Scheduling and MAC Simulation for ATM over Satellite with OPNET

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- ATM service categories over ATM-Sat (direct access)
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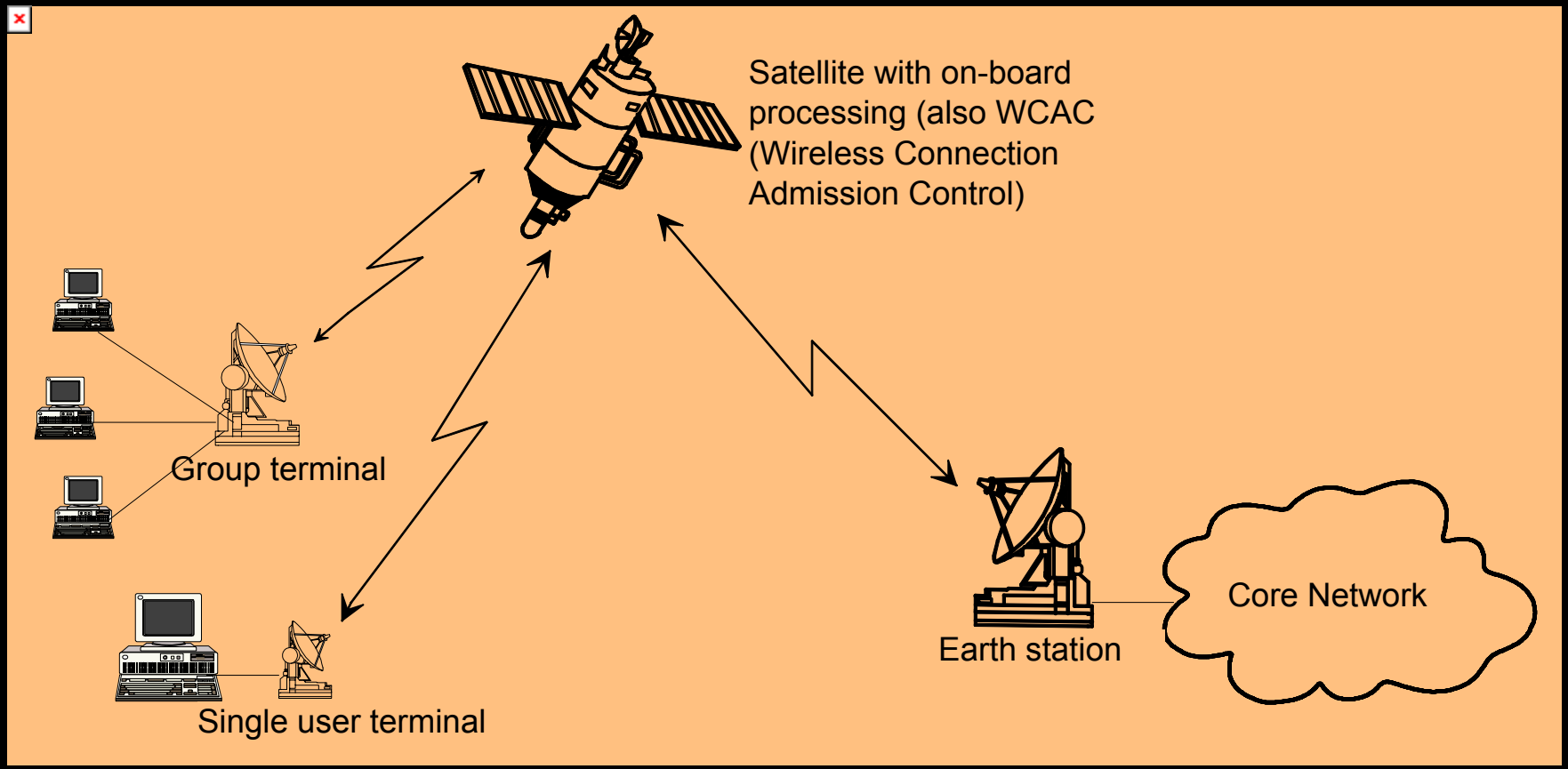
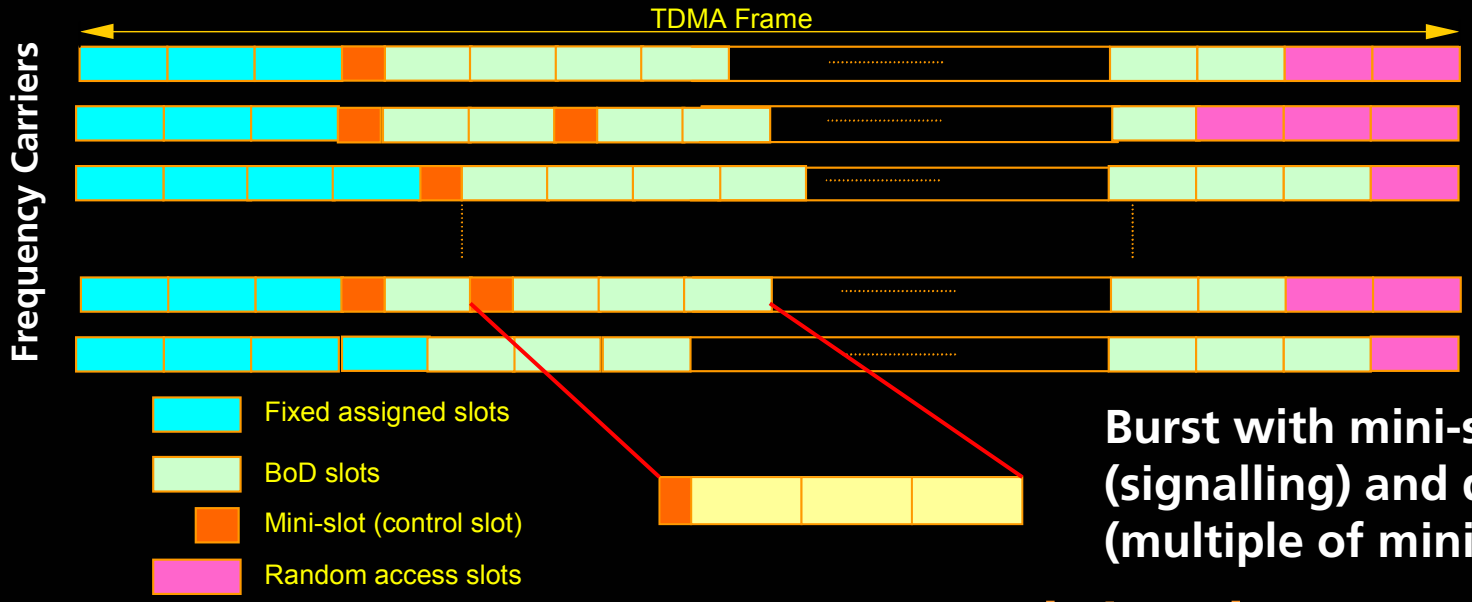
Scenario


Satellite with on-board processing (also WCAC (Wireless Connection Admission Control)
Group terminal
Single user terminal
Earth station
Core Network

MAC for User and Group Terminals Access

Uplink:

- **Multi-frequency Time Division Multiple AccessMF-TDMA:**
  - **Based on Combined Free-Demand Assignment Multiple Access (CF-DAMA)**



Burst with mini-slot (signalling) and data slots (multiple of mini-slot)

⇒ No guard time between time slots!

MAC for User and Group Terminals Access (cont.)

Downlink:

- Time Division Multiplexing (TDM): each terminal pick up only its packets
- TDMA: the information about the packets is broadcast at the beginning of the downlink frame

Bandwidth on Demand (BoD)

Resource requests:

- In-band signalling: piggy-backing; problem: the resource request should be sent only once per frame
- Out-of-band signalling:
  - *Reserved mini-slots*: preferred for long duration bursty connections
  - *Random slots*: can be used for connections with long off periods for initial requests

Resource assignment:

- Centrally based scheduling algorithm in satellite:
  - Uplink
  - Downlink

ATM Service Categories over ATM-Sat (Direct Access)

ATM Service Category	*Guaranteed Traffic Parameters*	*Not Guaranteed Traffic Parameters*	*Traffic Shaping in Satellite or Ingress Network Point*	*ATM-Sat Target System*
CBR	*PCR (Number)*	*(PCR)*	*PCR*	+
rt-VBR	*SCR*	*MBS, (PCR)*	*PCR,MBS*	-
nrt-VBR	*SCR*	*MBS, (PCR)*	*PCR,MBS*	+
ABR	*MCR*	*(PCR)*	*PCR*	o
UBR	*(MCR)*	*(PCR)*	*(PCR)*	+
GFR	*MCR*	*MBS,MFS,(PCR)*	*PCR,MBS*	+o

CBR: Constant Bit Rate
rt-VBR: real-time Variable Bit Rate
nrt-VBR: non real-time Variable Bit Rate
ABR: Available Bit rate
UBR: Unspecified Bit Rate
GFR: Guaranteed Frame Rate

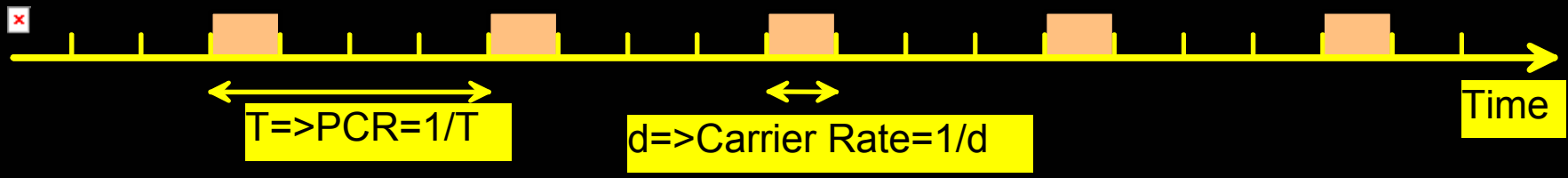
MBS: Maximum Burst Size
MCR: Minimum Cell Rate
MFS: Maximum Frame Size
PCR: Peak Cell Rate

+: Supported
o: Possibly supported
-: Not Supported

Peak Cell Rate (PCR)

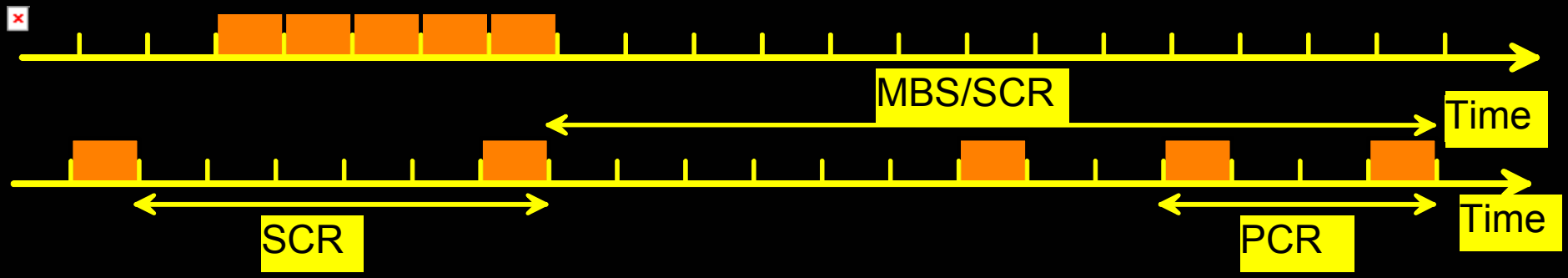
PCR does not only mean the number of cells per time unit but also minimum inter-cell time !!!

Why?



In uplink the cells are transmitted in bursts

⇒ Traffic shaping is needed to enforce PCR and MBS!!



Scheduling

Scheduling an important part of the QoS mechanism:

- Used where congestion can occur
- It enforces service guarantees and fair access to resources

What to guarantee:

- Bandwidth
- Delay
- Jitter

Queuing Structures

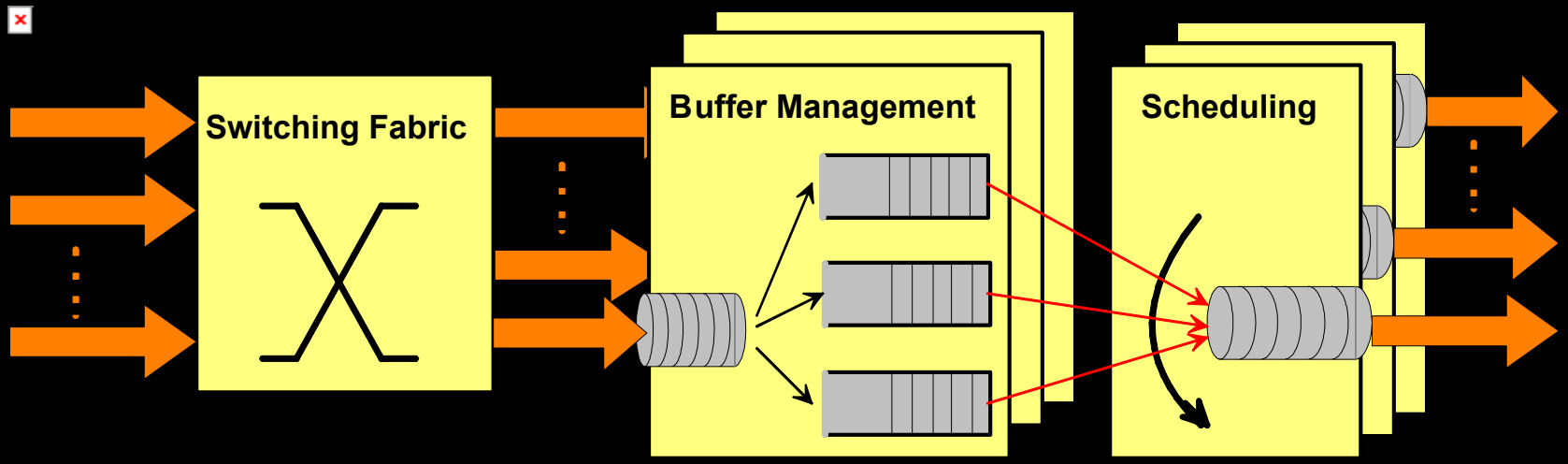
Per-group queuing:

- **Service category (CBR, VBR, ...)**
- **Service class (CBR with CTD = 250μs, CBR with CTD = 2.5ms, ...)**
- **Conformance definition (CBR.1, VBR.1, VBR.2, ...)**

Per-VC/VP queuing:

- **Ability to guarantee service to one flow *independent* of behaviour of other flows**

Switch Output Port Buffer Management and Scheduling

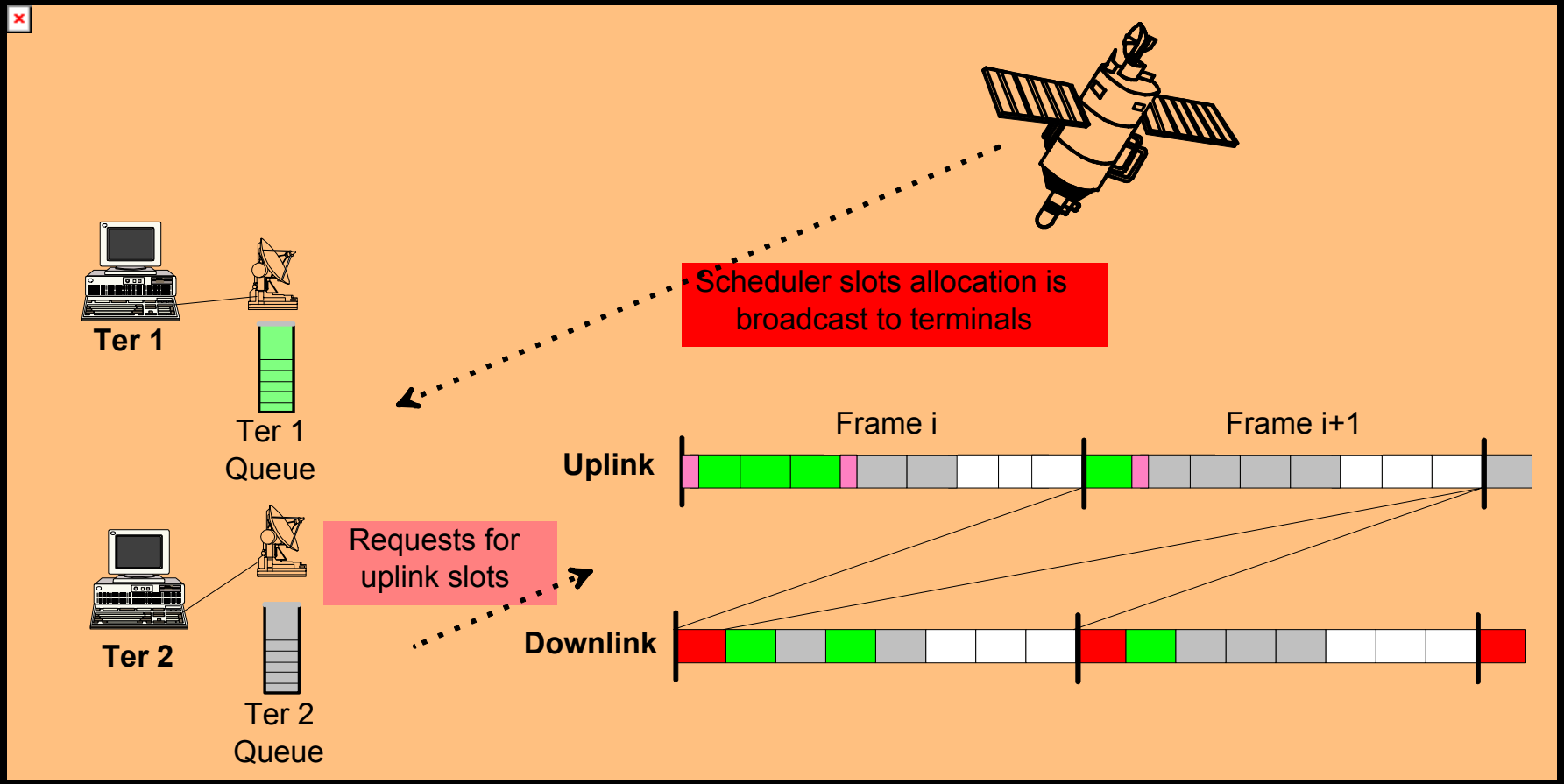


How to do that :
1. Installed by signalling
2. Predefined (carried in packets)

Algorithms:

- Weighted Fair Queuing (Routers)
- Weighted Round Robin (ATM switches)

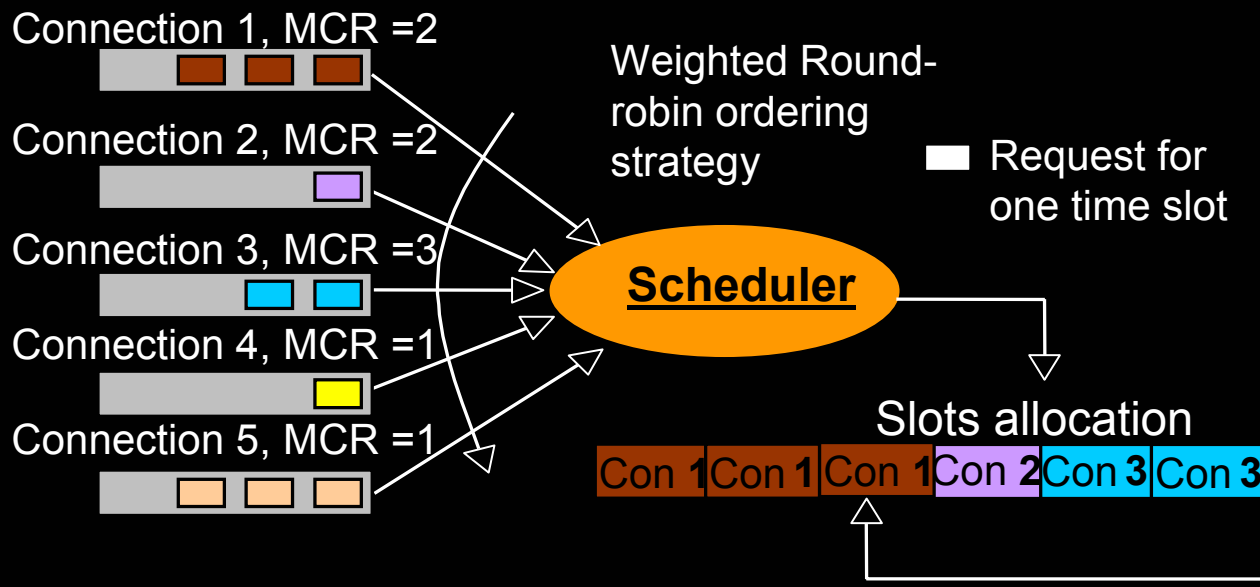
Shared Medium Uplink Scheduling



How to Guarantee MCR in the Uplink?

Algorithm similar to Weighted Round Robin (WRR)

- **Weight is set according to the Minimum Cell Rate**



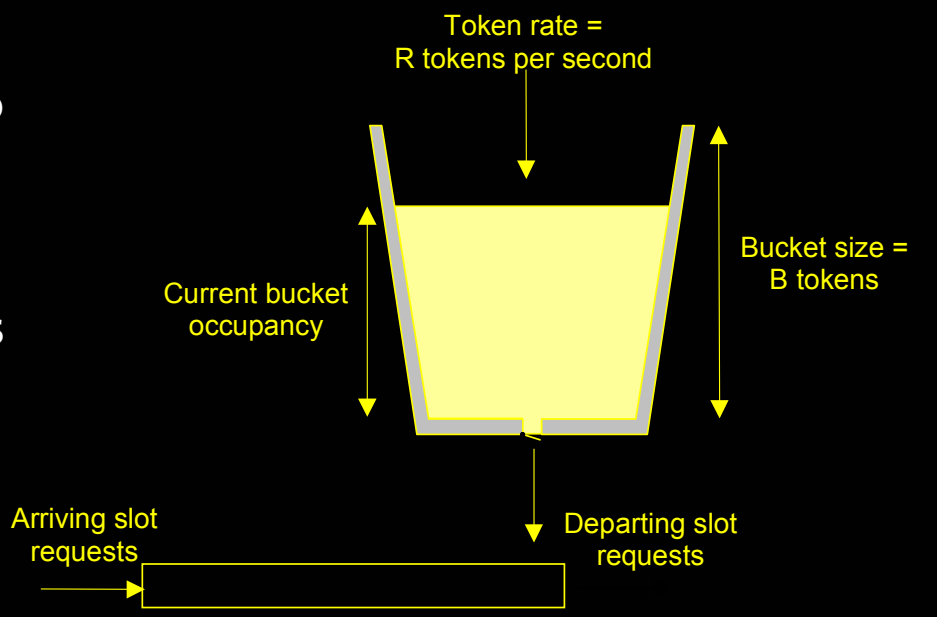
There are still free time slots:

- **Use free assignment if there are still slot requests**

How to guarantee SCR in the Uplink?

The SCR parameter is specified during the call setup:

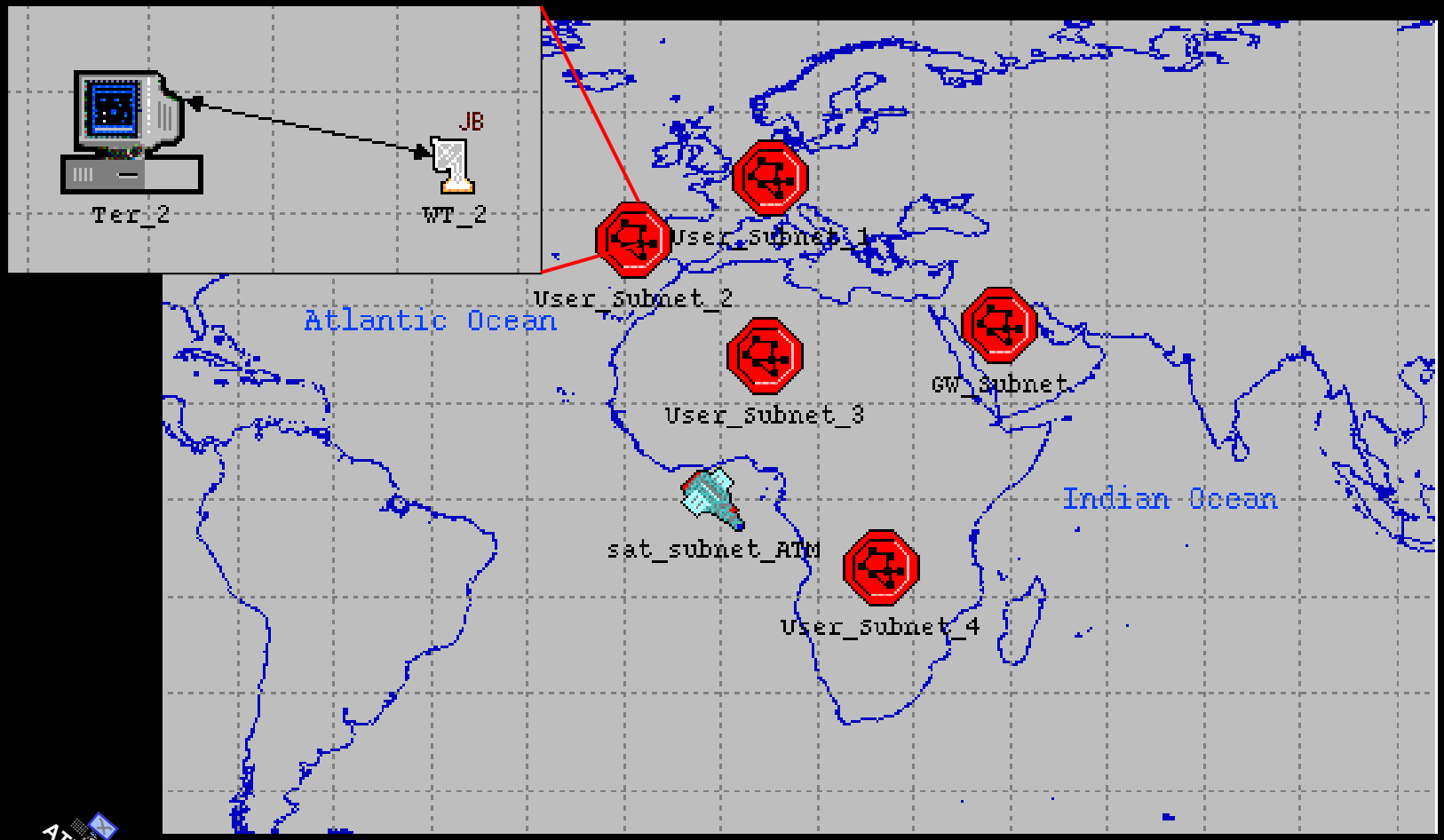
- **Token bucket process is active for each flow in satellite (scheduler)**
- **The resources are allocated according to the tokens in bucket nad resource requests**
- **The maximum number of allocated slots per frame may be limited.**
- **In the case that there is not enough resources WRR can be used with the weights of SCR**



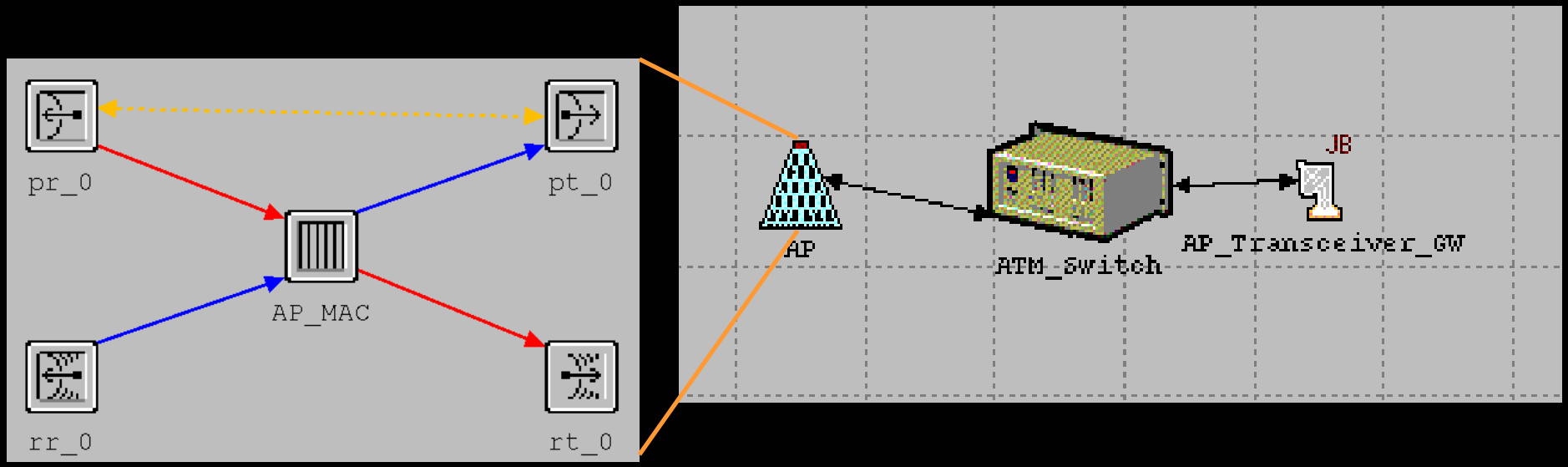
MAC Simulation with OPNET

- One satellite with standard OPNET ATM switch
- Earth station with permanent FDD links to satellite
- User terminals share the medium (FDD) in uplink (*TDMA*) and downlink (*TDM*):
  - Standard OPNET workstation models (TCP/IP)
  - UNI source OPNET models (native ATM)
- **New modules: wireless terminal transceiver with MAC and ATM interface, satellite transceiver with MAC and ATM interface**
- **Adjustable parameters:**
  - Carrier bit rates (asymmetric uplink-downlink possible), number of time slots, number of slots allocated to terminal, MAC frame length

OPNET Simulation Scenario



Sat_Subnet_ATM

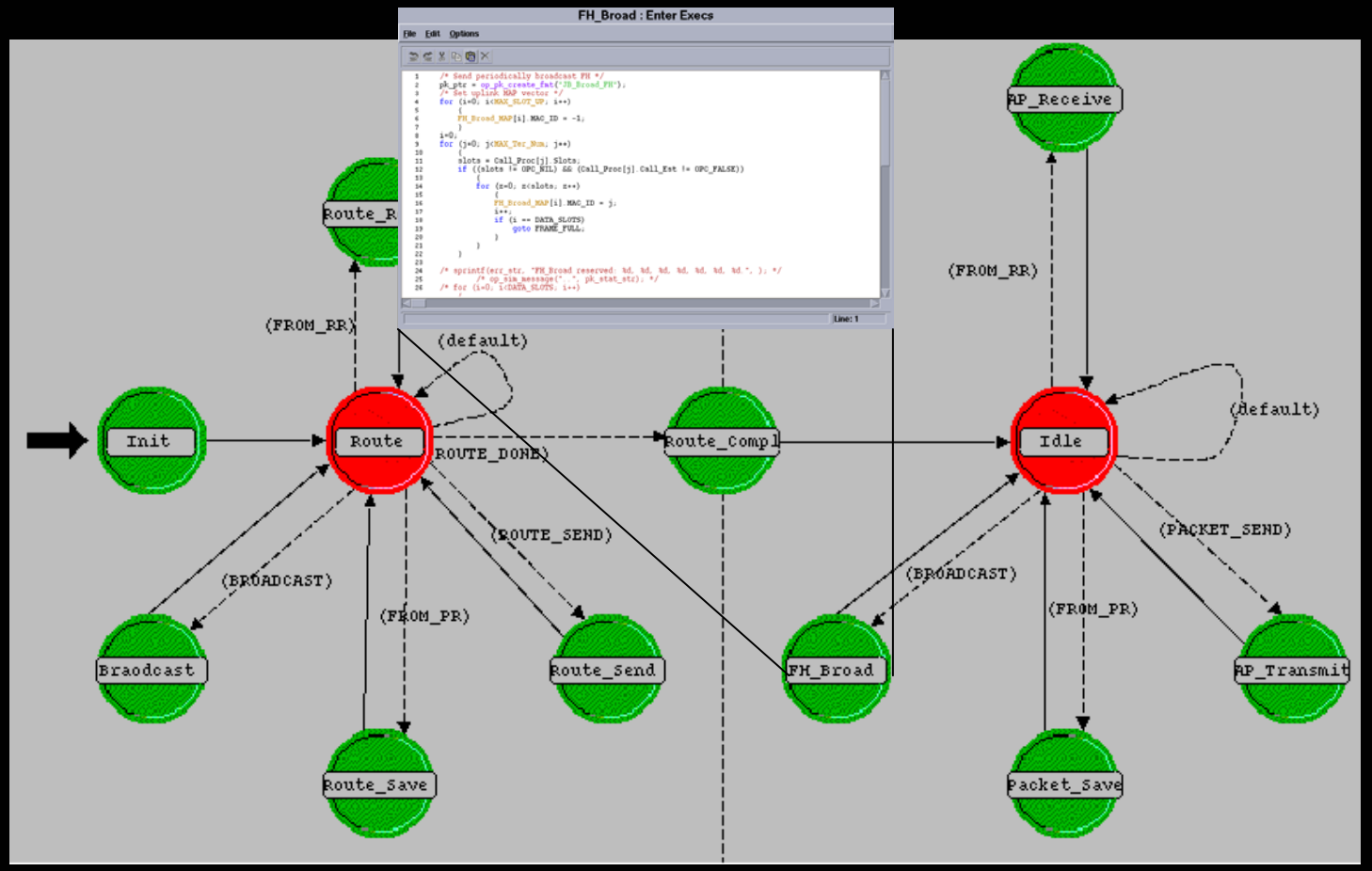


Satellite AP_MAC Finite State Machine

OPNET 6.0.L
ATM models for simulation with shared medium:

"**OPNETWORK2000**:

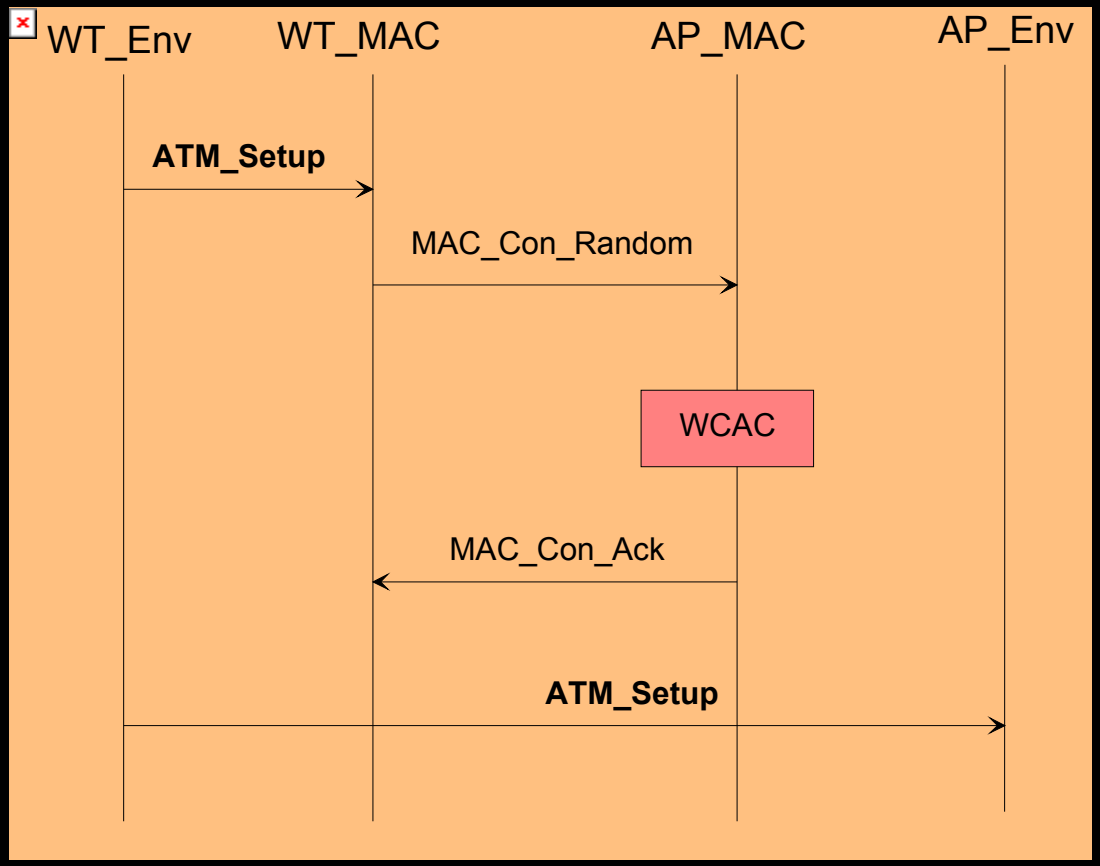
Wireless ATM Simulation with Standard OPNET 6.0.L Models"



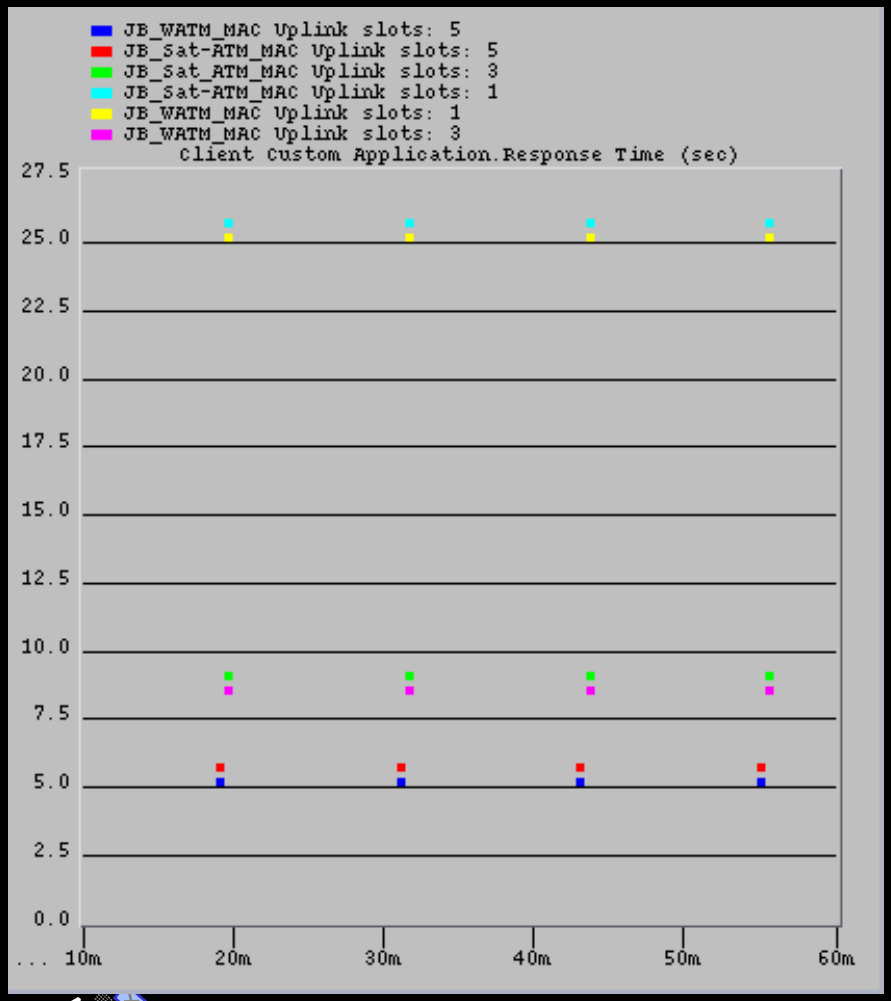
Message Sequence Chart for Outgoing Connection Setup

OPNET 6.0.L Version has a proprietary ATM signalling:

- **ATM signalling message is packed into one ATM cell**



Simulation Results (Response Time)



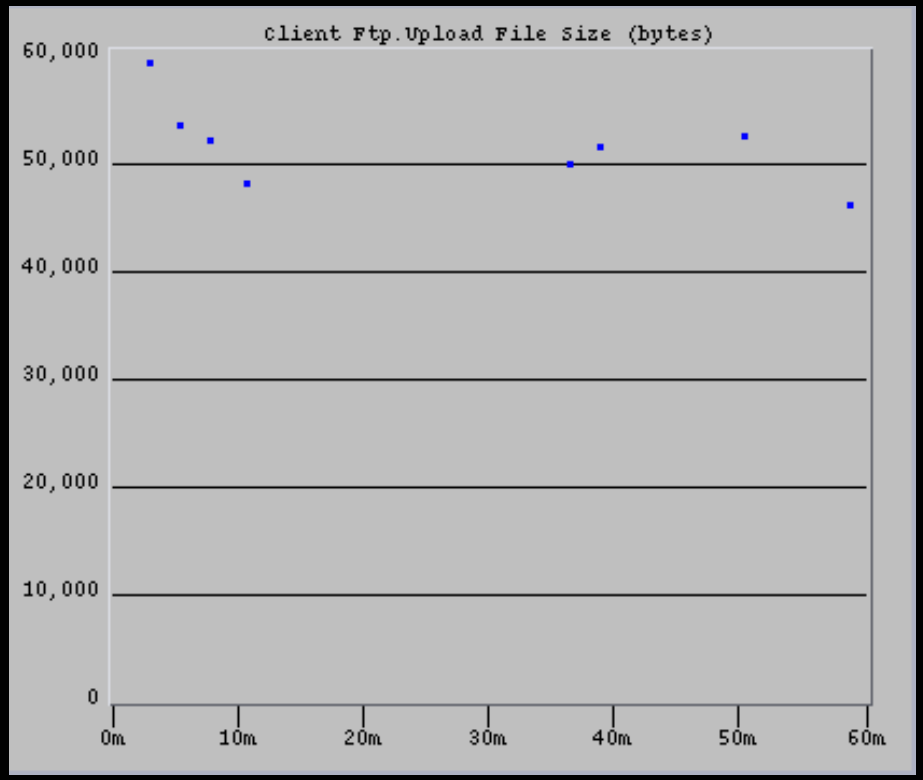
Simulation parameters:

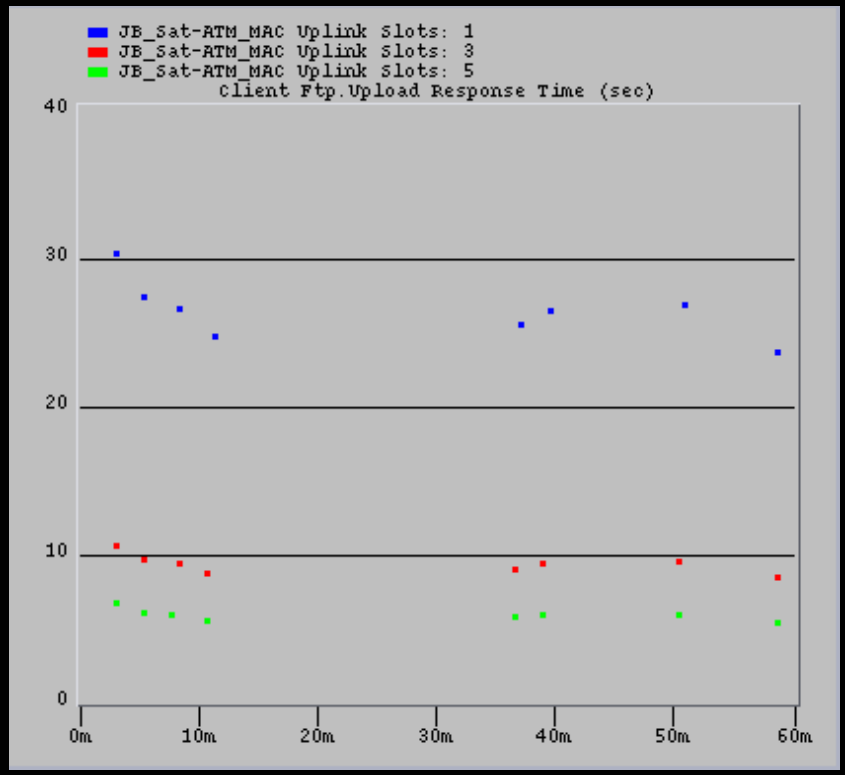
- **MAC:**
  - **Frame length: 24 ms**
  - **Time slots number: 100**
  - **Carrier bit rate: 2,150,000**
  - **MAC packet size: 57 bytes**
- **Protocols: ATM with AAL-5, Transport Adaptation Layer (TPAL)**
- **Application:**
  - **Transmission of packets with constant length of 50,000 bytes**

Response time difference between GEO satellite and WATM: ~527 ms

Simulation Results (cont.)

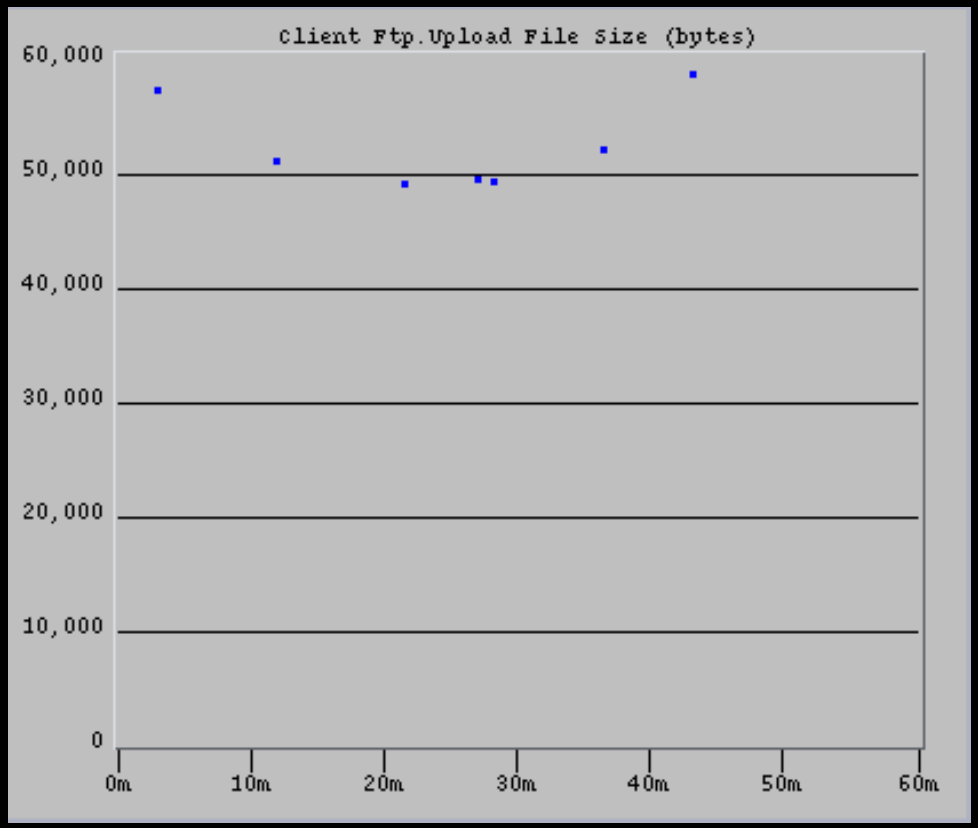
FTP transmission over satellite

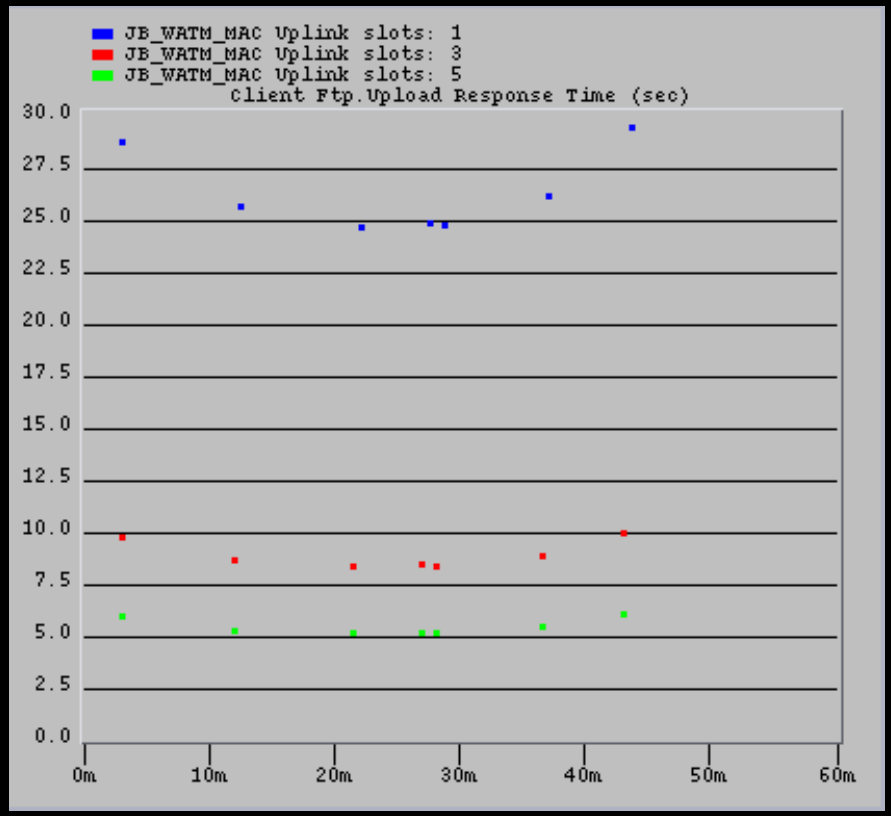




Simulation Results (cont.)

FTP transmission over WATM





Conclusions

ATM in satellite networks:

- **Bit rates for direct access are much lower (limitation for statistical multiplexing)**
- **In uplink direction the approaches differ from the ones in downlink or fixed network connections**
- **ABR, UBR and GFR service categories require similar parameters over the shared medium**

Ongoing work:

- ***Uplink scheduling algorithms implementation and evaluation***

Future work:

- ***OPNET simulation upgrade with emphasis on IP services***
- ***Selection of realistic applications***