A simulation-based algorithm for solving the resource-assignment problem in satellite telecommunication networks

Final Project of the UOC Master in Free and Open Source Software

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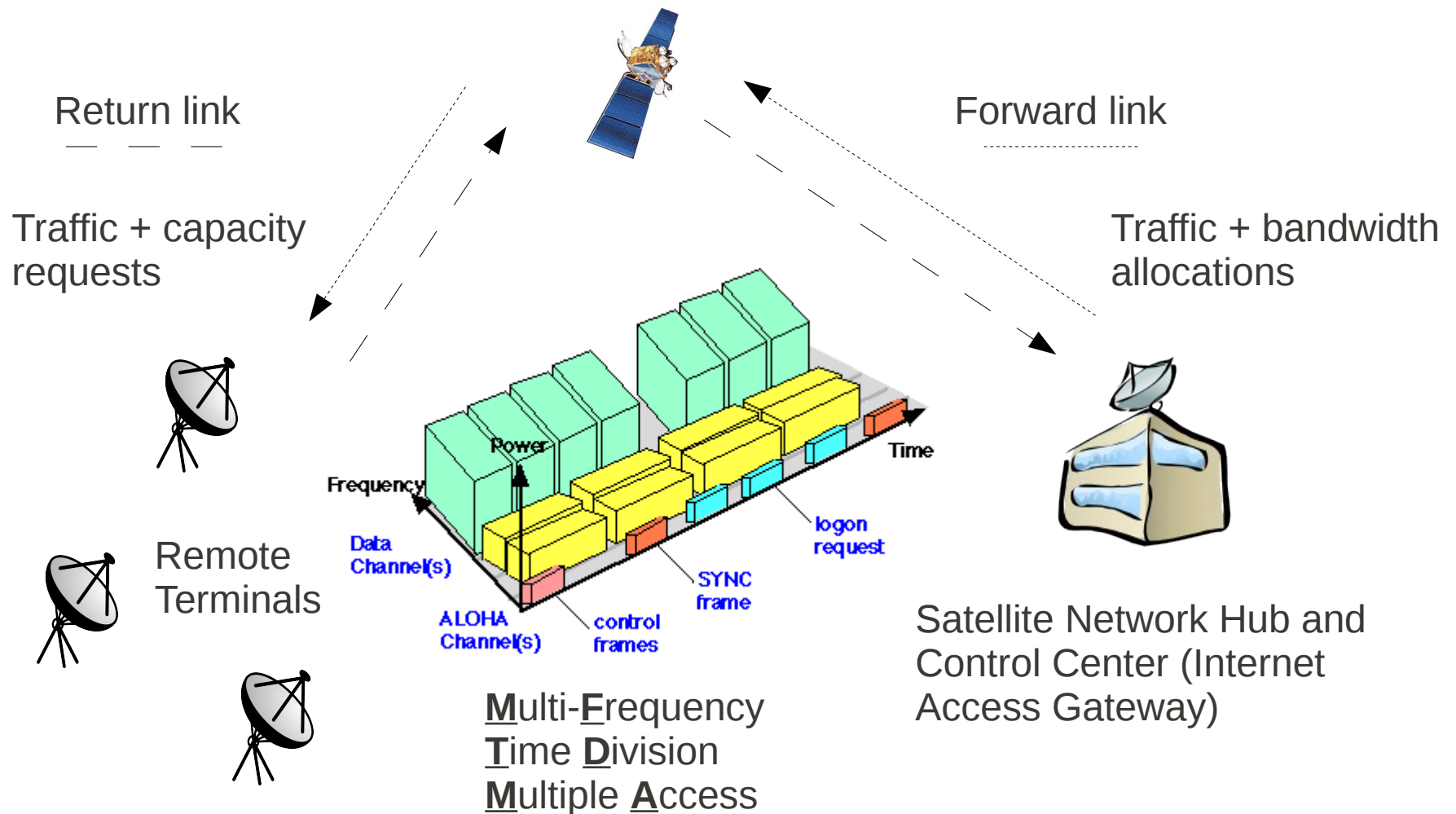
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Year 2012

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Introduction and Conceptual Framework (I)

Geostationary Satellite: fixed above Earth at 36,000 km

Return link

Forward link

Traffic + capacity requests

Traffic + bandwidth allocations

Remote Terminals

Multi-**F**requency **T**ime **D**ivision **M**ultiple **A**ccess

Satellite Network Hub and Control Center (Internet Access Gateway)

Power

Frequency

Time

Data Channel(s)

logon request

SYNC frame

ALOHA Channel(s)

control frames

Introduction and Conceptual Framework (II)

Adaptive Coding and Modulation

- Three types of Radio Frequency (RF) bursts for three channel conditions
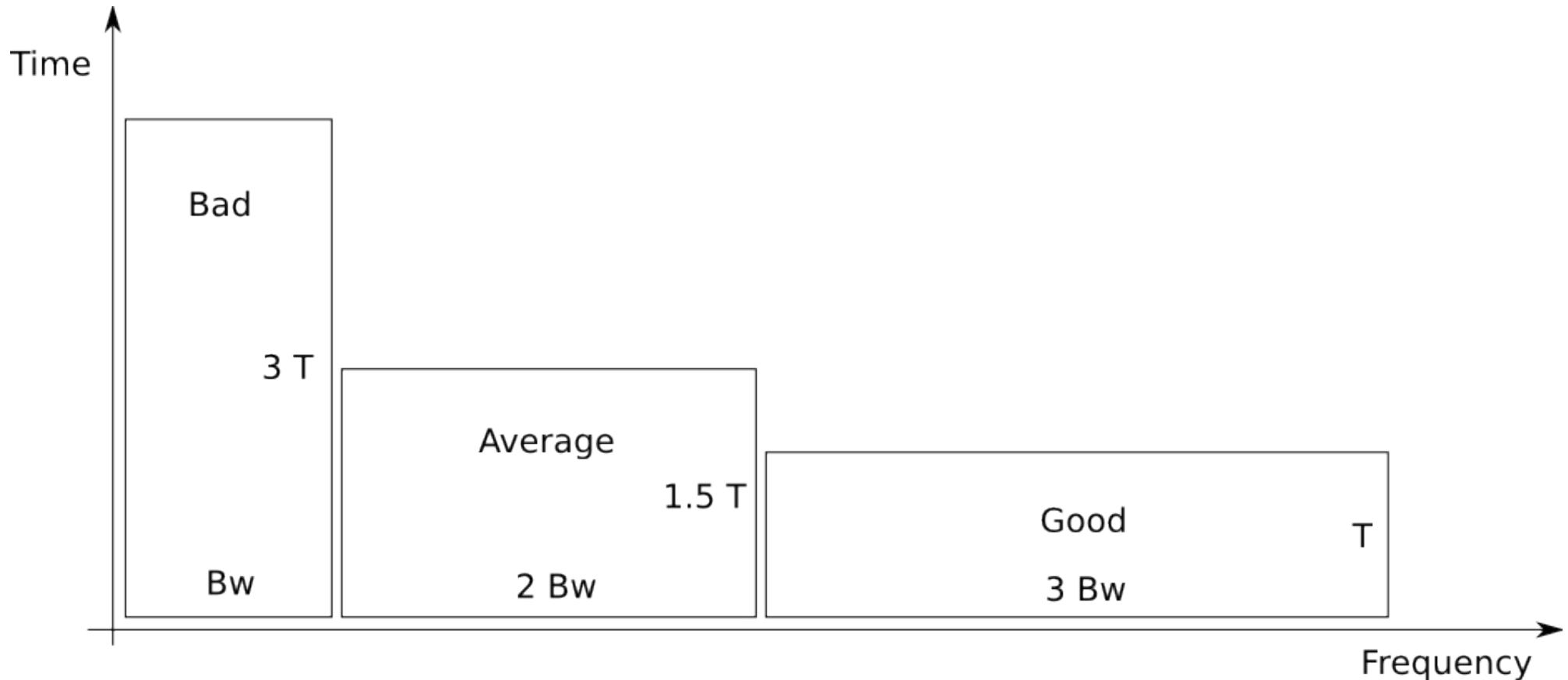
Introduction and Conceptual Framework (III)

Resources Assignment Period (TA)

Taking into account a message delay requirement given by TD and that the procedure of requesting resources and the subsequent transmission will involve a minimum propagation delay of 1.5 RTT (Round Trip Time), a first condition to be held is:

TA << TD - 1.5 RTT

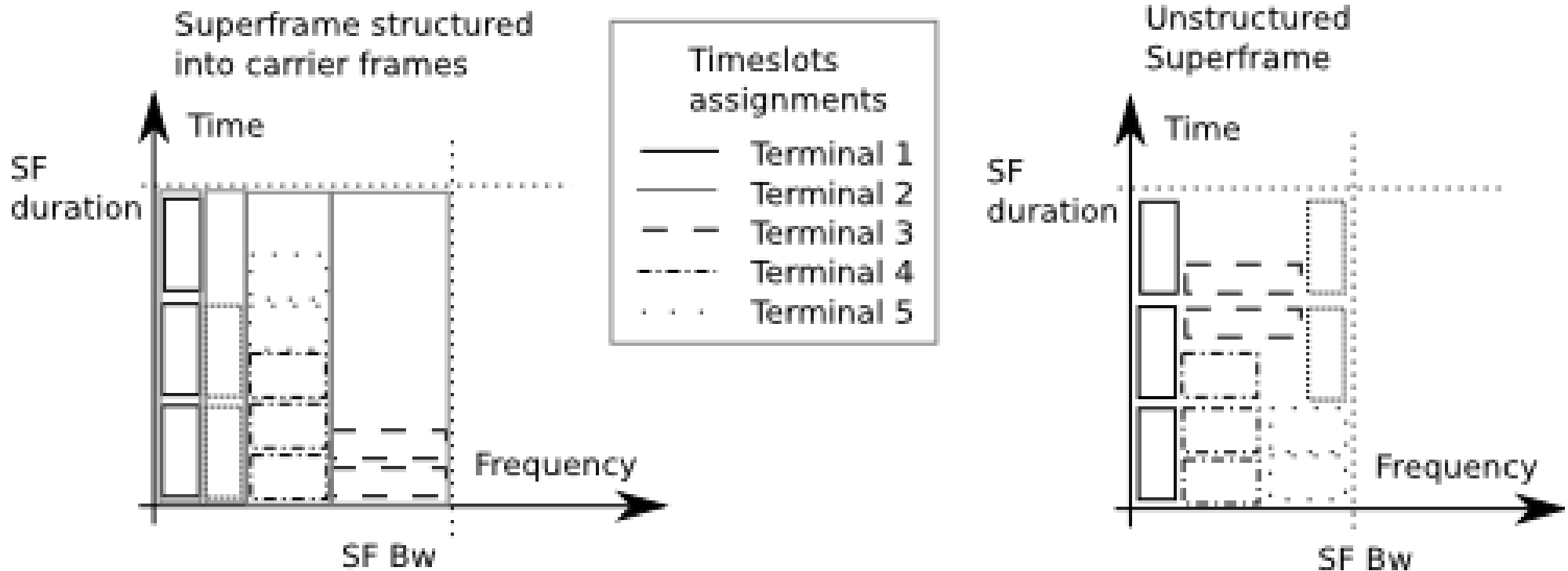Considering an engineering criterion TA <= 0.1(TD - 1.5 RTT), if TD = 4.7 s and RTT = 540 ms, then TA <=390 ms.

Taking TA a multiple of T=20 ms results

TA = 360 ms.

Introduction and Conceptual Framework (IV)

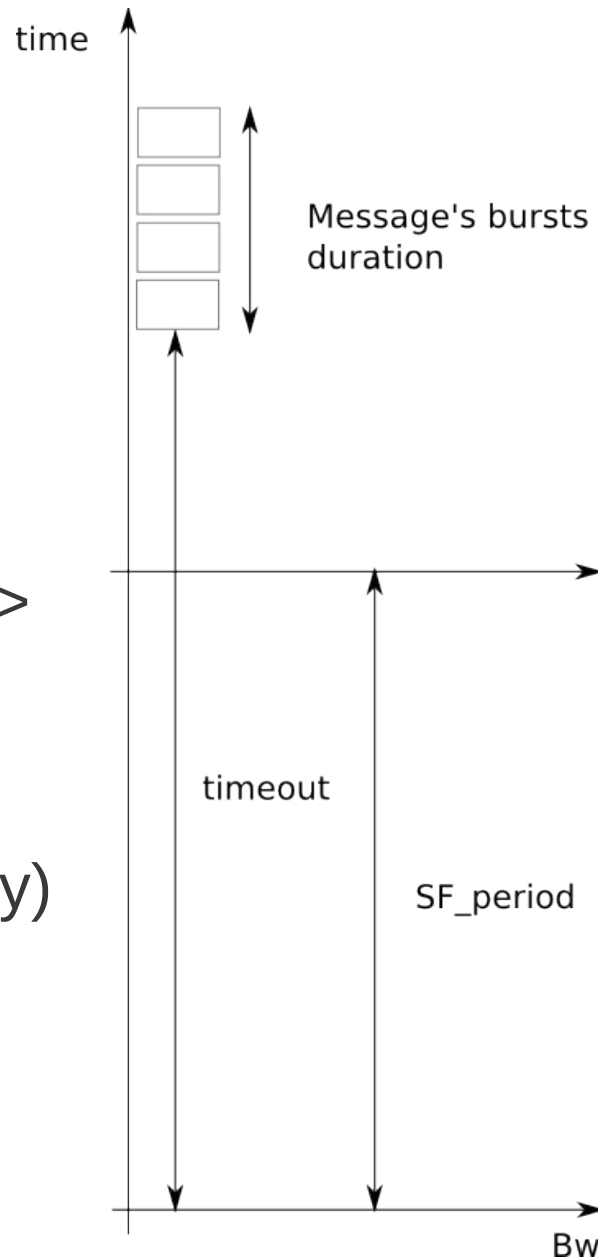## Time and spectrum organization

Introduction and Conceptual Framework (V)

Traffic Profile

- 5 trace files

Two types of Tx

- Mandatory
  (otherwise Tx timeout =>
  packet loss)

- Extra
  (to fill remaining capacity)

time

Message's bursts
duration

timeout

SF_period

Bw

Problem description

Minimize bandwidth required to process a given traffic profile,
but also the signalling required (BTP size),
with the next constraints:

- Traffic Profile Quality of Service (QoS):

    - Delay constraints: Tx timeout
    - Message losses constraints: maximum acceptable PLR

- Only one transmitter per terminal

- Traffic profile characteristics

    - Bursts types distribution
    - Bursts types bandwidth and duration

Related Work (Literature Survey)

- Telecommunications literature on Radio Resource Management

    Structured approaches. Not identical problem found.

- 2D oriented orthogonal strip packing algorithms

    Packing heuristics characteristics to select
    the most adequate to our case

- Meta-heuristics, randomization and parallelization

    Review of possible extensions for future work

Our Approach (Algorithm Explanation) (I)

Unstructured assignment of time and frequency resources

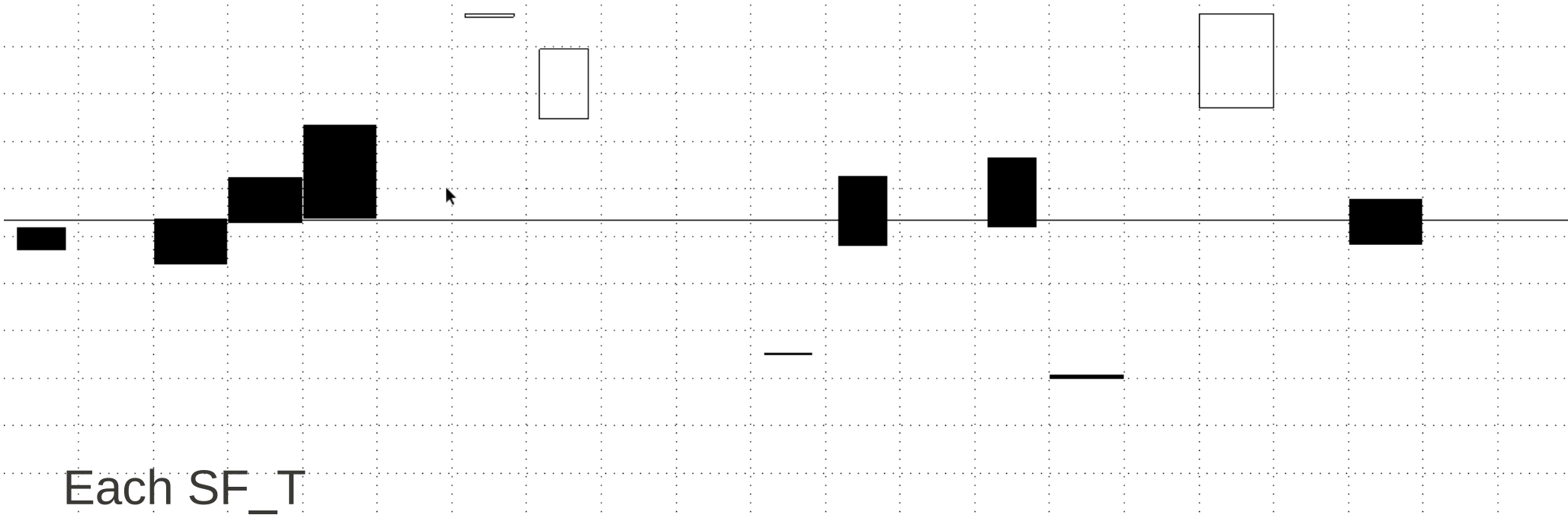But minimizing frequency hopping (so size of BTP)

2D oriented strip packing problem algorithm

Best Fit Decreasing Height heuristic adapted

Tetris game like representation of transmissions buffering
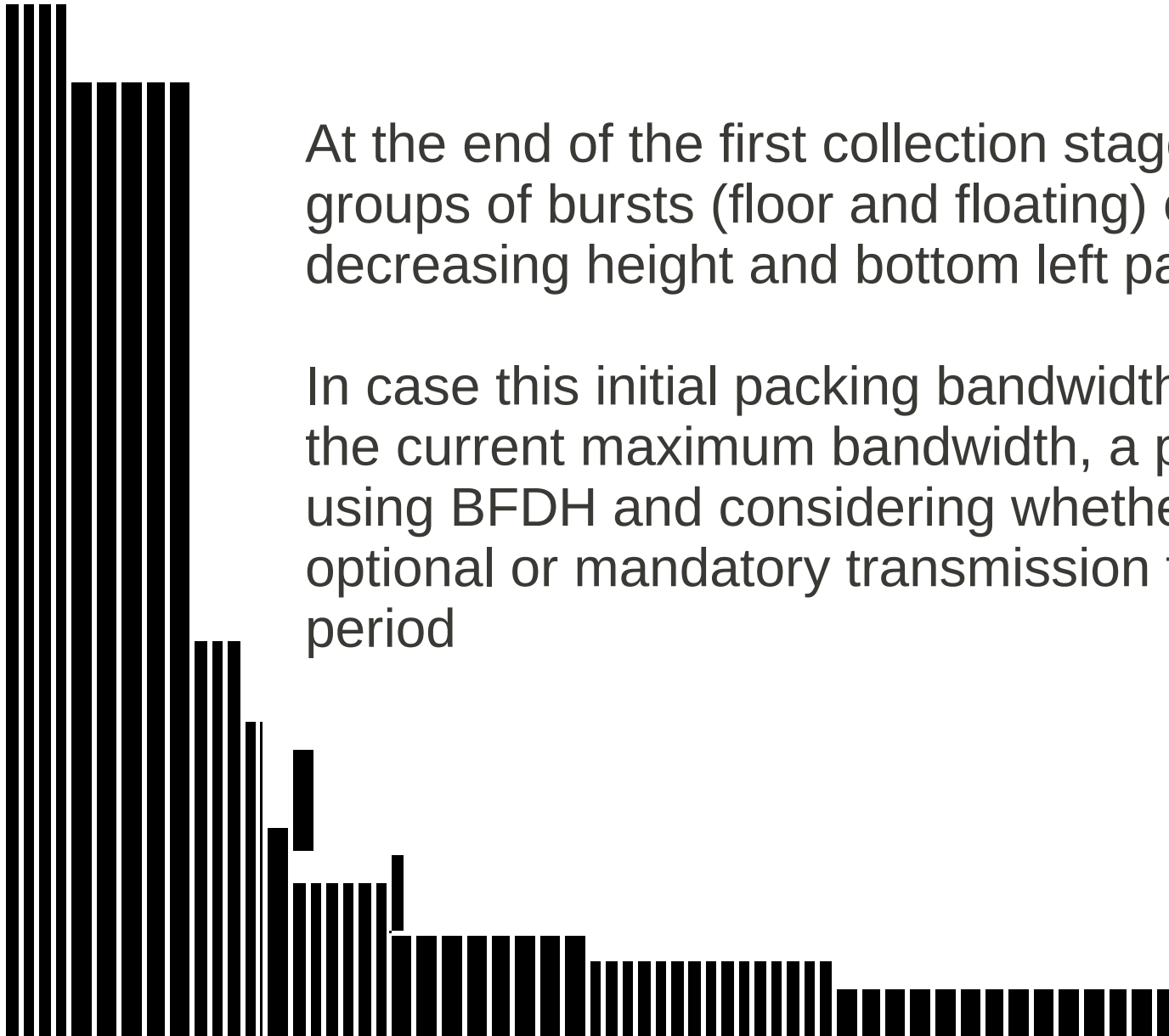
Earliest Deadline First (EDF) Scheduling

Our approach (Algorithm Explanation) (II)

Each SF_T

Pending transmissions with a timeout lower than the obliged Tx threshold are collected and aggregated by transmitter, then optional transmissions can be added.

Our Approach (Algorithm Explanation) (III)

At the end of the first collection stage there are two groups of bursts (floor and floating) ordered by decreasing height and bottom left packed

In case this initial packing bandwidth is higher than the current maximum bandwidth, a packing is done, using BFDH and considering whether bursts are of optional or mandatory transmission the current period

Our Approach (Algorithm Explanation) (IV)

The packing of obliged transmissions (solid) is performed first, then the remaining gaps are filled with optional transmissions (outlined)

To minimize signalling, items of the same bandwidth are packed together, otherwise a new level is created
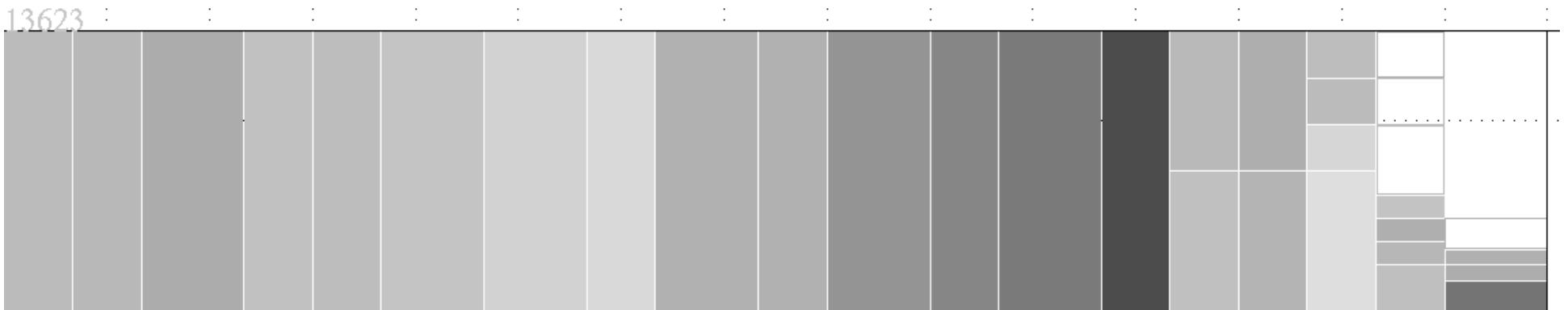
The algorithm is implemented for dimensioning purposes, so obliged transmissions are never discarded and the maximum bandwidth used is a result

Computational Experiments (I)

Algorithm developed as a C/C++ console application

GPLv3 licensed. Published in SourceForge:
https://sourceforge.net/projects/trafficprofilep/

OpenGL based viewer developed to **see it in action**

File #3 is the one with the highest load and file #1 the one with
the lowest load

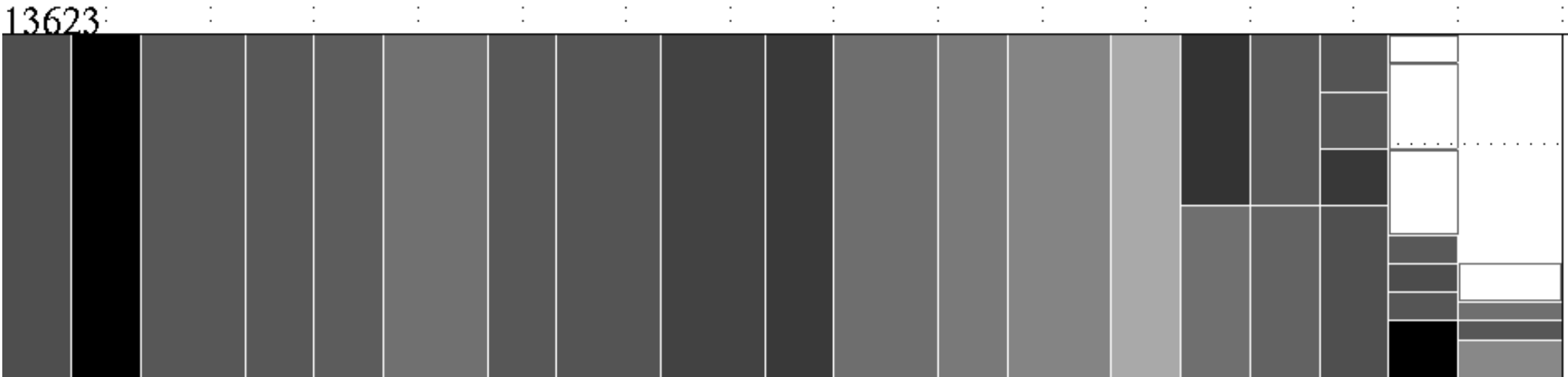Runs faster than real-time on a common laptop if compiled with
gcc -O3 flag

Computational Experiments (II)

Allocations performed in the SF of maximum bandwidth usage
for PLR=0 for files #1, #2, #5 and #3
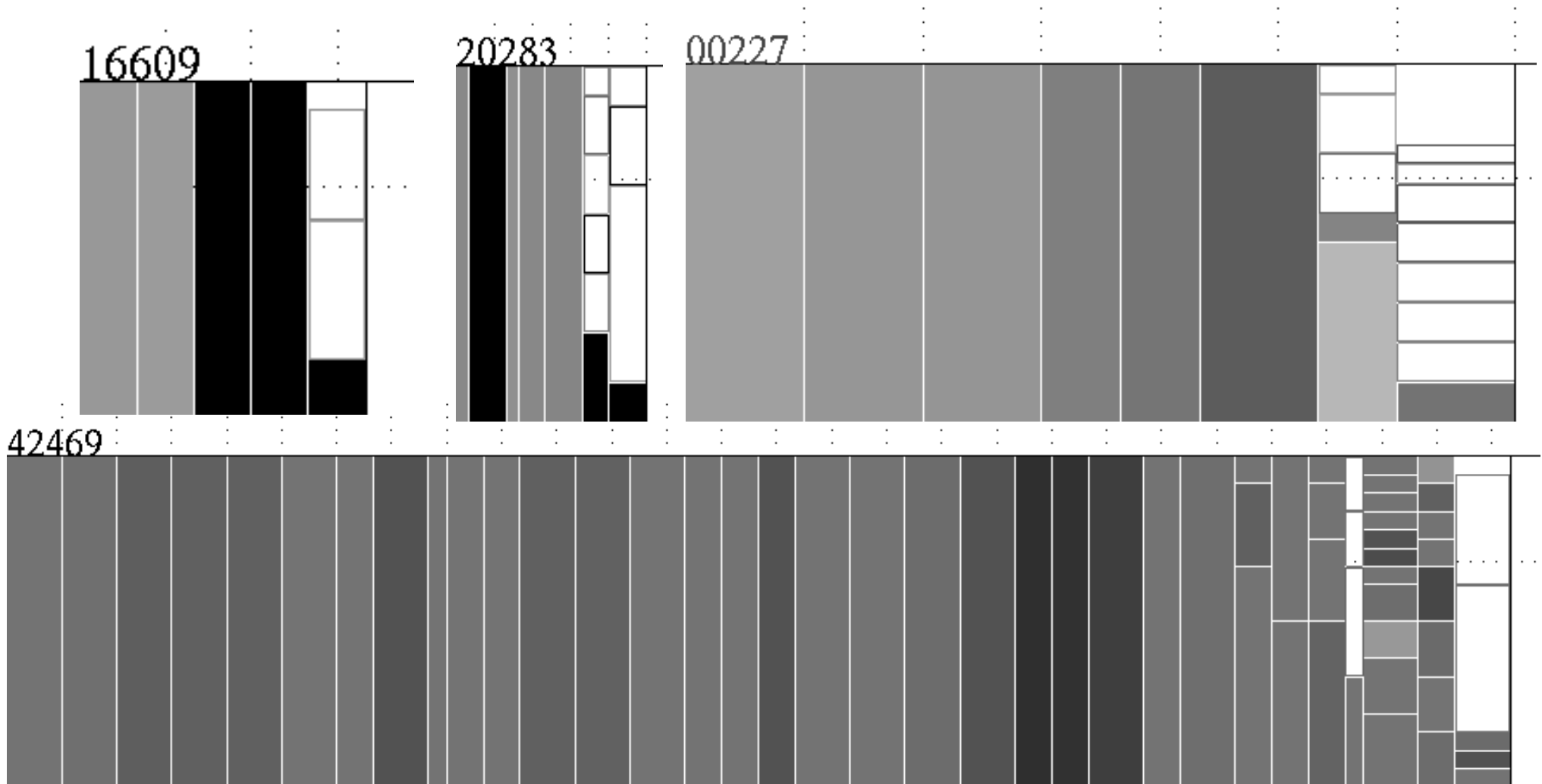
Computational Experiments (III)

Allocations performed in the SF of maximum bandwidth usage for file for PLR=0 for file #4
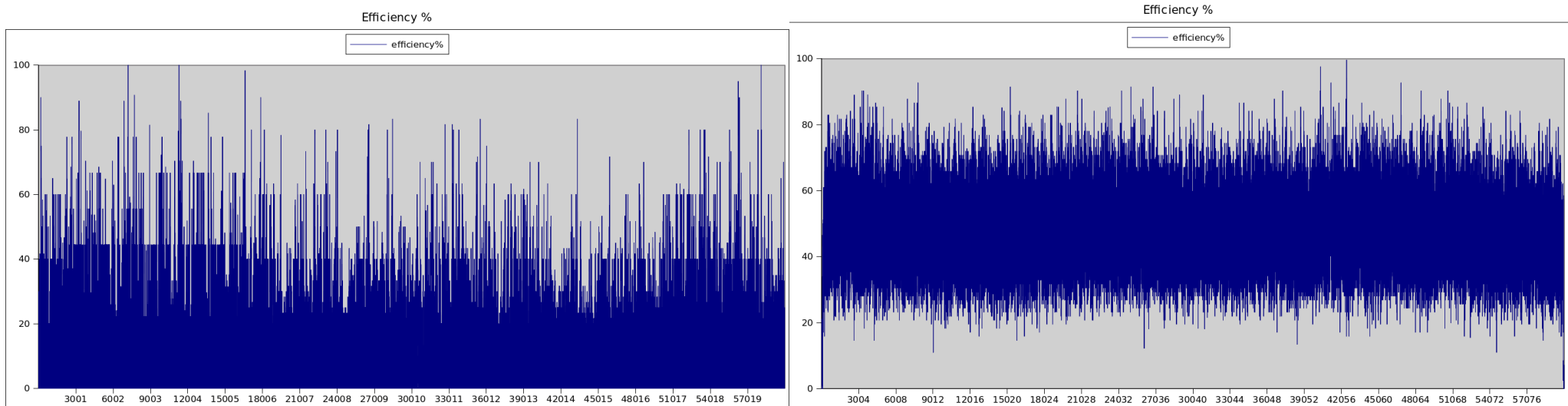
Computational Experiments (IV)

Resulting minimum bandwidth required fixed since the beginning in order to measure packing efficiency (area used vs. area available) to satisfy QoS for each file

> 95% packing efficiency is reached some times in all files.

The more traffic a file contains the greatest the efficiency is due to the greatest possibility to exploit multiplexing of traffic

Computational Experiments (V)

Resulting minimum bandwidth required does not seem to depend so much on the obliged Tx threshold value configured, to set a PLR due to overload
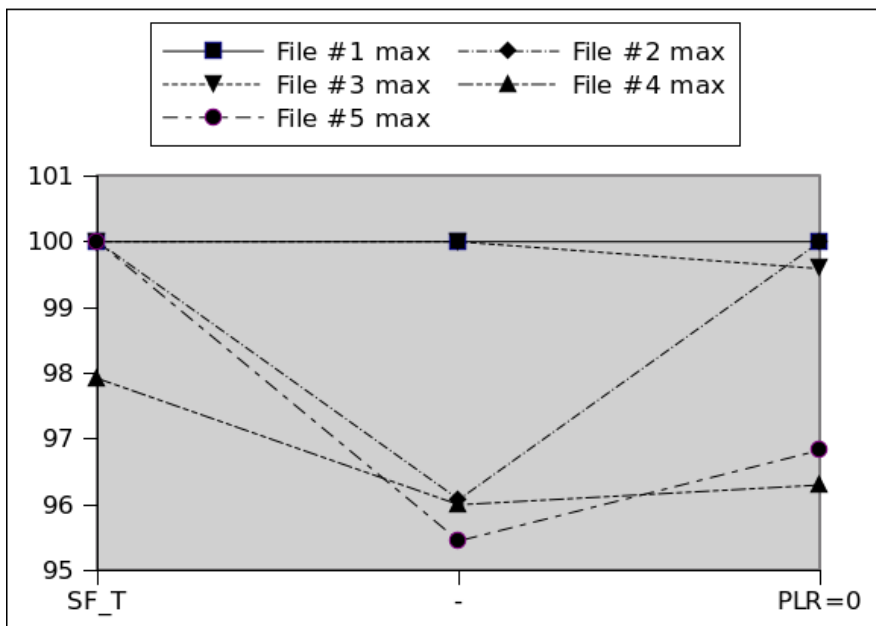

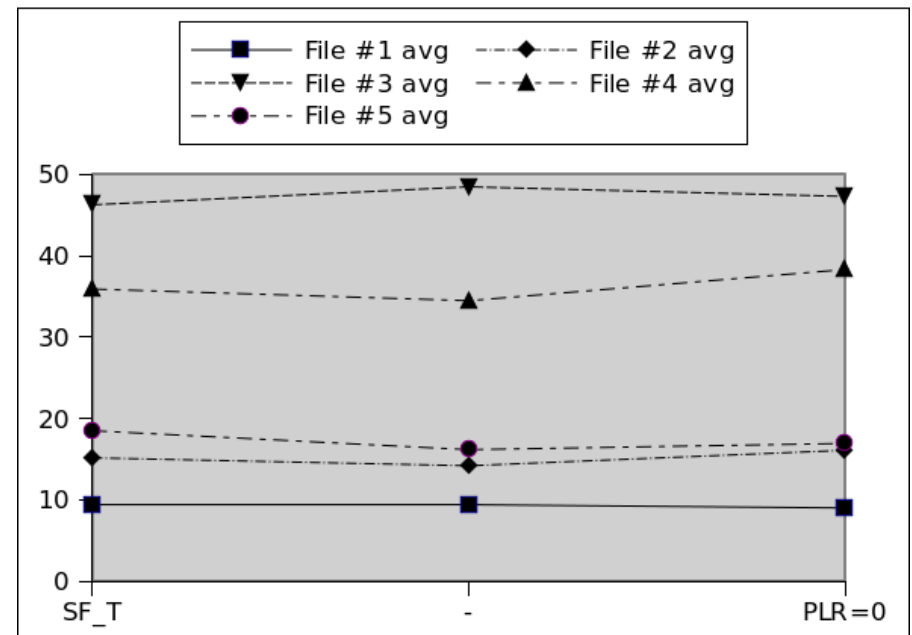Max Bw used in function of obliged Tx threshold
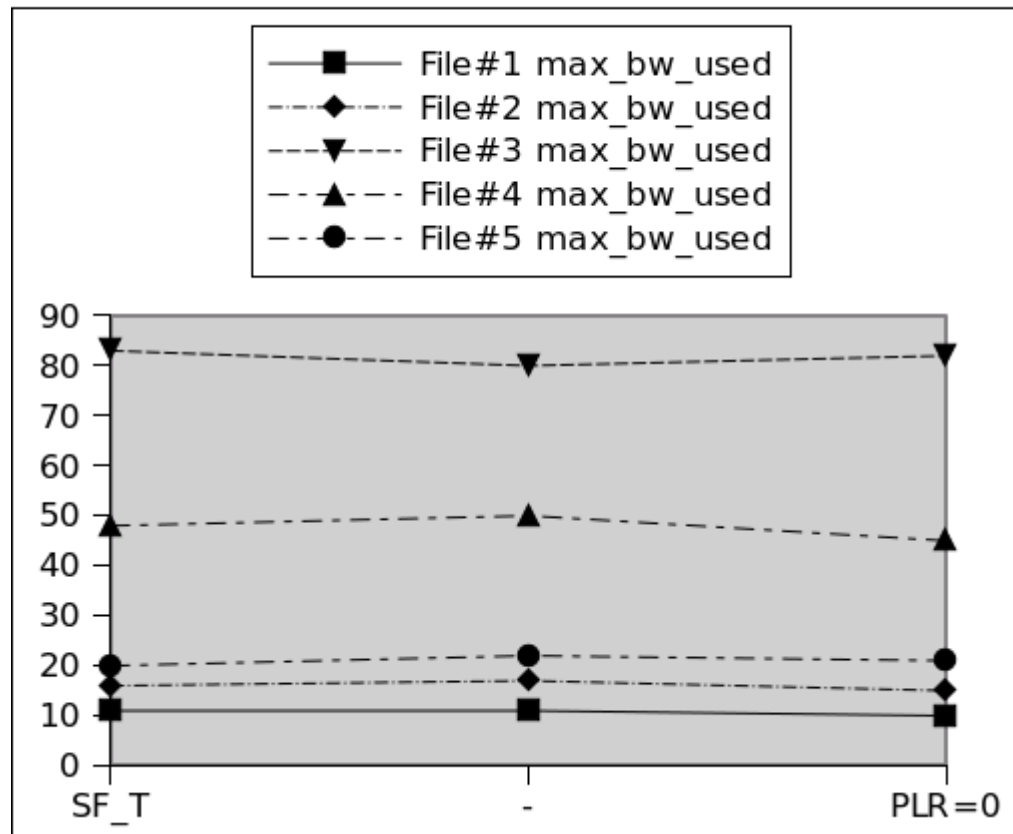
Computational Experiments (VI)

Packing efficiency does not seem to depend so much on the obliged Tx threshold value configured, to set a PLR due to overload
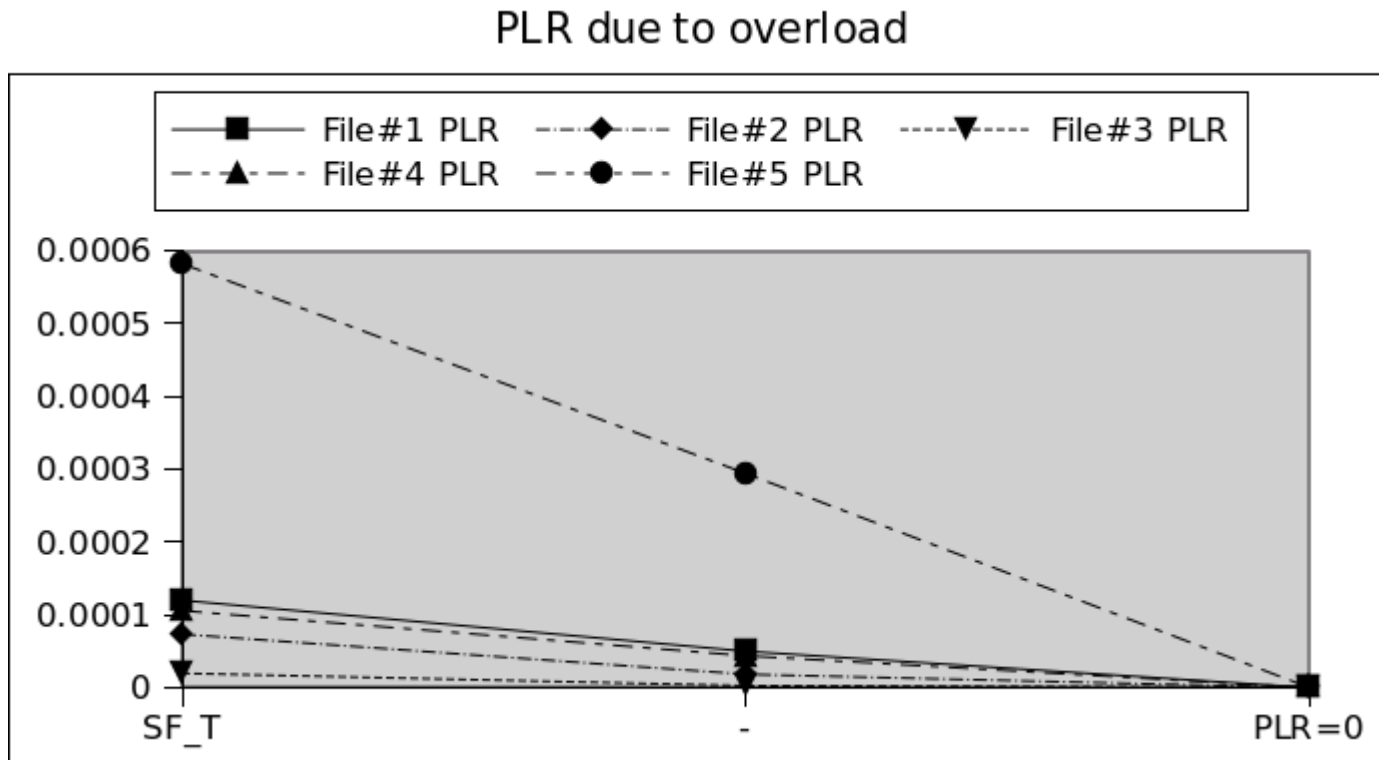
Computational Experiments (VII)

The PLR due to transmitter overload decreases as the obliged Tx threshold is increased

Conclusions and Future Work

Novel approach to the RRM in telecommunications networks for time critical communications

Computationally feasible unstructured approach

Adaptation of an heuristic from operations research (BFDH) to telecommunications

Future work

Comparison of this deterministic version with a randomized and parallelized version

Thank you for your attention.

Questions?

David Fernández Piñas, UOC, 2013