RRM

Mobile Radio Networks

Scheduling

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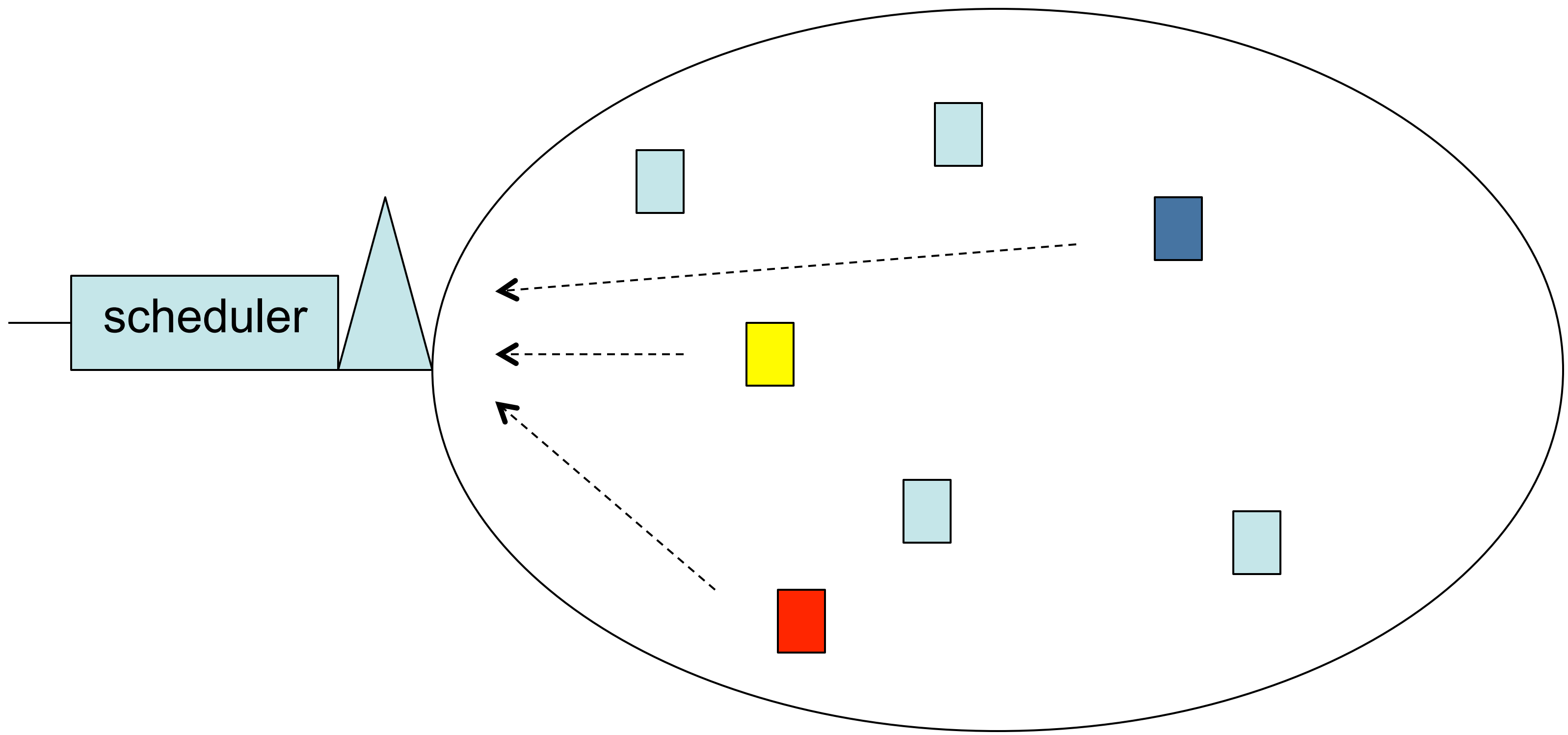
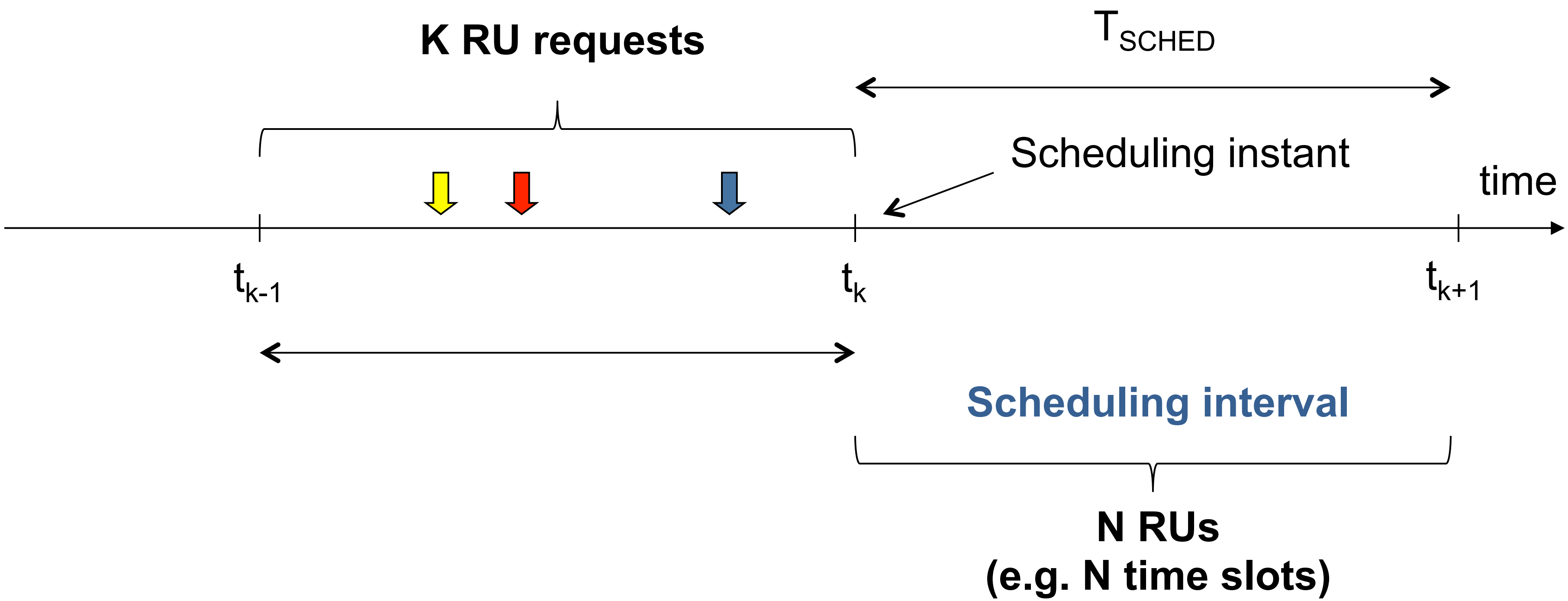
1. Scheduling

Scheduling



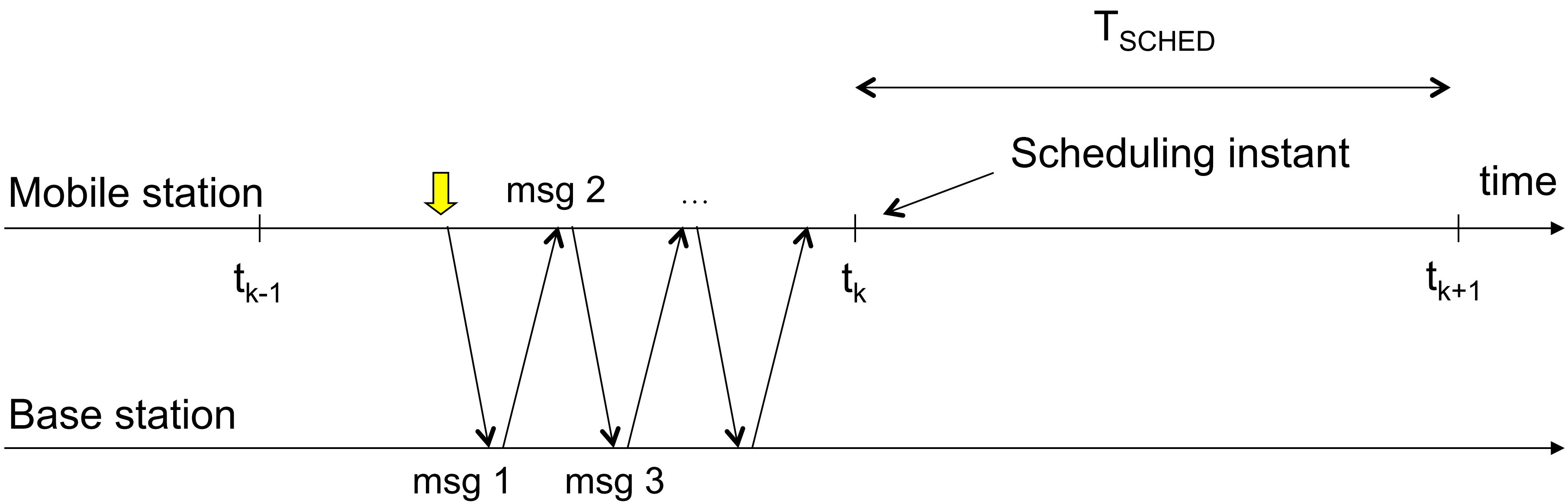
Scheduling



$K < N$ → All requests accomplished

$K > N$ → Some requests are queued and considered at t_{k+1}

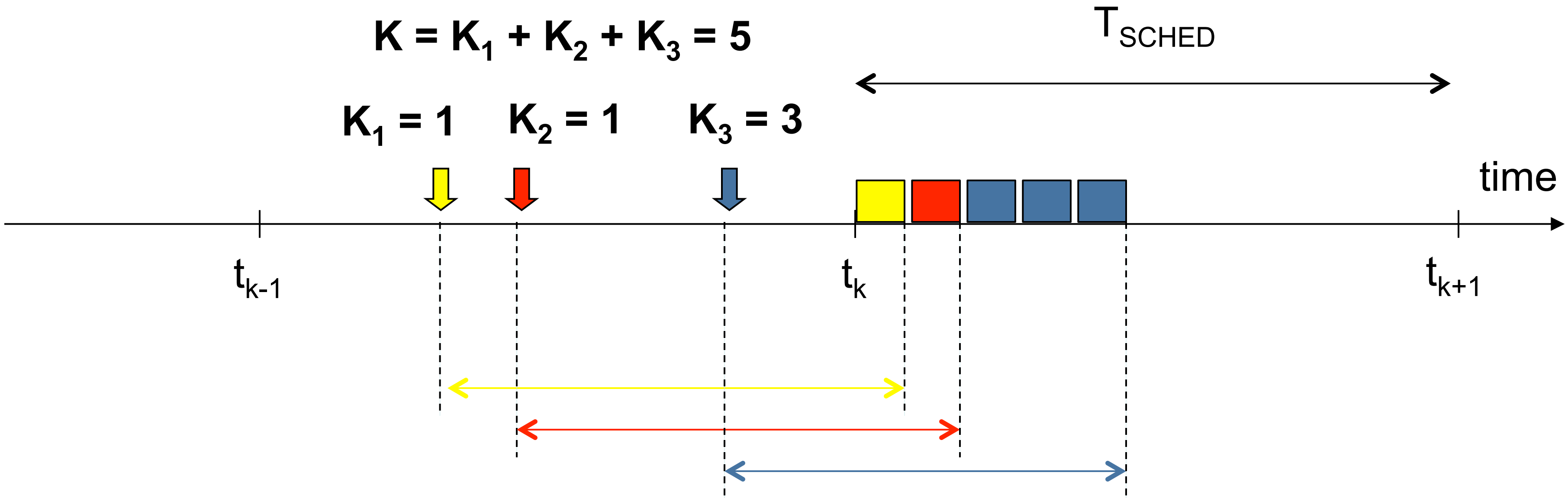
Scheduling



K < N → All requests accomplished

K > N → Some requests are queued and considered at t_{k+1}

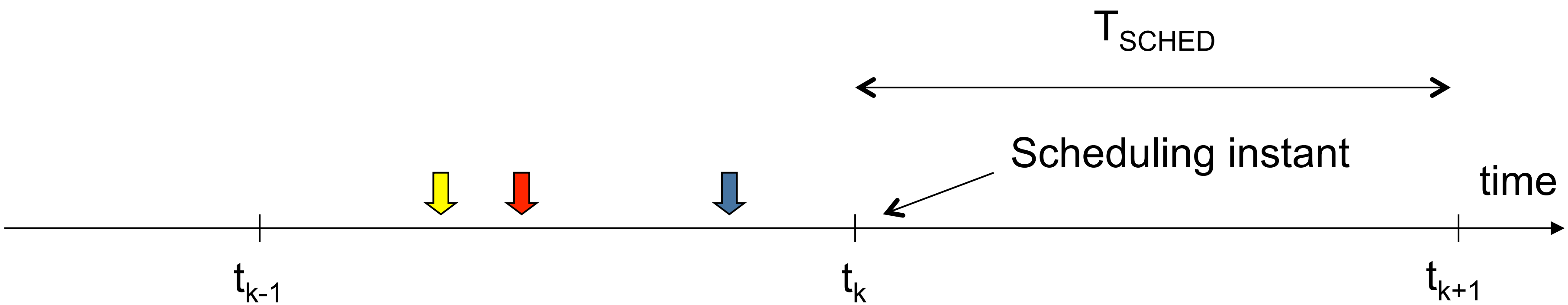
Scheduling: Example



The scheduling Interval:

To reduce latency	**→ small**
To increase assignment efficiency	**→ larger**
To reduce overhead	**→ large**
To use information on channel conditions	**→ small**

Scheduling

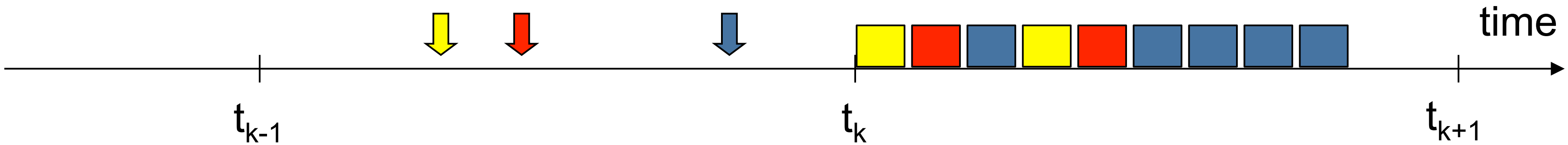


Scheduling Algorithm Classes:

Application Unaware Scheduling	**Ex: RR**
Application Aware Scheduling	**Ex: EDF**
Channel&Application Aware Scheduling	**Ex: MT, PF**
Cross-Layer Scheduling	

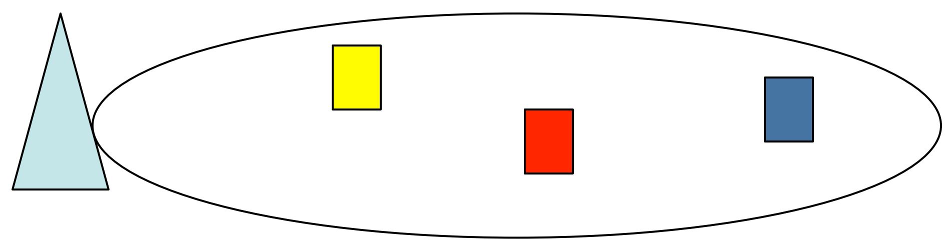
Scheduling: Round Robin

$K_1 = 2$ $K_2 = 2$ $K_3 = 5$

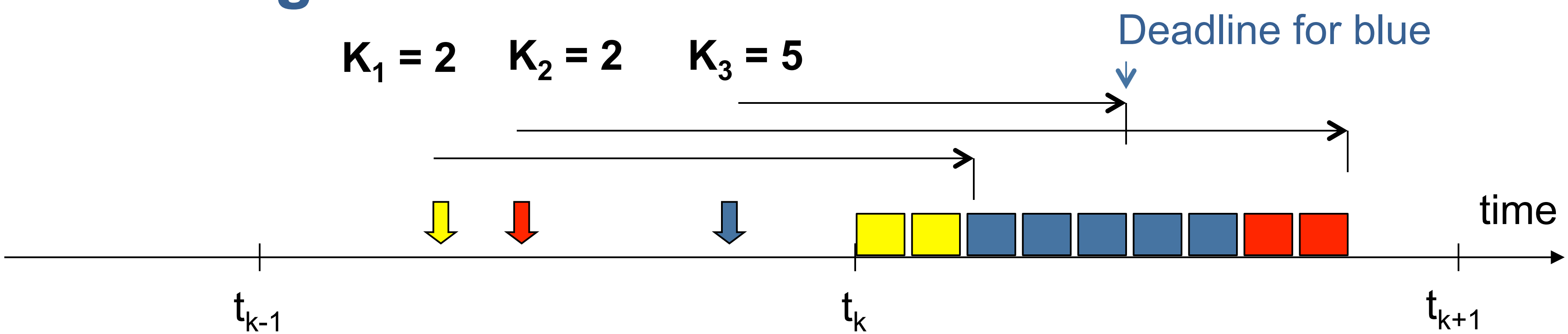


The scheduler assigns one RU per request, repeating the assignment till all requests are exhausted or there are no more RUs available.

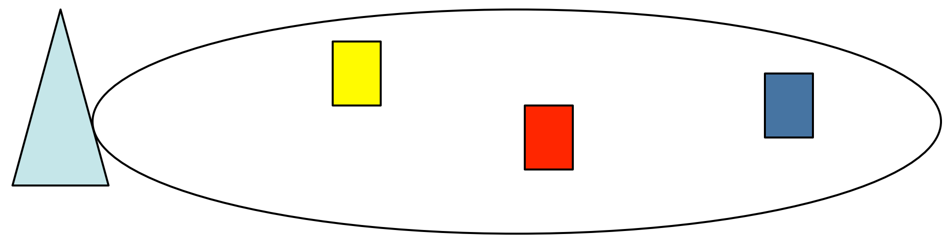
A RU is a RU is a RU.



Scheduling: Earliest Deadline First

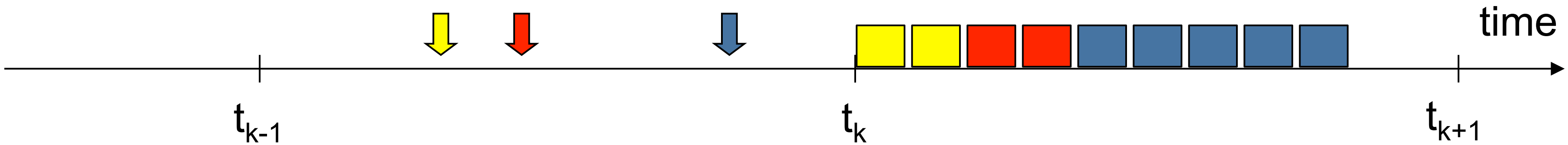


The scheduler computes the deadlines of requests, summing the maximum latency to the instant when the request was made. Then, it assigns Rus, starting from the earliest deadline, assigning as many RUs are needed to fulfil the request, before considering the request with the next earliest deadline.



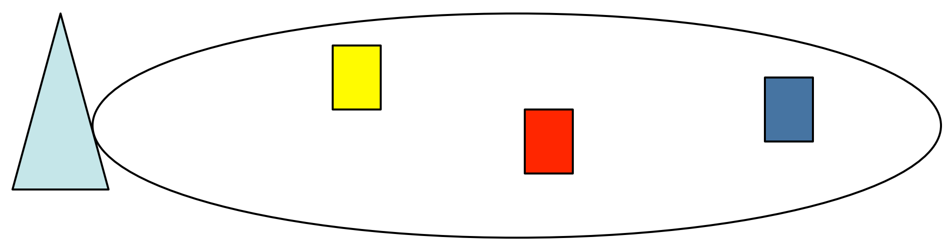
Scheduling: Maximum Throughput

$K_1 = 2$ $K_2 = 2$ $K_3 = 5$

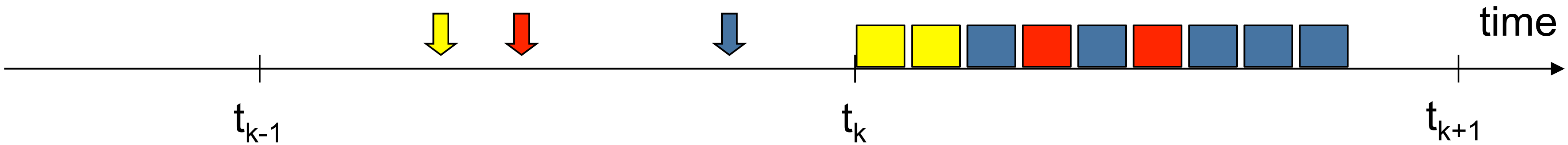


The scheduler computes for each RU the throughput that every link would provide to each user, and assigns each RU k to the request i maximizing the throughput, till all requests are exhausted or the scheduling interval has expired.

$$U_i = Bc \log_2(1+SNRm_i)\ \eta_p\ (1-BLER_i)$$

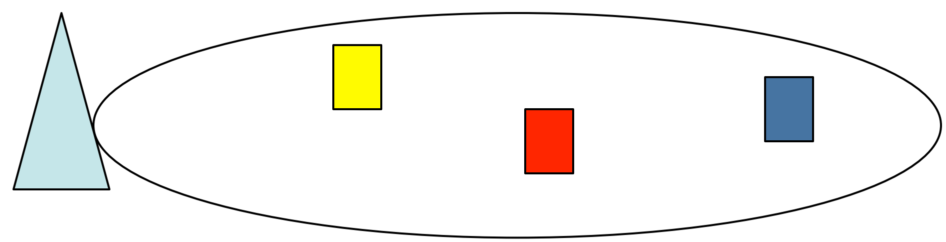


Scheduling: Proportional Fair



The scheduler computes for each RU the throughput that every link would provide to each user, then assigns each RU k to the request i maximizing the following ratio:

$$U_i \;/\; (Thp_i + Thc_i)$$



where

$Thp_i = \Sigma^{L}_{j=1} U_{i,j}$ (sum over a window made of L previous intervals)

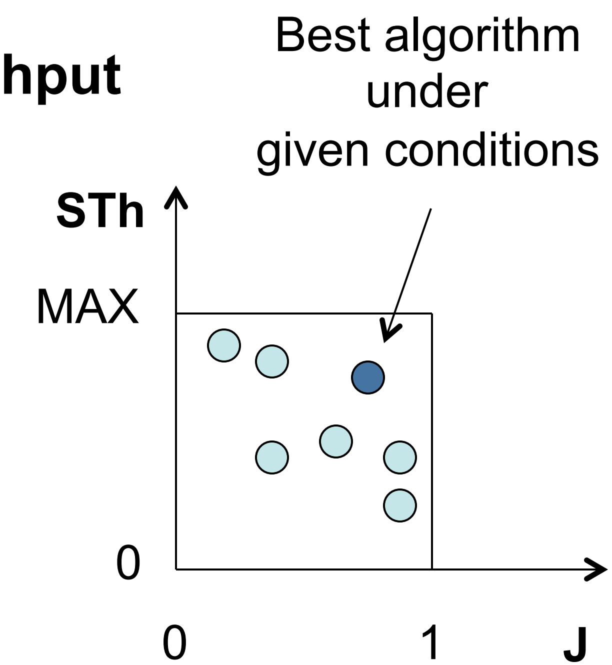
$Thc_i = \Sigma^{k-1}_{j=1} U_{i,j}$ (sum over all RUs assigned so far in current interval)

Scheduling: Fairness vs Opportunism

Opportunism*

Can be measured through the sum throughput achieved by the whole set of RUs during one scheduling interval

$$STh = \Sigma^{N}_{j=1} U_j (t_k)$$



Fairness*

Can be measured through the Jain index

$$J = (\Sigma^{K}_{i=1} Tha_i)^2 / K \Sigma^{K}_{i=1} Tha_i^2 \leq 1$$

$Tha_i = < U_i >$ **(average over a window made of several intervals)**

*** Throughput Th can be replaced by other metrics**

Exercise RRM#1

A scheduler executes scheduling every 10 ms, assigning up to 20 orthogonal radio resource units per scheduling interval. Three users, A, B, C, request assignment at time $T_i = t_0 - \Delta t_i$, of a number R_i of resource units, with maximum latencies τ_i. They are located at distances d_i from the base station they are trying to access to. The value of these parameters are given below for i = A, B and C. The SNR is equal to 86 dB at the distance of 1 m. The received power follows a distance dependent power law with propagation exponent equal to 4. Assume that the transmitters use a MCS requiring a minimum SNR* = 9 dB to achieve BLER = 0. The BLER is equal to 1 for SNR < SNR*. Assign resources to the users according to RR, EDF, MT and PF algorithms, running at t_0. Compute in each case the Sum Throughput and the Jain index (in terms of RUs).

	Δt_i	τ_i	R_i	d_i
A	5 ms	15 ms	12	50 m
B	4 ms	60 ms	15	10 m
C	2 ms	10 ms	2	100 m

Exercise RRM#2

A scheduler executes scheduling every 10 ms, assigning up to 20 orthogonal radio resource units per scheduling interval. Three users, A, B, C, request assignment at time $T_i = t_0 - \Delta t_i$, of a number R_i of resource units, with maximum latencies τ_i. They are located at distances d_i from the base station they are trying to access to. The value of these parameters are given below for i = A, B and C. The SNR is equal to 86 dB at the distance of 1 m. The received power follows a distance dependent power law with propagation exponent equal to 4. Assume that the transmitters use a MCS requiring a minimum SNR* = 9 dB to achieve BLER = 0. The BLER is equal to 1 for SNR < SNR*. Assign resources to the users according to RR, EDF, MT and PF algorithms, running at t_0. Compute in each case the Sum Throughput and the Jain index (in terms of RUs).

	Δt_i	τ_i	R_i	d_i
A	5 ms	15 ms	12	100 m
B	4 ms	60 ms	15	10 m
C	2 ms	10 ms	2	100 m

Exercise RRM#3

A scheduler executes scheduling every 10 ms, assigning up to 20 orthogonal radio resource units per scheduling interval. Three users, A, B, C, request assignment at time $T_i = t_0 - \Delta t_i$, of a number R_i of resource units, with maximum latencies τ_i. They are located at distances d_i from the base station they are trying to access to. The value of these parameters are given below for i = A, B and C. The SNR is equal to 86 dB at the distance of 1 m. The received power follows a distance dependent power law with propagation exponent equal to 4. Assume that the transmitters can use several MCSs providing up to 50 Kbit/s/RU. The channel bandwidth per RU is 10 KHz. Assign resources to the users according to RR, EDF, MT and PF algorithms, running at t_0. Compute in each case the Sum Throughput and the Jain index (in terms of bit/s, using Shannon bound).

	Δt_i	τ_i	R_i	d_i
A	5 ms	15 ms	12	50 m
B	4 ms	60 ms	15	10 m
C	2 ms	10 ms	2	100 m