# Emulation of a Downlink Spreading Factor Allocation Strategy for Rel'99 UMTS

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# Outline



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## What is a Spreading Factor (SF)?

- Used to transmit data over the UMTS wireless interface.
- Binary code of length $X$.
- 1 user symbol $\Rightarrow$ $X$ chips with a SF of $X$.
- $3,840,000$ chips per second over the wireless interface.
- SF $\Rightarrow$ data rate.

| **Spreading Factor** | **Maximum User Data Rate ($\frac{1}{2}$ rate coding)** |
|---|---|
| 512 | 3 *kbps* |
| 256 | 7 *kbps* |
| 128 | 15 *kbps* |
| 64 | 30 *kbps* |
| 32 | 60 *kbps* |
| 16 | 120 *kbps* |
| 8 | 240 *kbps* |
| 4 | 480 *kbps* |

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## SF ALLOCATION INFLUENCE: TRAFFIC CLASSES

- UMTS standard define 4 traffic classes.
- Hypotheses:
  - 4 representative applications.
  - Different QoS requirements (focus on delay).
  - Non-homogeneous distribution.

| **Traffic Class** | **Rep. Application** | **Max. Delay Bound** | **Distrib.** |
|---|---|---|---|
| Conversational | VoIP | 100 *ms* | 27% |
| Interactive | Web Browsing | 1,000 *ms* | 48% |
| Streaming | Video Streaming | 100 *ms* | 10% |
| Background | E-mail Transferring | 10,000 *ms* | 15% |

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## SF Allocation Influence: User Profiles

- UEs population divided in 4 user profiles based on the Belgian operators prepaid/postpaid repartition.
- Different QoS requirements.
- Different services accessibility.
- Non-homogeneous distribution.

| User Profile | Definition | Distribution |
|---|---|---|
| Platinum | Business Contract | 5% |
| Gold | Deluxe Pre-paid contract | 10% |
| Silver | Ordinary Pre-paid contract | 15% |
| Bronze | Post-paid contract | 70% |

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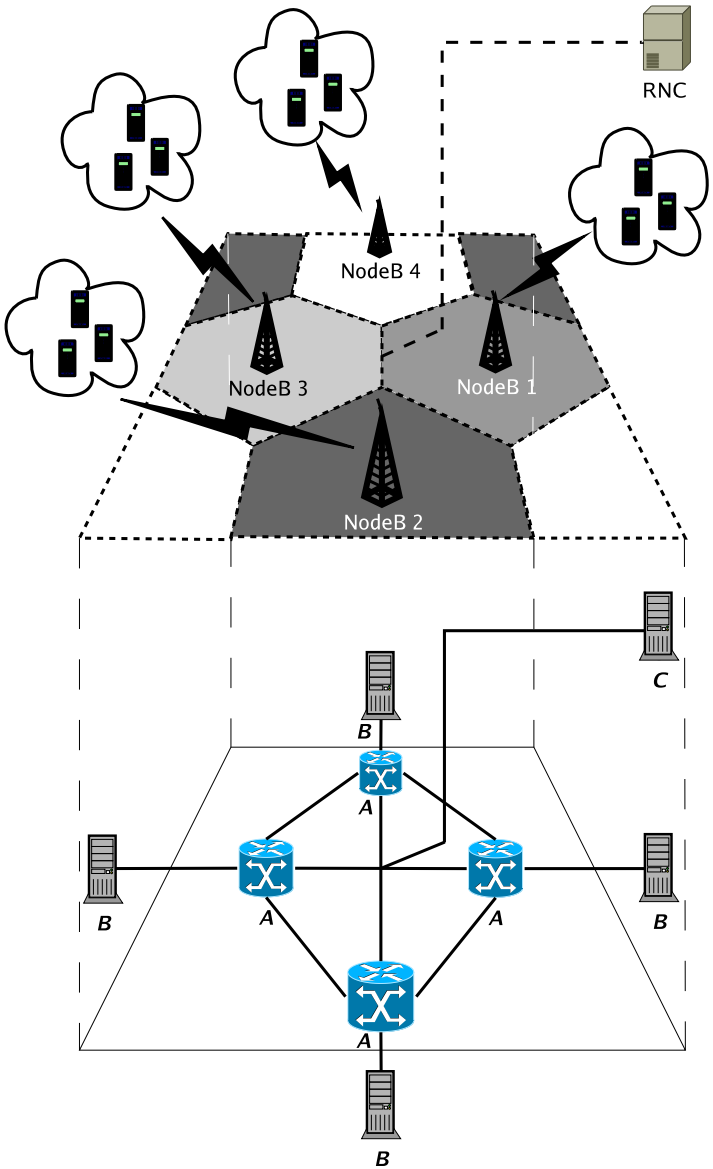


## Testbed Description

- 9 PCs.
- A: 4 macrocell trisectorial NodeBs.
- B: 4 population of UEs.
- C: 1 RNC.
- 27 $km^2$ emulated world surface.
- UE mobility with wrap-around.

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## Assumptions

- Testbed.
- Single static user.
- Simulation length of $5,000$ $s$.
- Inter-session length based on a Poisson arrival with a mean of 300 $s$.
- Perfect RLC layer (Ethernet links).

## Objective

To find a range of SF able to meet the different traffic classes QoS requirements.

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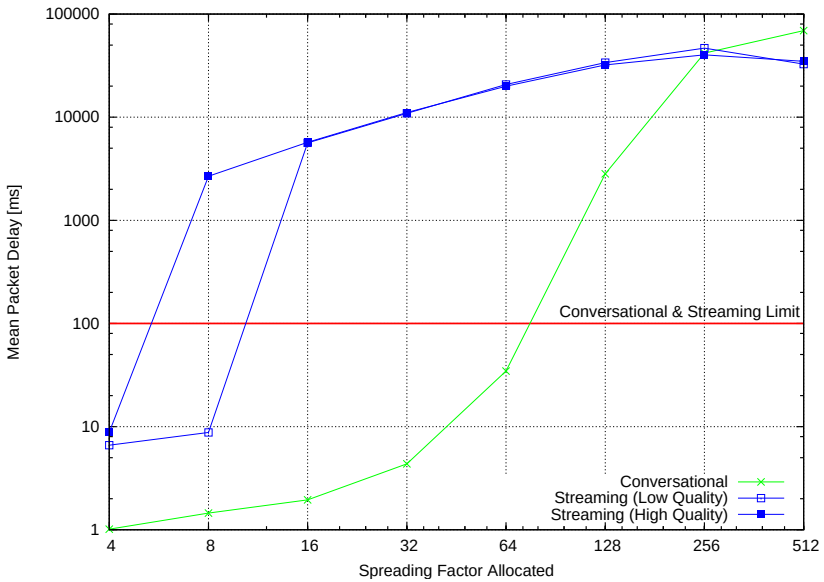
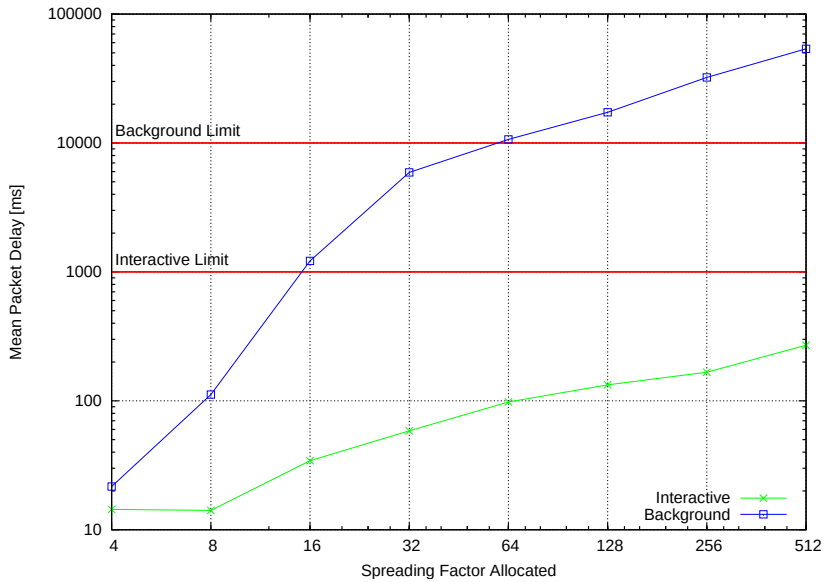


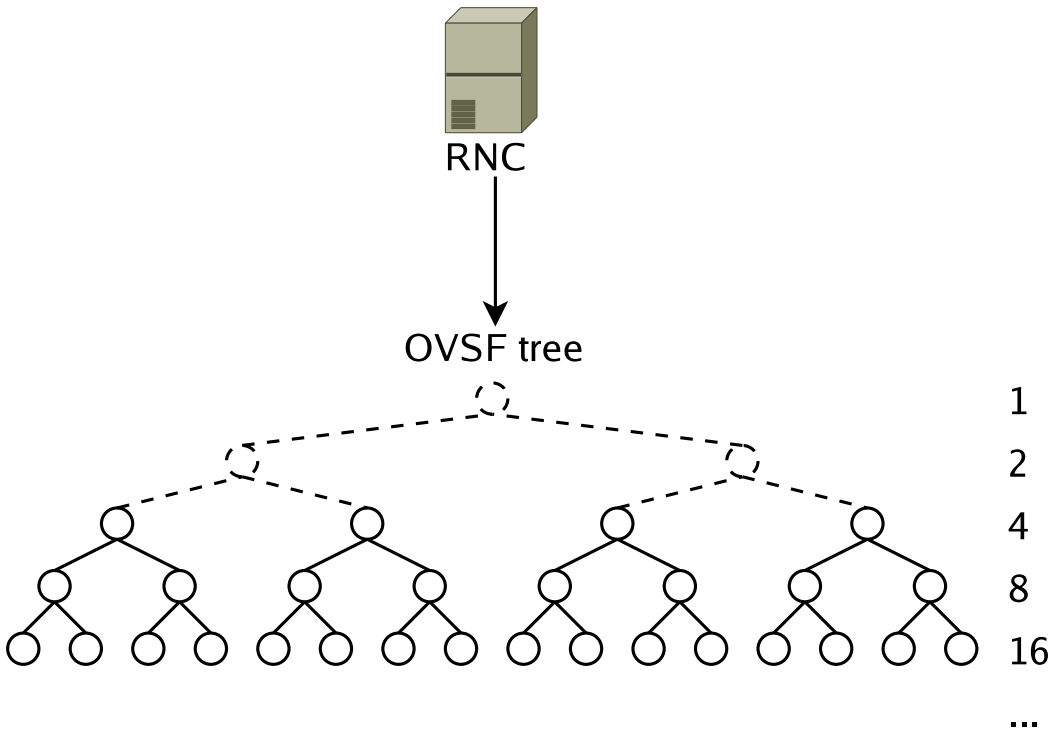




## Spreading Factor Allocation Map

| | Platinum | Gold | Silver | Bronze |
|---|---|---|---|---|
| **Conv.** | [64] | [64] | [64] | [64] |
| **Inter.** | [16 : 512] | [32 : 512] | [64 : 512] | [128 : 512] |
| **Stream. H** | [4] | n.a. | n.a. | n.a. |
| **Stream. L** | [8] | [8] | [8] | [8] |
| **Back.** | [8 : 32] | [16 : 32] | [32] | [32] |

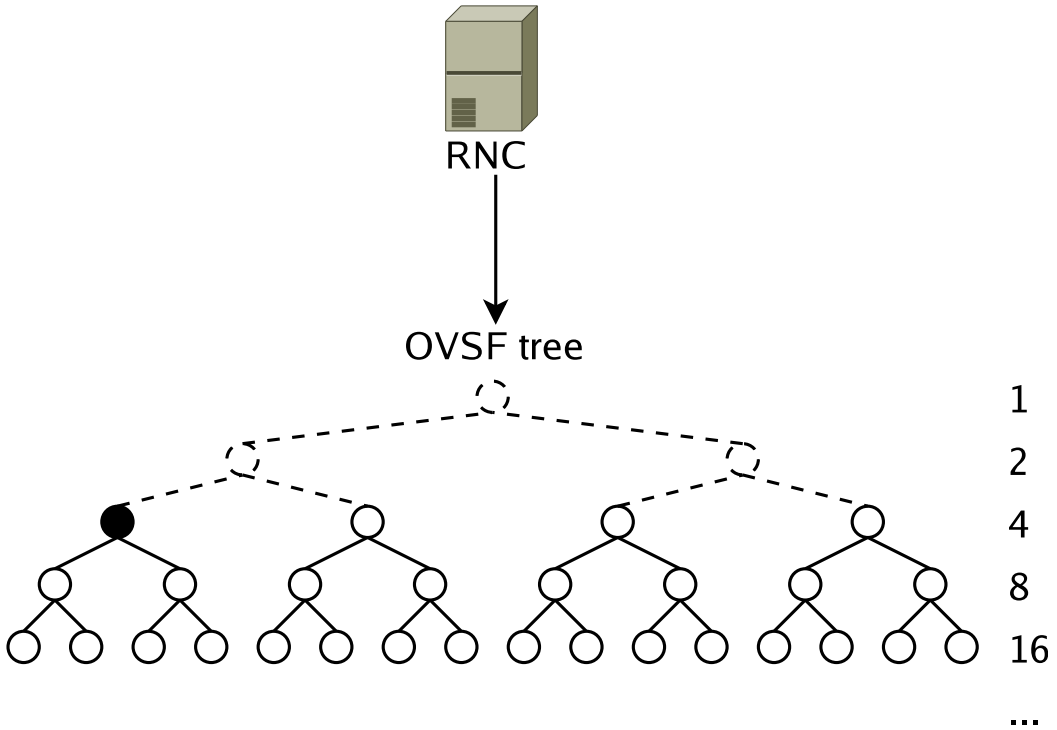
## Spreading Factors and the OVSF Tree

- The SFs are managed by the RNC for each sector.
- They are stored in a tree structure called the OVSF tree.



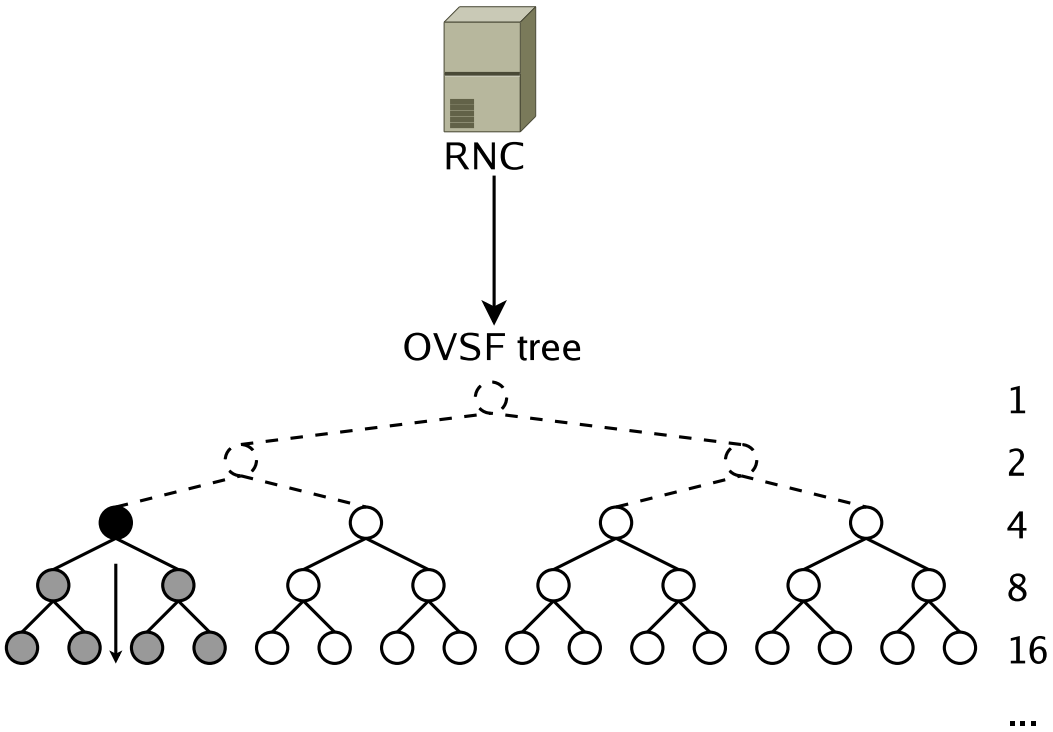
## SF=4 Query

- When a data flow has to be sent over the wireless interface it has to book a SF.
- The shorter the SF, the higher located in the OVSF tree.



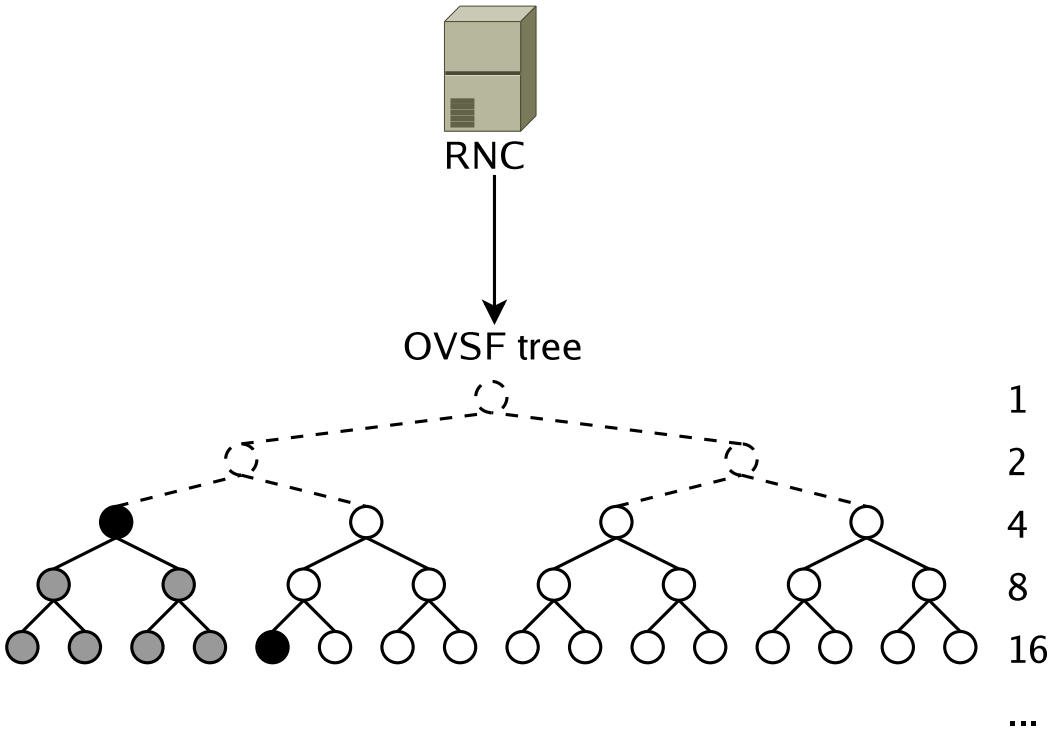
## OVSF Tree Downward Orthogonality

- Orthogonality property of the OVSF tree: all the downwards of a newly allocated SF unusable.
- These SFs can not be allocated to new queries.



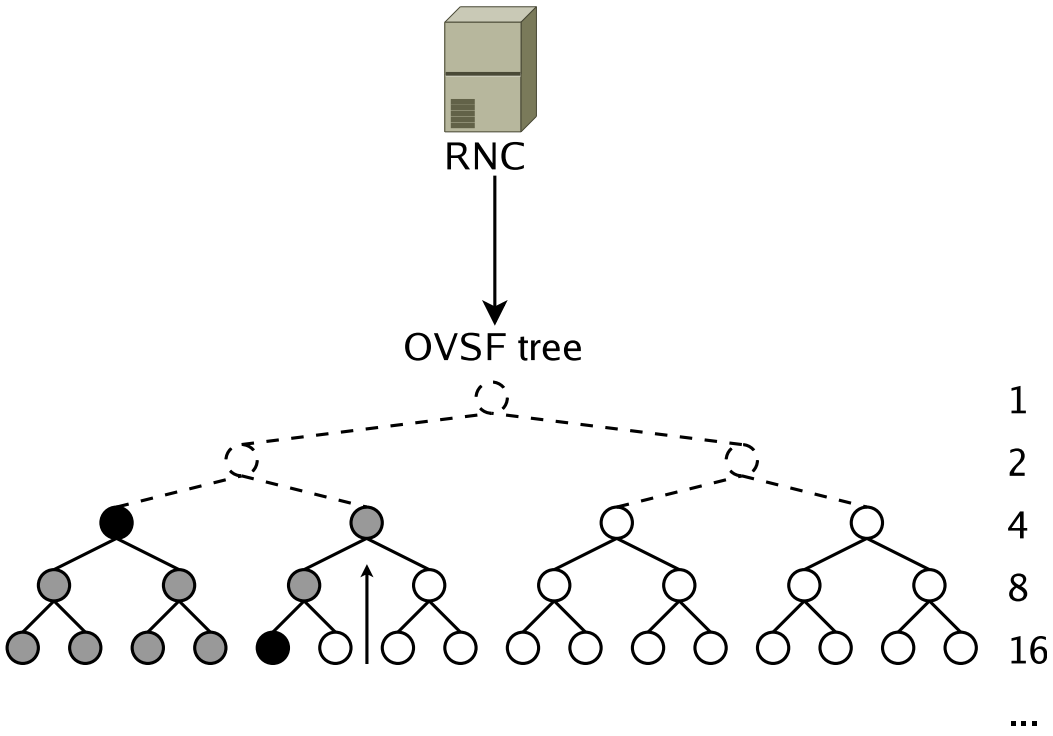
## SF=16 Query

- Another SF query arrives.
- The RNC has to chose one of the unused ones.



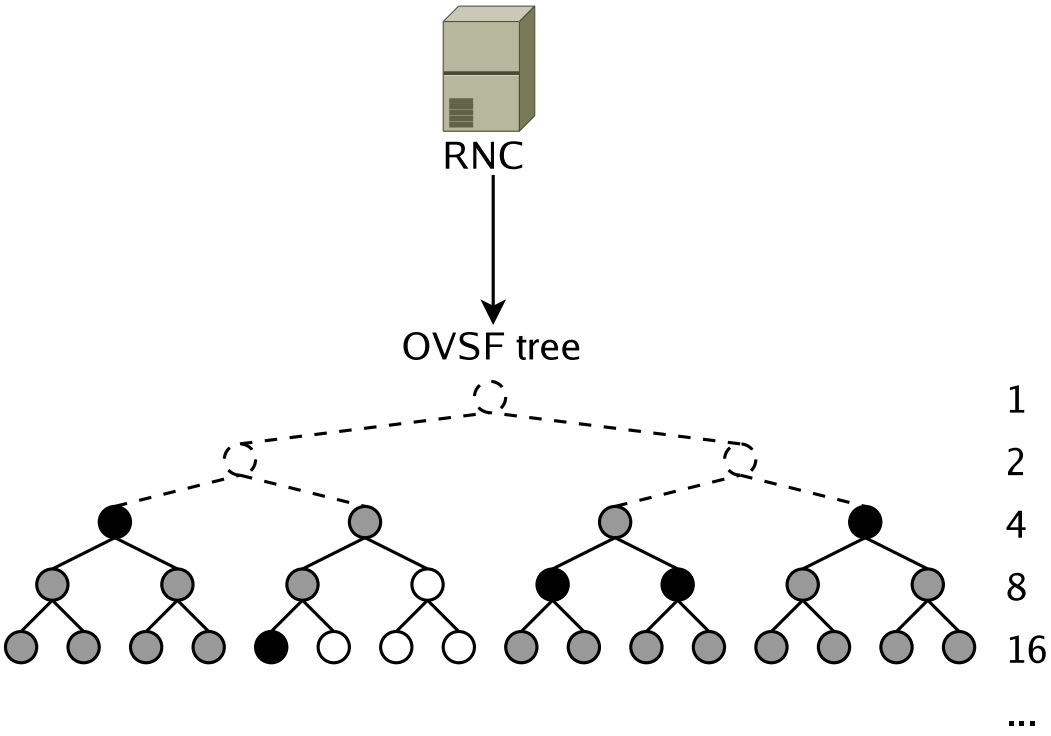
## OVSF Tree Upward Orthogonality

- Orthogonality property of the OVSF tree: all the upwards of the newly allocated SF are also unusable for new queries.



## SF=4 blocked query

- OVSF tree almost full.
- New query blocked since there is no room left in the tree.



## Operator's Worst Case (OWC)

- All the users get their best (smallest) possible SF .
- Maximal bandwidth and minimal delay.
- Maximal blocking rate.

## User's Worst Case (UWC)

- All the users get their worst (longest) possible SF.
- Minimal bandwidth and maximal delay still acceptable.
- Minimal blocking rate.

## OWC with Degradation (OWC+)

- OWC + SF degradation accepted.
- Tradeoff between bandwidth/delay and blocking rate.

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## Assumptions

- 8 users per Sector (total of 96 users in the emulated world).
- Simulation length of $5,400\ s$.
- Generation of all the traffic classes with different inter-session arrival.
- Urban area scenario:
  - 30% at 3 $km/h$,
  - 40% at 30 $km/h$,
  - 20% at 70 $km/h$, and
  - 10% at 120 $km/h$.

## Objective

To find the optimal SF allocation strategy using the previously introduced map.

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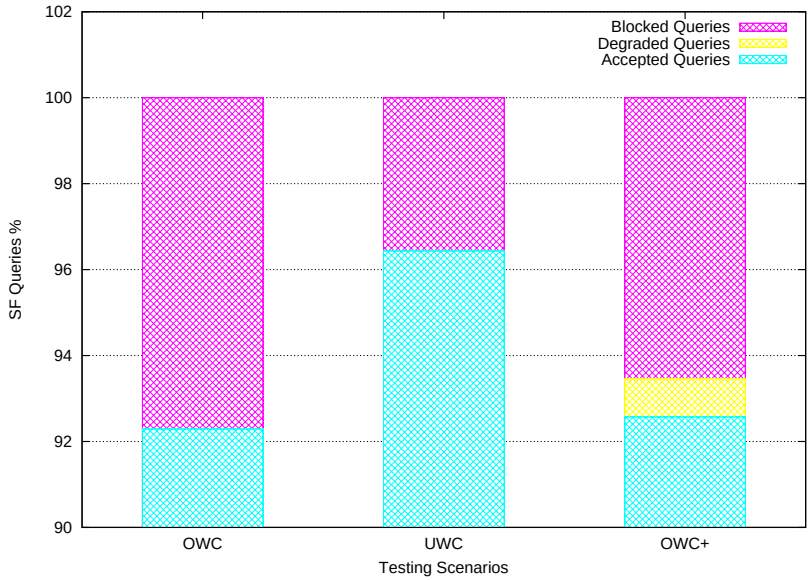


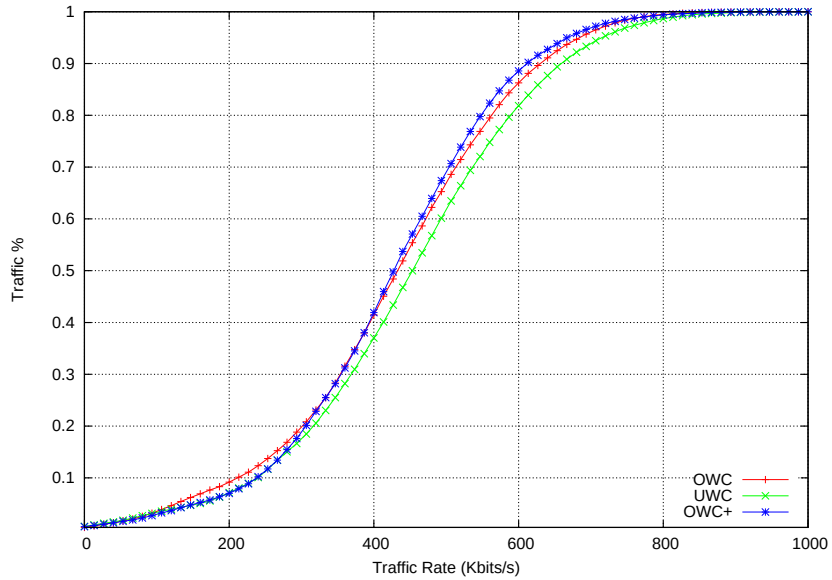


## Traffic Classes Mean Packet Delay

| **Traffic Class** | **OWC** | **UWC** | **OWC+** | **Limit** |
|---|---|---|---|---|
| Conv. | 23*ms* | 21*ms* | 20*ms* | $< 100ms$ |
| Inter. | 97*ms* | 392*ms* | 87*ms* | $< 1,000ms$ |
| Stream. | 3*ms* | 3*ms* | 3*ms* | $< 100ms$ |
| Back. | 2,119*ms* | 2,375*ms* | 2,017*ms* | $< 10,000ms$ |

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- Users point of view:
  - SF allocation map.
  - Delay and bandwidth requirements.
- Operators point of view:
  - SF allocation strategy.
  - Blocking and throughput requirements.

## Future Work

- Other transport channels (shared): FACH and DSCH.
- Emulation the wireless links typical packet loss rate over Ethernet.

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