>BUSINESS MADE **SIMPLE**

On Enhanced Transmission Selection

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From the PAR

> *This standard specifies enhancement of transmission selection to support allocation of bandwidth amongst traffic classes.* ***When the offered load in a traffic class doesn't use its <u>allocated</u> bandwidth, enhanced transmission selection will allow other traffic classes to use the available bandwidth****. The bandwidth allocation priorities will coexist with strict priorities. It will include managed objects to support bandwidth allocation.*

> The problem is not new and was discussed for per stream allocation for IP Integrated Service (IntServ) and ATM service categories.

> The extension to traffic classes is trivial and is considered for the IP Differentiated Service (DiffServ) for the expedited forwarding (EF) per hop behavior (PHB).

The Ideal Scheduler: Generalized Processor Sharing (GPS)

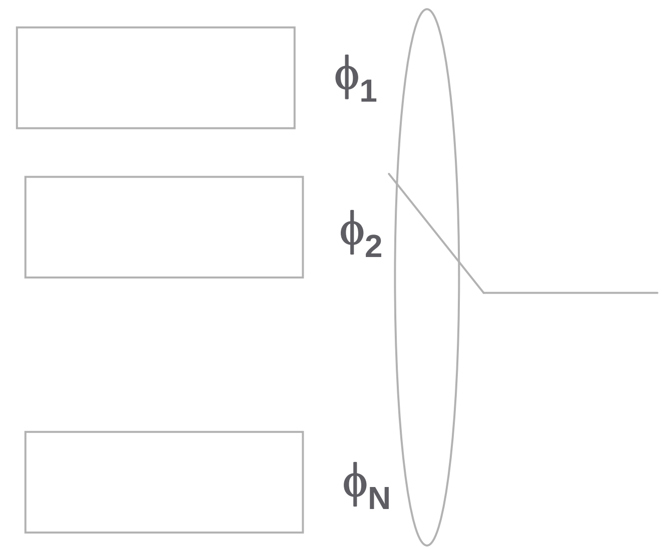
> Described by Parekh and Gallager in their seminal paper, "*A Generalized Processor Sharing Approach to Flow Control in Integrated Services Networks*", IEEE/ACM Transactions of Networking, April 1993.

> It is characterized by a set of positive numbers $\phi_1, \phi_2, \ldots \phi_N$

> Operate on all backlogged queues at the same time, i.e. it doesn't operate on a frame as an entity → fluid flow approximation

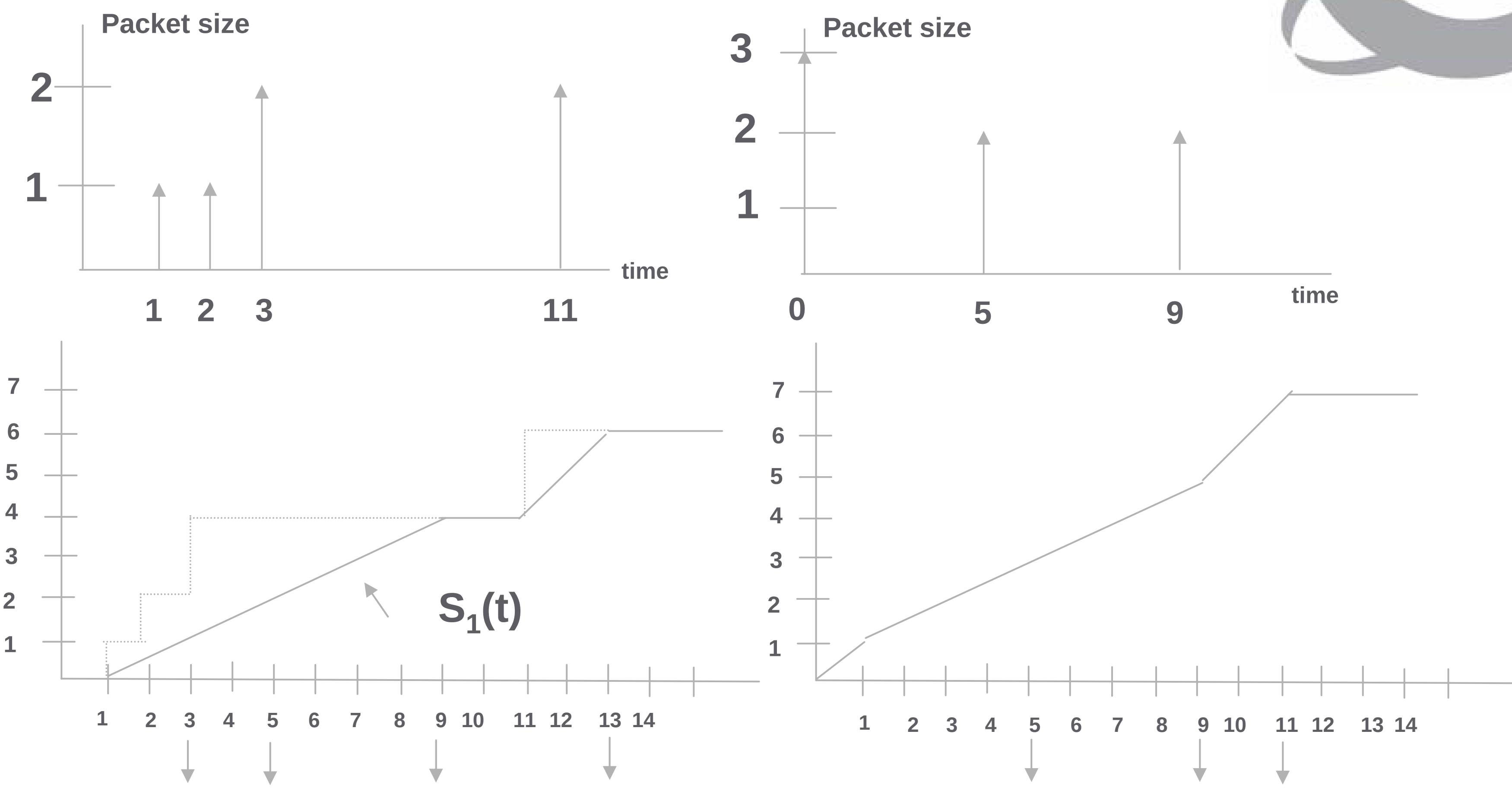
> $S_i(\tau, t)$ is the amount of class i traffic served in the interval (τ, t), then for any class i that is continuously backlogged in the interval (τ, t),

$$\frac{S_i(\tau,t)}{S_j(\tau,t)} \geq \frac{\phi_i}{\phi_j}, \quad j = 1,2,\ldots,N$$



GPS Operation ($\phi_1 = \phi_2$)

Service rate = 1



> GPS is an idealized discipline since it does not transmit packets (frames) as entities.
  - With GPS each frame has a given departure time that depends on the rate allocation and the frame length.

> A packetized GPS (PGPS) scheduler was developed in the same paper that ranks packets based on their departure time.
  - Compared to GPS, PGPS introduces an additional delay in the order of the time needed to transmit the maximum packet size.

A Way to Characterize a Scheduler

> Schedulers are characterized by the scheduler discipline (the selection process) and the rate allocation per class
  - One important issue is how to define “rate” and over what time scale.
  - The same issue with related to an early definition of the EF PHB.

> Alternatively a scheduler can be characterized by its performance relative to the idealized scheduler, GPS. For a guaranteed rate (GR) scheduler[1],

$$d_n \le f_n + \varepsilon, \quad \text{where}$$

$$f_0 = 0$$

$$f_n = \max[a_n, f_{n-1}] + \frac{l_n}{r} \quad \text{for } n \ge 1$$

d_n is the departure time of the nth packet

a_n is the arrival time of the nth packet

ε is an error term depends on scheduling algorithm

r is the allocated rate per class

l_n is the length of the nth packet

[1] P. Goyal, S. Lam, and H. Vin, “Determining End-to-End Delay Bounds in Heterogeneous Networks”, Proc. Of the 5th International Workshop on Operating Systems Support for Digital Audio and Video.

Examples

- Absolute Priority Scheduler: AP scheduler is in general not a GR scheduler. It is a GR scheduler for the highest priority class with r = C (the link speed) and $\varepsilon = L_{max}/C$.
- For round-robin scheduler with N classes each is allocated a rate r, $\varepsilon = (N*L_{max})/C$

A Possible Way Forward

- The DCB TG intention is not to mandate a particular scheduler.
- Instead the TG can characterize a GPS idealized scheduler including the rate allocation parameters $\{\phi_i\}$ and an error term, ε.
- A particular scheduler can then be evaluated relative to the GPS set up and its error term, ε can be specified.