Ranged Impairment Allocation

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Problem Statement

Requirements:

- It is desirable to estimate the actual performance levels achieved on an end-to-end path
- The operator must be able to say if the requested performance objectives can be met or not
- The process must eventually be automatic

Goal:

- Achieve end-to-end IP performance objectives on as many UNI-UNI paths as possible

Problem Statement

Challenges:

- End to end path may go over many types of facilities, technologies, multiple network providers
- End to end performance is based on the aggregation of individual network segments
- The number of network segments in the path will vary request-by-request
- The impairment level of any given network segment is highly variable

Required performance impairments of ITU-T Y.1541 Network QoS Classes

- Consistent with Rec. G.1010
- Provides several network QoS classes to carry traffic having broadly similar requirements
- Doesn't try to meet specific QoS requirements for each application

	QoS Classes					
Network Performance Parameter	**Class 0**	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Class 5 Un-specified**
Transfer delay	100ms	400ms	100ms	400ms	1 s	U
Delay variation	50ms	50ms	U	U	U	U
Packet loss ratio	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	U
Packet error ratio	$1*10^{-4}$					U

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Applications of Y.1541 QoS classes

QoS Class	Applications (Examples)	Node Mechanisms	Network Techniques
0	Real-Time, Jitter sensitive, high interaction(VoIP, VTC)	Separate Queue with preferential servicing, Traffic grooming	Constrained Routing and Distance
1	Real-Time, Jitter sensitive, interactive (VoIP, VTC).		Less constrained Routing and Distances
2	Transaction Data, Highly Interactive, (Signaling)	Separate Queue, Drop priority	Constrained Routing and Distance
3	Transaction Data, Interactive		Less constrained Routing and Distances
4	Low Loss Only (Short Transactions, Bulk Data, Video Streaming)	Long Queue, Drop priority	Any route/path
5	Traditional Applications of Default IP Networks	Separate Queue (lowest priority)	Any route/path

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Y.1541 provisional QoS classes

Network Performance Parameter	QoS Classes	
	Class 6	Class 7
Transfer delay	100 ms	400 ms
Delay variation	50 ms	
Packet loss ratio	1 × 10–5	
Packet error ratio	1 × 10–6	
Packet re-ordering ratio	1 × 10–6	

- These classes are intended to support the performance requirements of high bit rate user applications that were found to have more stringent loss/error requirements than those supported by Classes 0 through 4

Solving the Problem

- Need to specify and control impairments in each network segment to meet overall end to end requirements
- Known as QoS apportionment
- There are two basic approaches: Impairment allocation approach, Impairment accumulation approach
- *Ranged impairment allocation* is one of dynamic QoS apportionment approaches

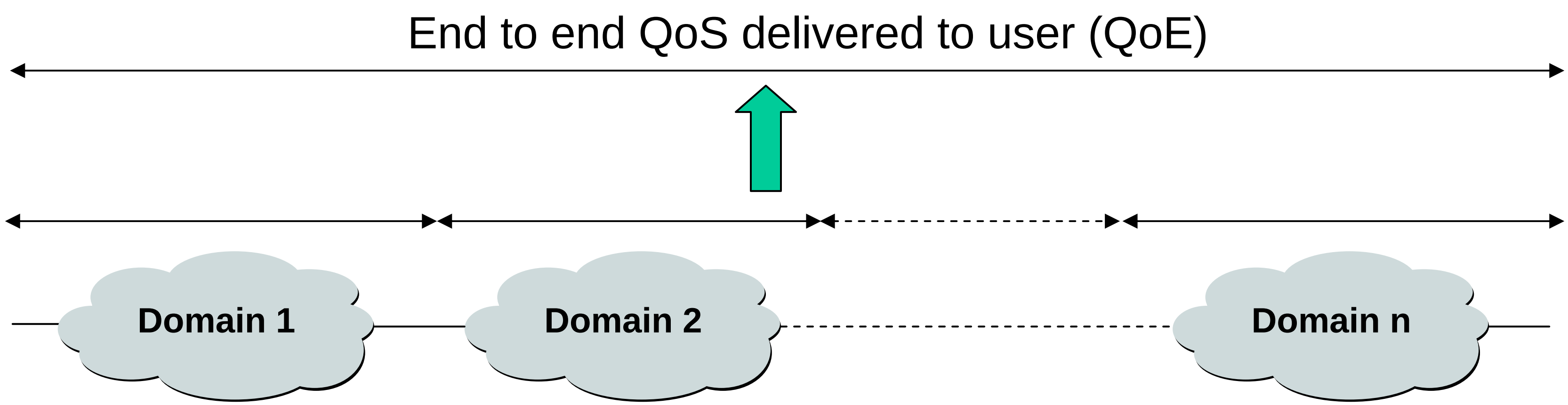
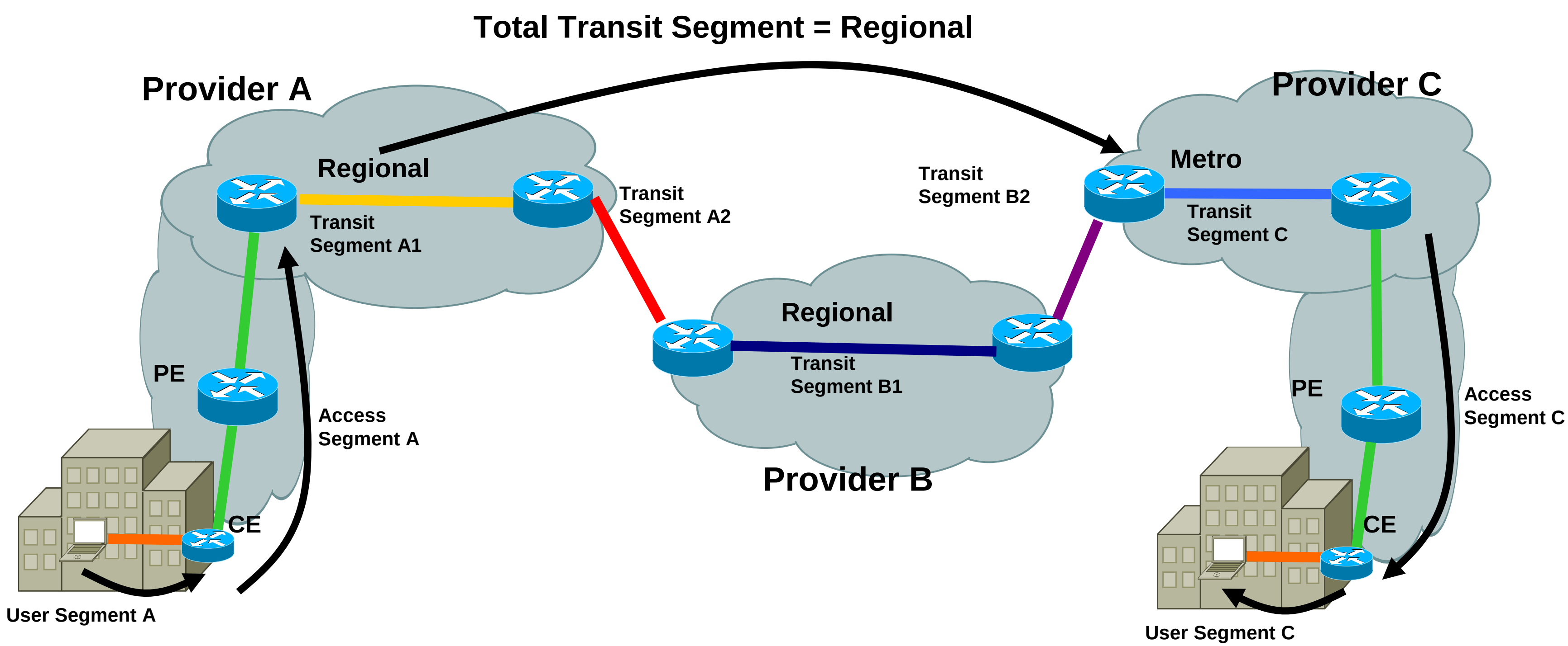


Figure 1/G.FEPO – Example topology for impairment allocation

- ✓ The UNI-UNI performance consists of the edge-to-edge performance of each network segment.
- ✓ Regardless of the approach, there is no guarantee that the desired end-to-end objectives will be met. Any approach can fail to achieve a specific set of objectives on a highly congested path through a complex network topology and/or over extremely long distances.



Main Idea of Ranged Impairment Allocation

- A “bottom-up” method is applied for ranged impairment allocation approach.
- The range between the minimum and maximum of the allocated impairment budget for each segment along the data path is negotiated and calculated out by the use of resource management and signaling among the segments.
- The aggregation of all segment impairments within their ranges doesn’t exceed the overall end-to-end performance levels specified in a requested QoS class.
- So each segment itself can choose one appropriate value within its allocated budget range under the consideration of optimizing its resource utilization.

Main Idea of Ranged Impairment Allocation

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As an example, three network providers are interconnected (Provider A, B and C) as shown in Figure 2 .

- For Segment i, the allocated range is [$\min_i$, $\max_i$].
- The aggregation of ($\min_A$ $\min_B$ $\min_C$) ⩽ The requested end-to-end Performance objective
- The aggregation of ($\max_A$ $\max_B$ $\max_C$) ⩽ The requested end-to-end Performance objective
- The actual performance achieved in provider A should be within the range [$\min_A$, $\max_A$]. i.e. $\min_A \leqslant Perf_A \leqslant \max_A$
- So the actual achieved end-to-end performance can meet the requested end-to-end Performance objective.

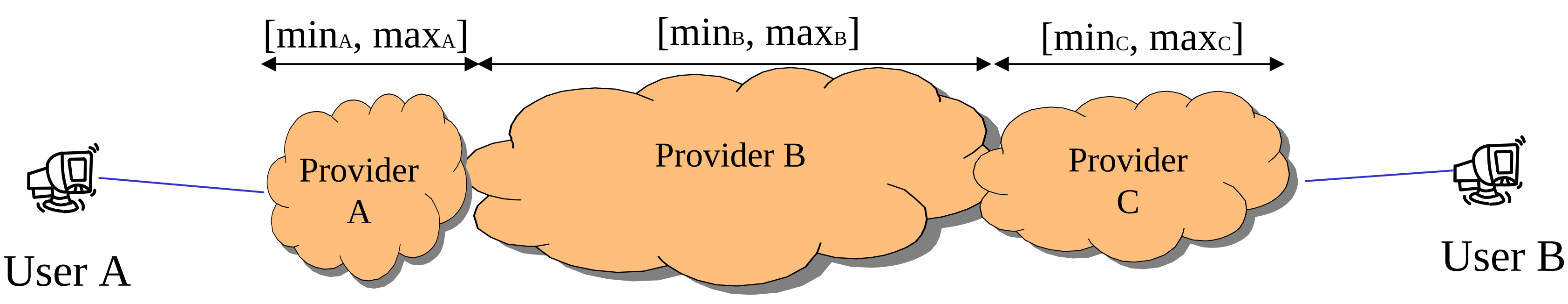

Figure 2

Key points of Ranged Impairment Allocation

- Firstly, the minimum impairment budgets for every segment along the data path are negotiated out.
- Secondly, the total minimum impairment budget of the data path is calculated.
- Thirdly, the ratio of the minimum to maximum equals the total minimum impairment divided by the desired UNI-UNI impairment budget.
- Finally, the maximum impairment budgets for every segment are calculated out by dividing the minimum budgets by this ratio.

Process Steps of Ranged Impairment Allocation

In Figure 2, the user determines the desired UNI-UNI performance objectives, and solicits provider A for the total impairment target (e.g. IPTD). Then,

(1) Provider A

i) determines and inserts its own minimum impairments to the request message;

ii) sends the request message to its downstream provider B.

(2) Provider B does the same as Provider A does

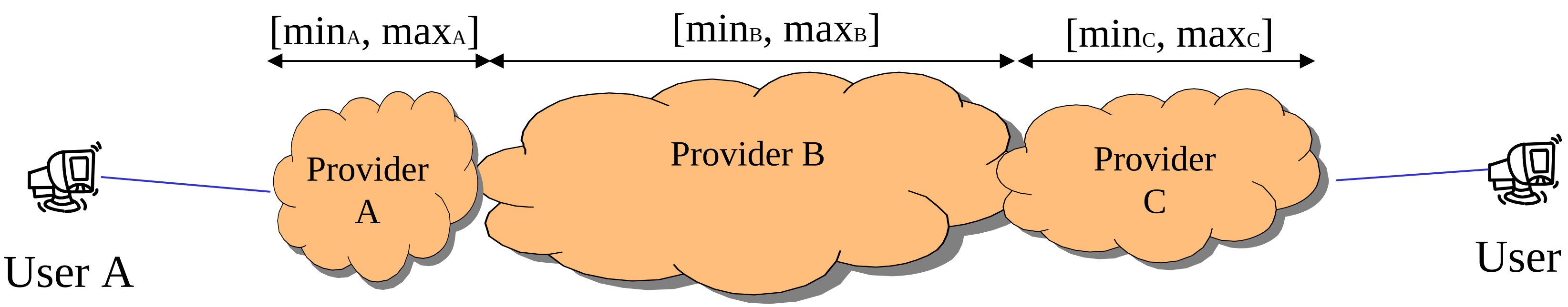

Figure2

Process Steps of Ranged Impairment Allocation (continued)

(3) Provider C

i) calculates the total minimum allocated impairments;

ii) calculates the ratio of the total minimum allocated impairments to the desired UNI-UNI performance objectives;

iii) calculates its own maximum impairment budget by this ratio;

iv) sends the ratio back to its upstream provider B.

(4) Provider B

i) calculates its own maximum impairment budget by the ratio;

ii) sends the ratio to its upstream provider A.

(5) Provider A

i) calculates its own maximum impairment budget by this ratio.

Finally, all providers know their impairment range for achieving the user requested UNI-UNI performance objectives. Each provider can choose an appropriate value within its range under the consideration of optimizing its resource utilization.

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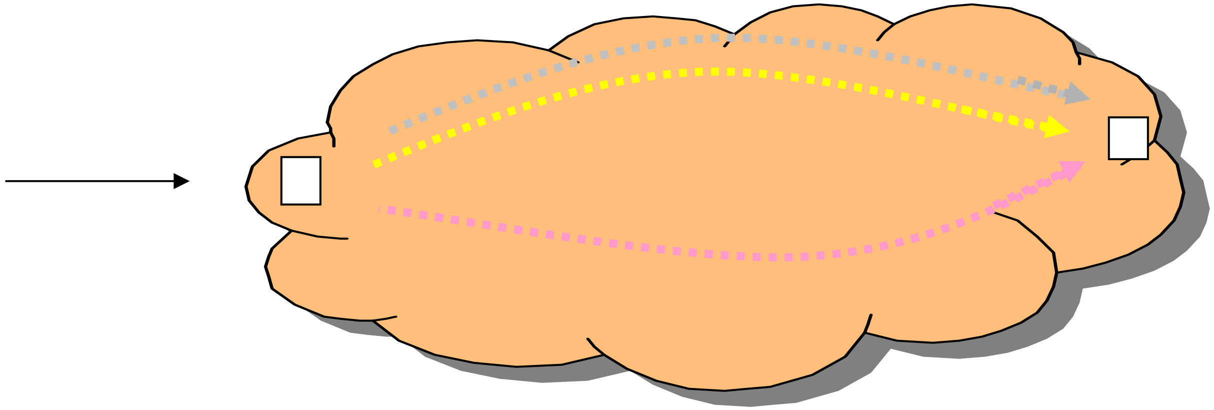
Ranged allocation for Y.1541 IPTD

- IPTD – IP Transfer Delay
- IPTD is the sum of propagation delays, queuing delays and transmission delays.
- Different forwarding paths and queue schedulers have different IPTD performance.



Ranged allocation for Y.1541 IPTD (continued)

- For Y.1541 IPTD

  The range of IPTD for each network segment is easy to calculate for the ranged allocation approach.

  $IPTD\_min_{UNI\text{-}UNI} = IPTD\_min_1 + IPTD\_min_2 + \ldots\ldots + IPTD\_min_n$

  $Ratio_{min/max} = IPTD\_min_{UNI\text{-}UNI} \ / \ IPTD\_desired_{UNI\text{-}UNI}$

Then,

  $IPTD\_max_i = IPTD\_min_i \ / \ Ratio_{min/max}$

  The IPTD Range for Segment i = [$IPTD\_min_i$, $IPTD\_max_i$]

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Ranged allocation for Y.1541 IPTD (continued)

For example, the desired UNI-UNI IPTD is < 100ms.

- The minimum IPTDs contributed by provider A, B and C are 5ms, 30ms and 5ms, respectively.

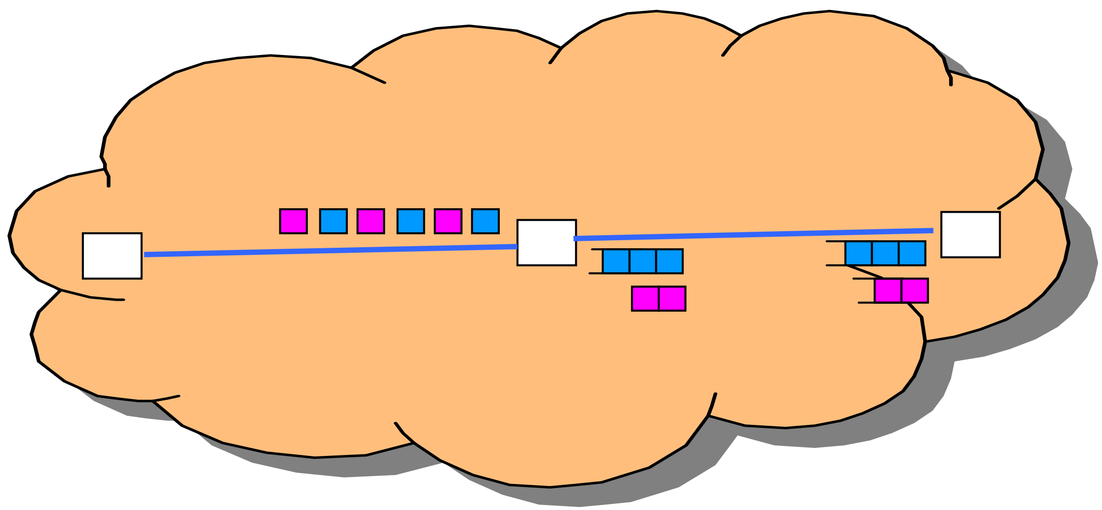
- $Ratio_{min/max}$ = $IPTD\_min_{UNI\text{-}UNI}$ / $IPTD\_desired_{UNI\text{-}UNI}$ = (5+30+5)/100 = 0.4

- $IPTD_max_A = IPTD_min_A / Ratio_{min/max} = 5/0.4 = 12.5$ms
  $IPTD_max_B = IPTD_min_B / Ratio_{min/max} = 30/0.4 = 75$ms
  $IPTD_max_C = IPTD_min_C / Ratio_{min/max} = 5/0.4 = 12.5$ms

- Then, the IPTD range for provider A, B and C are [5ms, 12.5ms], [30ms, 75ms] and [5ms, 12.5ms], respectively.

Ranged allocation for Y.1541 IPLR

- IPLR – IP Loss Ratio
- IPLR is related to the queue capacities, the link capacities and the drop priorities.
- Different Queues and drop priorities have different IPLR performance.



Ranged allocation for Y.1541 IPLR (continued)

- For Y.1541 IPLR

The approximate range of IPLR for each network segment can be estimated. It is easy to prove that the upper bound on the actual IPLR is always less than the desired UNI-UNI IPLR.

Assuming the extreme, where every section contributes the maximum IPLR, the UNI-UNI max IPLR is:

$$IPLR\_max_{UNI\text{-}UNI} = 1 - (1- IPLR\_max_1) \times (1- IPLR\_max_2) \times \ldots \times (1- IPLR\_max_n)$$

as:

$$\begin{aligned} IPLR\_max_{UNI\text{-}UNI} &= 1 - (1- IPLR\_max_1) \times (1- IPLR\_max_2) \times \ldots \times (1- IPLR\_max_n) \\ &= IPLR\_max_1 \times (1 - IPLR\_max_2) \times \ldots \times (1 - IPLR\_max_n) \\ &\quad + \{1 - (1 - IPLR\_max_2) \times (1 - IPLR\_max_3) \times \ldots \times (1 - IPLR\_max_n)\} \\ &<= IPLR\_max_1 + \{1 - (1 - IPLR\_max_2) \times (1 - IPLR\_max_3) \times \ldots \times (1 - IPLR\_max_n)\} \\ &<= IPLR\_max_1 + IPLR\_max_2 + IPLR\_max_3 + \ldots + IPLR\_max_n \end{aligned}$$

So:

$$IPLR\_max_{UNI\text{-}UNI} <= IPLR\_desired_{UNI\text{-}UNI}$$

Ranged allocation for Y.1541 IPLR (continued)

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For example, the desired UNI-UNI IPLR is $< 10 \times 10^{-4}$.

- The minimum IPLRs contributed by provider A, B and C are 1×10^{-4}, 3×10^{-4} and 2×10^{-4}, respectively.

- $Ratio_{min\text{-}max} = IPLR\_min_{UNI\text{-}UNI} \ / \ IPLR\_desired_{UNI\text{-}UNI} = (1+3+2)/10 = 0.6$

- $IPLR\_max_A = IPLR\_min_A \ / \ Ratio_{min/max} = 1/0.6 = 1.7 \times 10^{-4}$
  $IPLR\_max_B = IPLR\_min_B \ / \ Ratio_{min/max} = 3/0.6 = 5 \times 10^{-4}$
  $IPLR\_max_C = IPLR\_min_C \ / \ Ratio_{min/max} = 2/0.6 = 3.3 \times 10^{-4}$

- The actual max IPLR is 9.997×10^{-4}, which approximately equals to the desired UNI-UNI IPDL(10×10^{-4}).

Ranged allocation for Y.1541 IPDV

- IPDV – IP Delay Variation
- The IPDV is related to the queuing delay.
- A short queuing delay requires a short queue, and the resource used by the flows with small IPDV is limited.
- The resources about the IPDV should be optimized according the actual desired IPDV.
- For IPDV, the approximate range can be estimated, and a more exact algorithm for the ranged allocation is for further study.

Key Features Review

- ✓ A "bottom-up" method is applied for ranged impairment allocation approach.
- ✓ The range between the minimum and maximum of the allocated impairment budget for each segment along the data path is negotiated and calculated out by the use of resource management and signaling among the segments.
- ✓ The aggregation of all segment impairments within their ranges doesn't exceed the overall end-to-end performance levels specified in a requested QoS class.
- ✓ So each segment itself can choose one appropriate value within its allocated budget range under the consideration of optimizing its resource utilization.

Thanks for your attention.