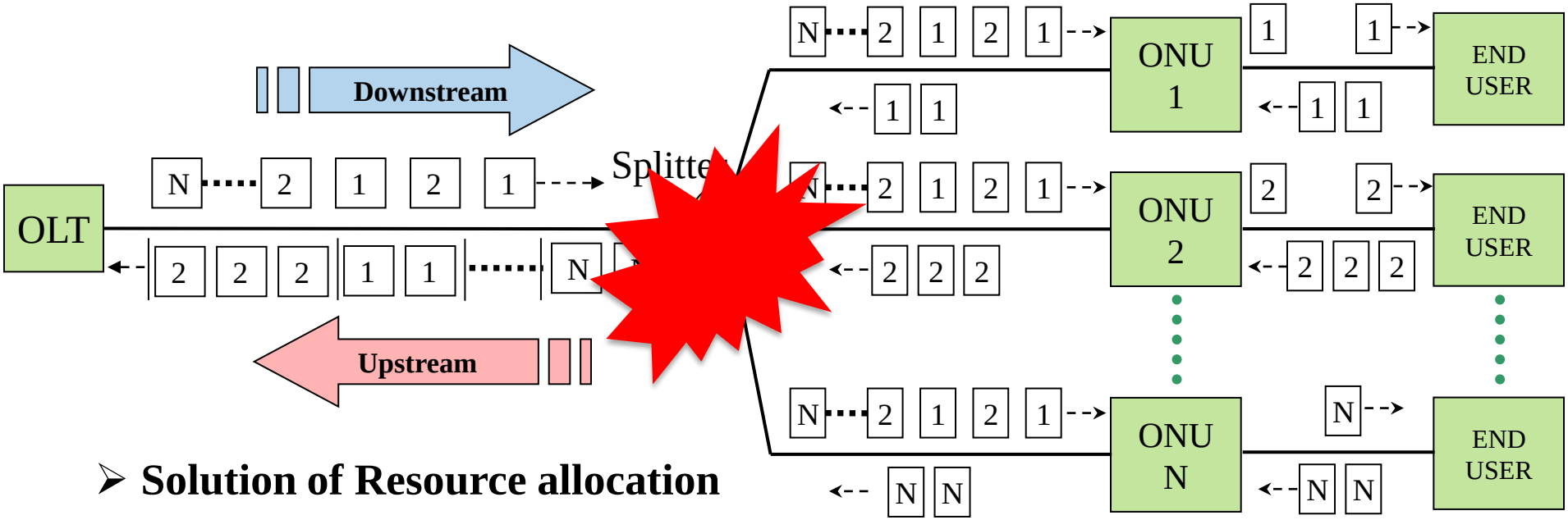
   - Development of Dynamic Subcarrier Allocation (DSA)

   - Development of Dynamic Time and Subcarrier Allocation (DTSA)

3. Future Development and Implementation Issues

Introduction I

- **Resource allocation of MAC protocol in Upstream**



- **Solution of Resource allocation**
  - TDMA
  - WDMA
  - OFDMA
  - Hybrid TDMA/OFDMA
  - Hybrid TDMA/WDMA

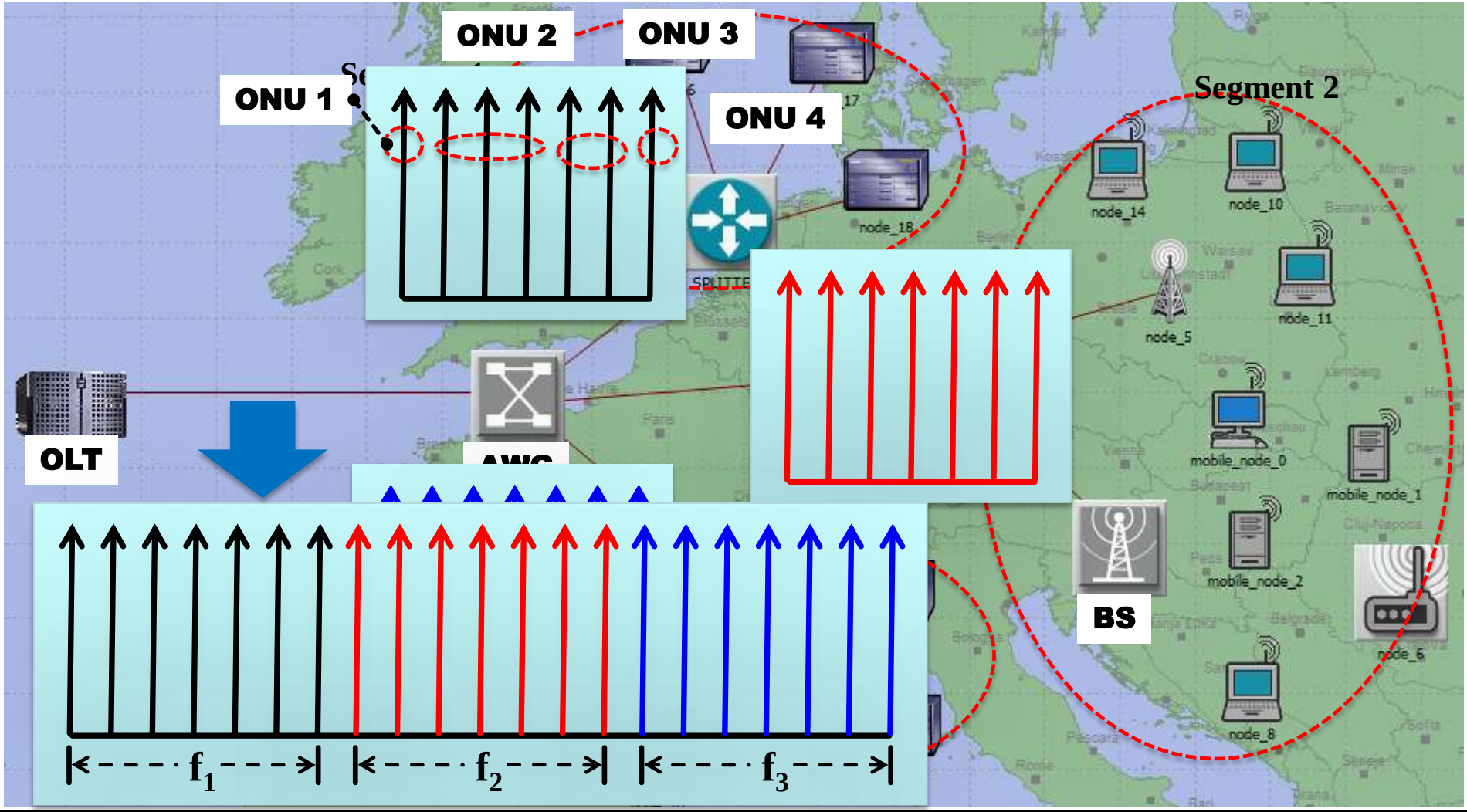
Introduction II

➢ Main Objectives of the ACCORDANCE MAC

- The enhancement of existing protocols/frames to support **FDM** and **OFDMA** operation.
- The study of the advantages and drawbacks regarding **hybrid OFDMA/TDMA** dynamic bandwidth assignment.
- Modelling and simulations of algorithms that exploit **OFDMA/TDMA** operation and comply with **specific service level agreements**.
- Identify protocol extensions to include **wireless functionality**.
- Study how bit-rate adaptation via **dynamic QAM level adjustment** can be exploited to complement the bandwidth assignment at the MAC layer.

Introduction III

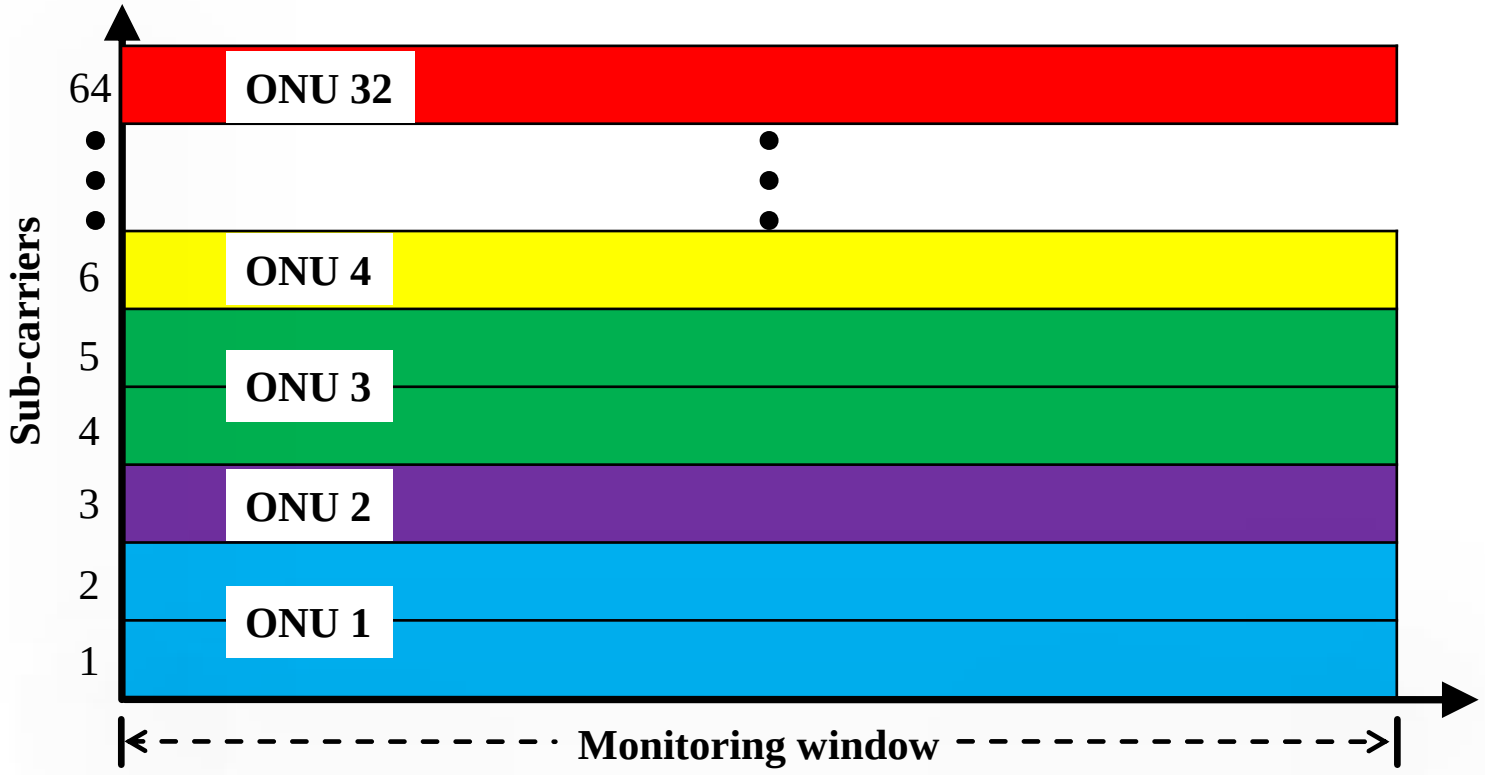
- **Resource allocation of ACCORDANCE MAC protocols**



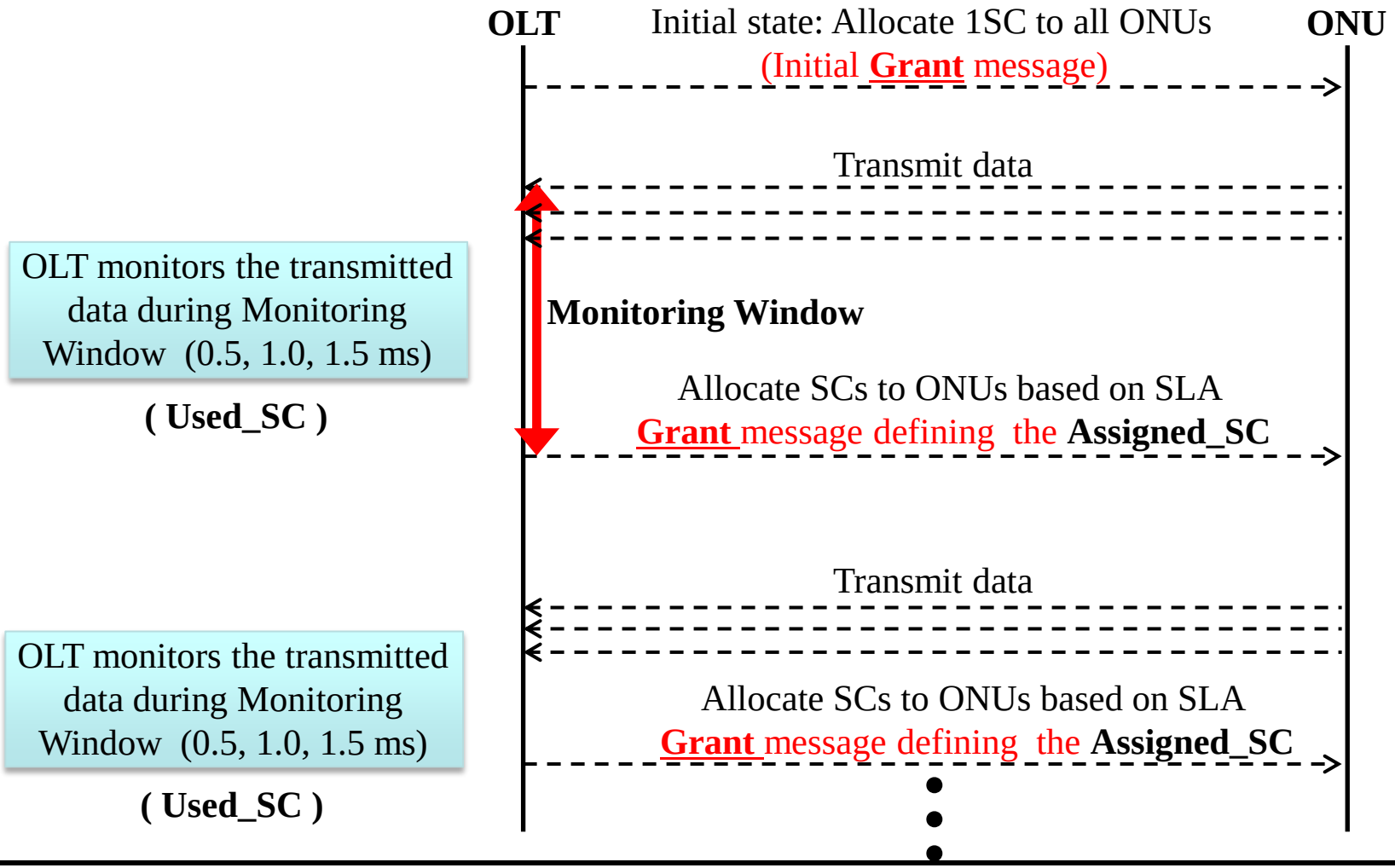
- **Dynamic subcarrier allocation (DSA)**

  - Based on OFDMA processing

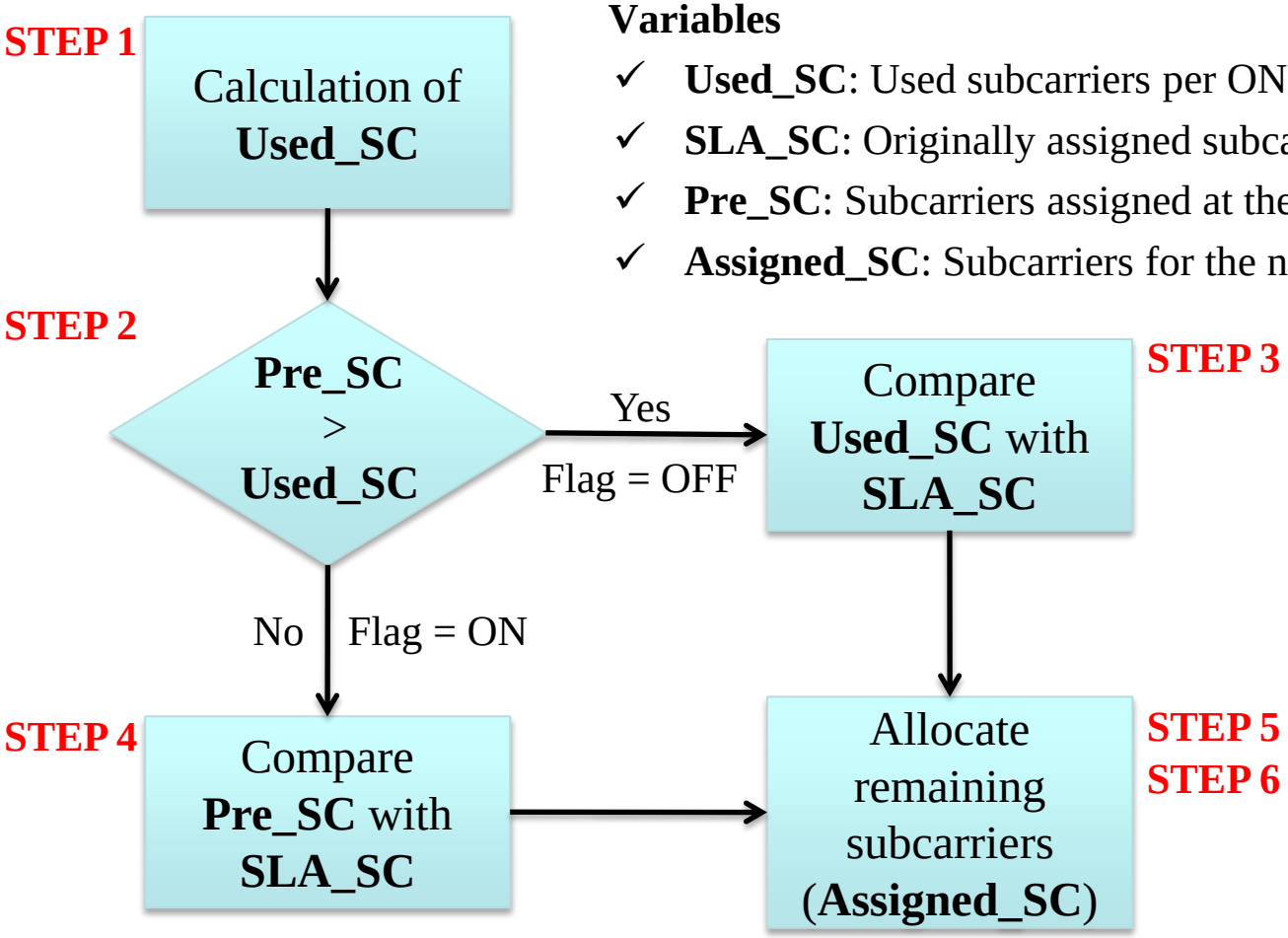
  - Subcarrier allocation according to different SLA levels



➢ Bandwidth allocation with Monitoring Window mechanism



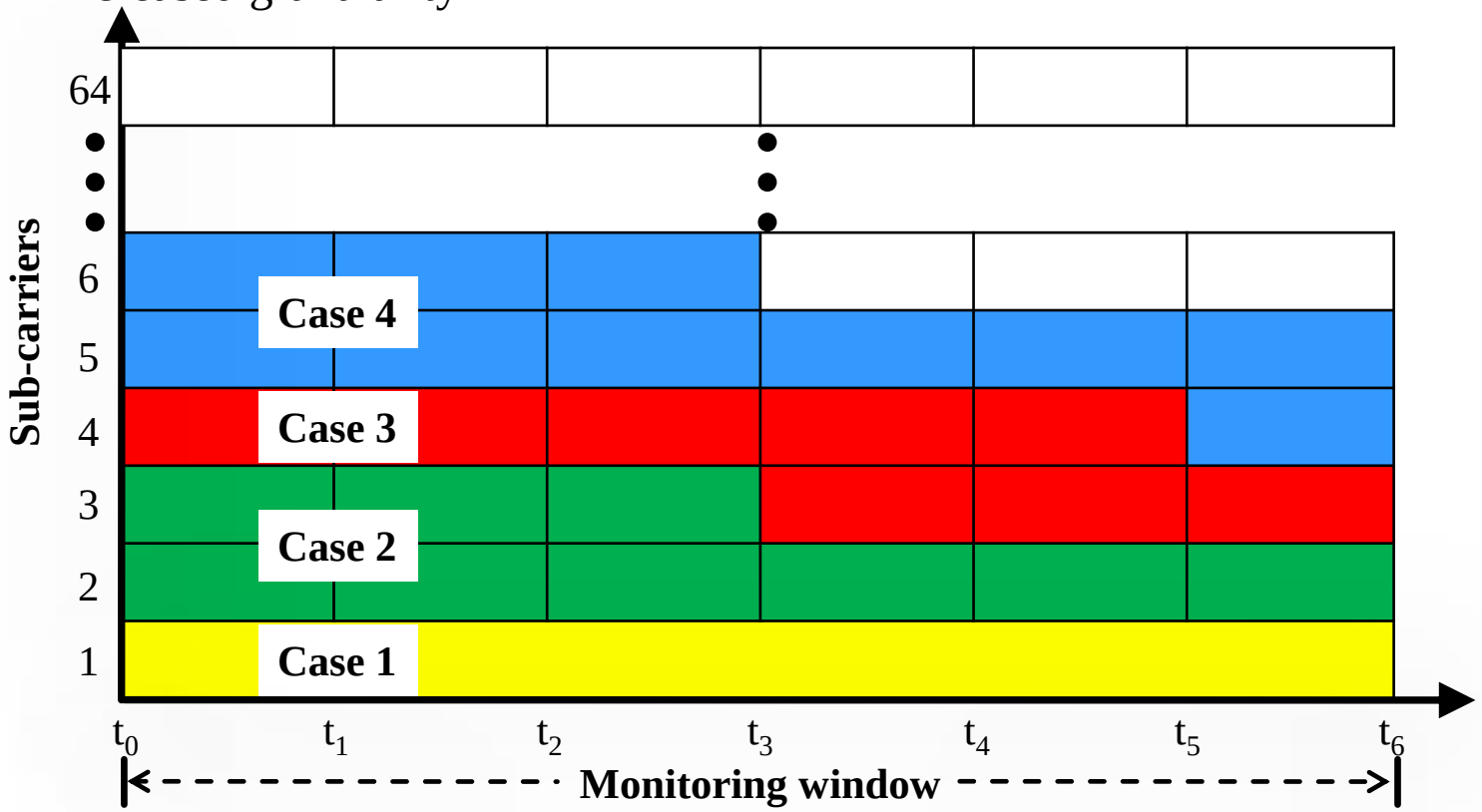
➢ Flowchart of DSA at the end of each Monitoring Window



Variables

- ✓ **Used_SC**: Used subcarriers per ONU during Monitoring window
- ✓ **SLA_SC**: Originally assigned subcarriers
- ✓ **Pre_SC**: Subcarriers assigned at the previous window
- ✓ **Assigned_SC**: Subcarriers for the next window

- **Dynamic time and subcarrier allocation (DTSA)**
  - Based on hybrid TDMA/OFDMA processing
  - 2-dimentional (time/subcarrier) bandwidth allocation
  - Increased granularity



➢ 4 Allocation Types scenarios in use with DTSA

1. Pure Subcarrier allocation (**Case 1**)

   ➔ Use of whole subcarrier/s by an ONU.

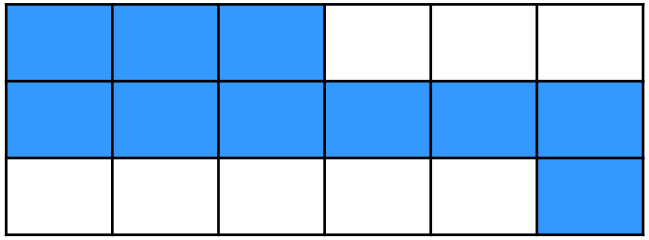
2. Required Subcarriers (to fulfil granular bandwidth requirement) = Scheduled Subcarriers

   ➔ Allocation starting at the first time slot (**Case 2**)

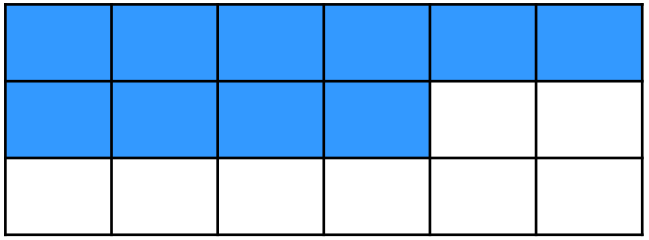
   ➔ Allocation starting at middle (or any other) time slot (**Case 3**)

3. Required Subcarriers < Scheduled Subcarriers (**Case 4**)

   ➔ For example



Scheduled Subcarriers are **three**.

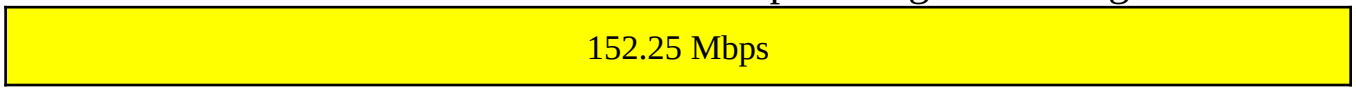


Subcarriers required are **two**.

- **4 Cases apply** (based on 10Gbps, 64 SCs, 32 ONUs, divided by 6)

Case 1

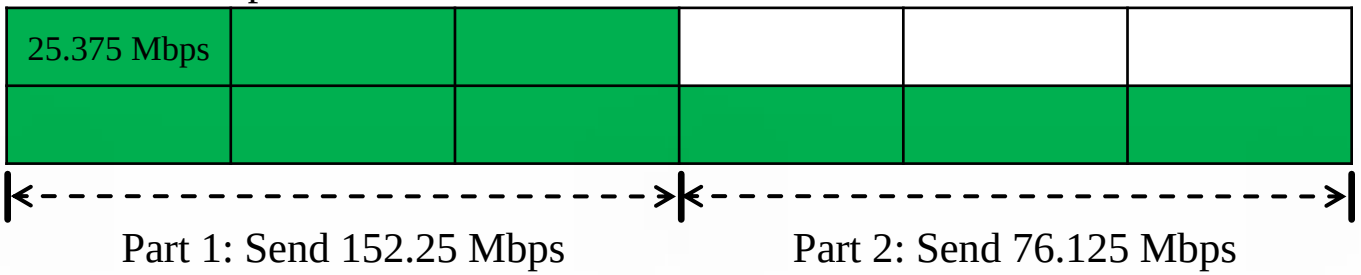
No time slots. ONUs send data at 152.25 Mbps during monitoring window time.



Case 2

Each time slot supports 25.375 Mbps (10Gbps/64/6 = 25.375 Mbps).

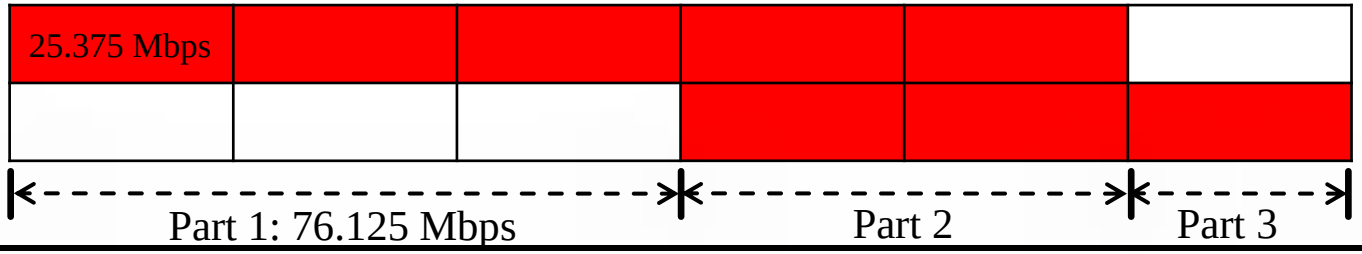
Divide in two parts.



Case 3 and 4

Each time slot supports 25.375 Mbps (10Gbps/64/6 = 25.375 Mbps).

Divide in three parts.



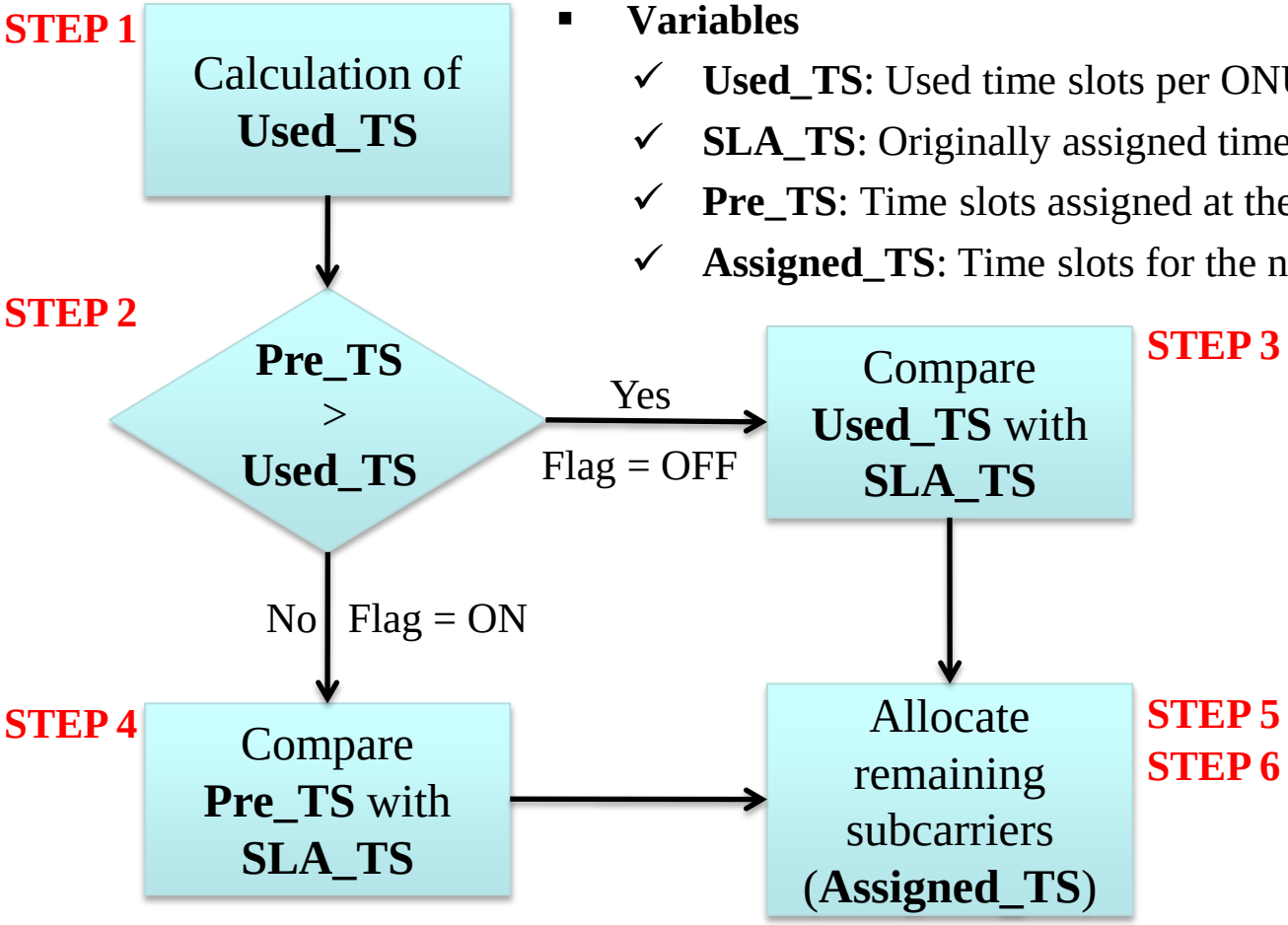
- **Important parameters for the Grant message**

Parameters	Description
Pure	Separate Case 1 from other Cases
Start time	Start time slot index of the first subcarrier
Stop time	Stop time slot index of the last subcarrier
Total time slots	Total number of time slots for ONU
Scheduled subcarriers	Allocated subcarriers for ONU

- **Grant Message**

Src_address	Dest_address	CoS	DBA_Type
Start_time	Stop_time	Start_SC	End_SC

➢ Flowchart of DTSA at the end of each Monitoring Window



- **Variables**
  - ✓ **Used_TS**: Used time slots per ONU during Monitoring Window
  - ✓ **SLA_TS**: Originally assigned time slots
  - ✓ **Pre_TS**: Time slots assigned at the previous window
  - ✓ **Assigned_TS**: Time slots for the next window

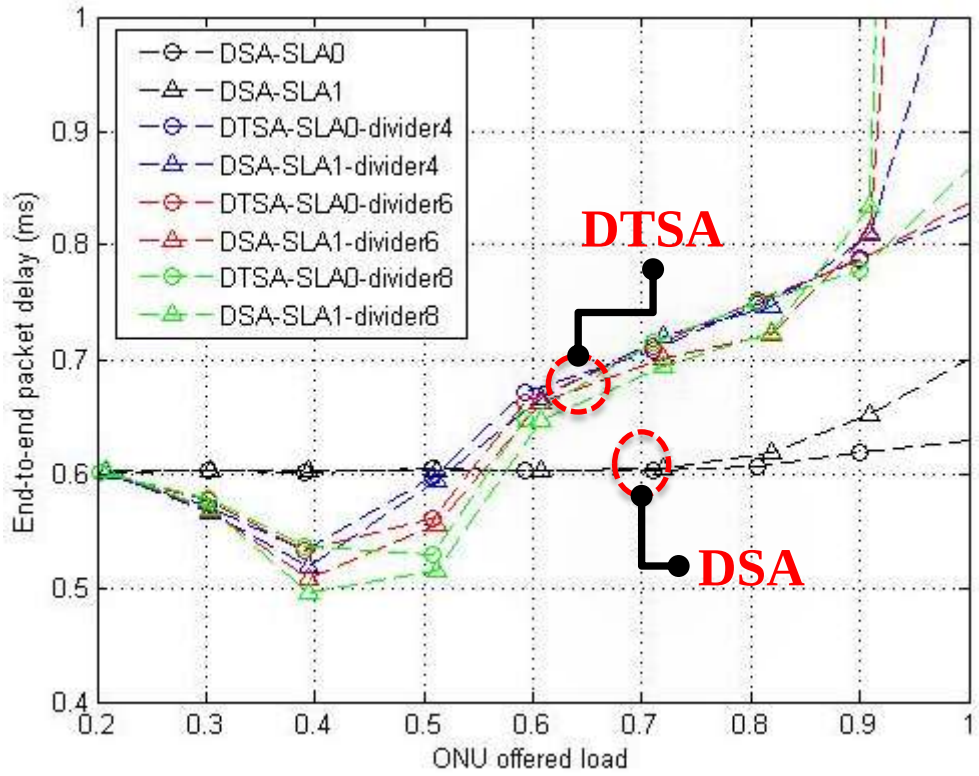
OPNET Simulation

- **Simulation environments**

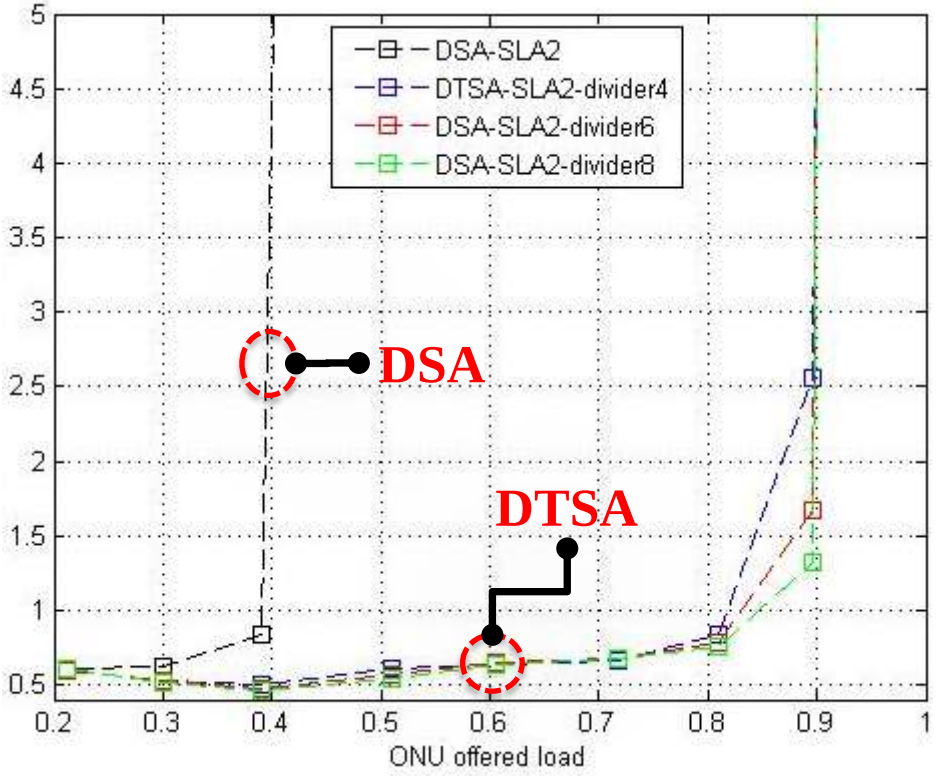
Parameters	Description	
Total network capacity	10 Gbps	2.5 Gbps
Data rate per subcarrier	156.25 Mbps (10Gbps/64)	39.0625 Mbps
Total subcarriers	64	64
Total ONUs	32	32
	SLA0 : SLA1 : SLA 2 = 2 : 10 : 20	
ONU offered load 1.0	312.5 Mbps (10Gpbs/32)	78.125 Mbps
Network offered load 1.0	10 Gbps	2.5 Gbps
Divider	4, 6, and 8	
Window time	0.5, 1.0 and 1.5 ms	
Grant processing delay	5 us	
Propagation delay	5 us/Km	
Guard time between ONUs	5 us	

Simulation results I

- **End-to-end delay**
  - Total capacity: 10 Gbps, window time: 1.0 ms, SLA 0, SLA 1 and SLA 2



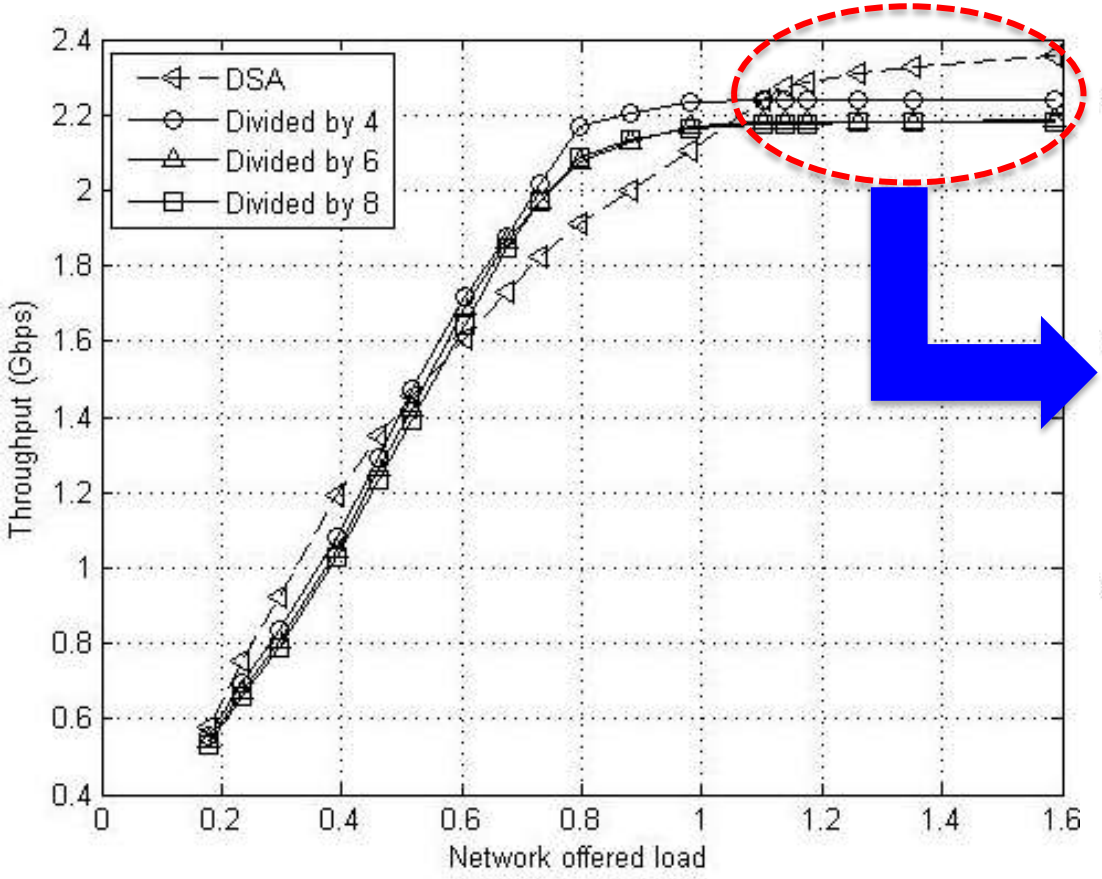
SLA 0 and SLA 1

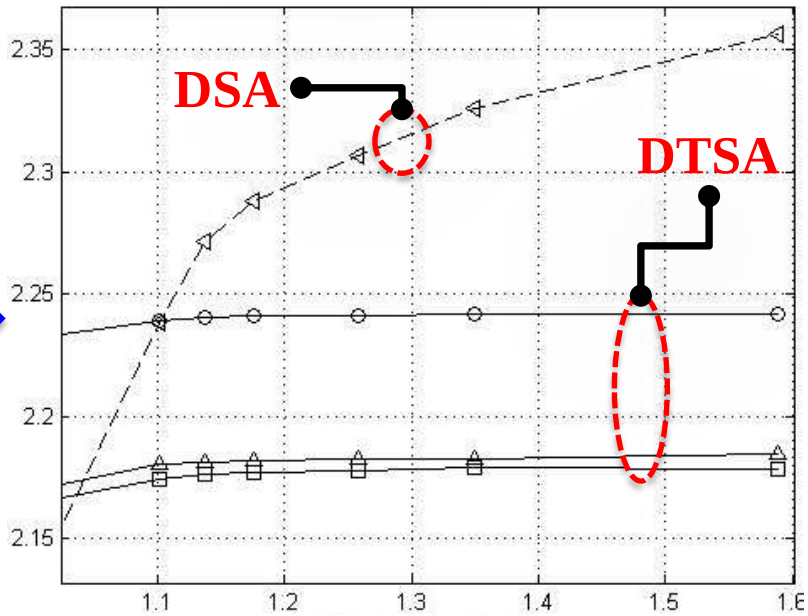


SLA 2

Simulation results II

- **Network throughput between DSA and DTSA**
  - Total capacity: 2.5 Gbps, window time: 1.0 ms





Summary

➢ End-to-end delay

- **DSA** supports low end-to-end packet delay for SLA0 and SLA1 (< **0.7 ms**).
- End-to-end packet delay of SLA 2 is very high with DSA (traffic load: 0.5, delay: 42 ms).
- Although the end-to-end delay of SLA 0 and SLA1 in DTSA is greater than in DSA, **DTSA** in overall still achieves delays for all SLAs (divide by 4 at 0.9 traffic load) of **2.5 ms**.

Delay (ms)	SLA0	SLA1	SLA2
DSA	<0.7	<0.7	>100
DTSA	<0.8	<0.9	<2.5

➢ Network throughput

- Network throughput of **DSA** (is almost 94% of total capacity) in comparison to **DTSA** (almost **90%**) for a divider of 4.
- A divider of 4 provides the optimum throughput for DTSA.

Further Development & Implementation Issues

- Further Development
  - Compare Grant/Monitoring mechanism with Grant/Reporting mechanism
  - Considering class of service (CoS)
  - Improve DTSA algorithm
- Implementation Issues
  - Timing control issue: GPON-like or EPON-like
  - ONU activation and ranging, PLOAM
  - SR or NSR approach for DBA
  - Support wireless backhauling
  - Upstream OBI using guard subcarriers @ MAC layer