Resource Management for Reliable Handoff in Low Earth Orbit (LEO) Satellite ATM Networks

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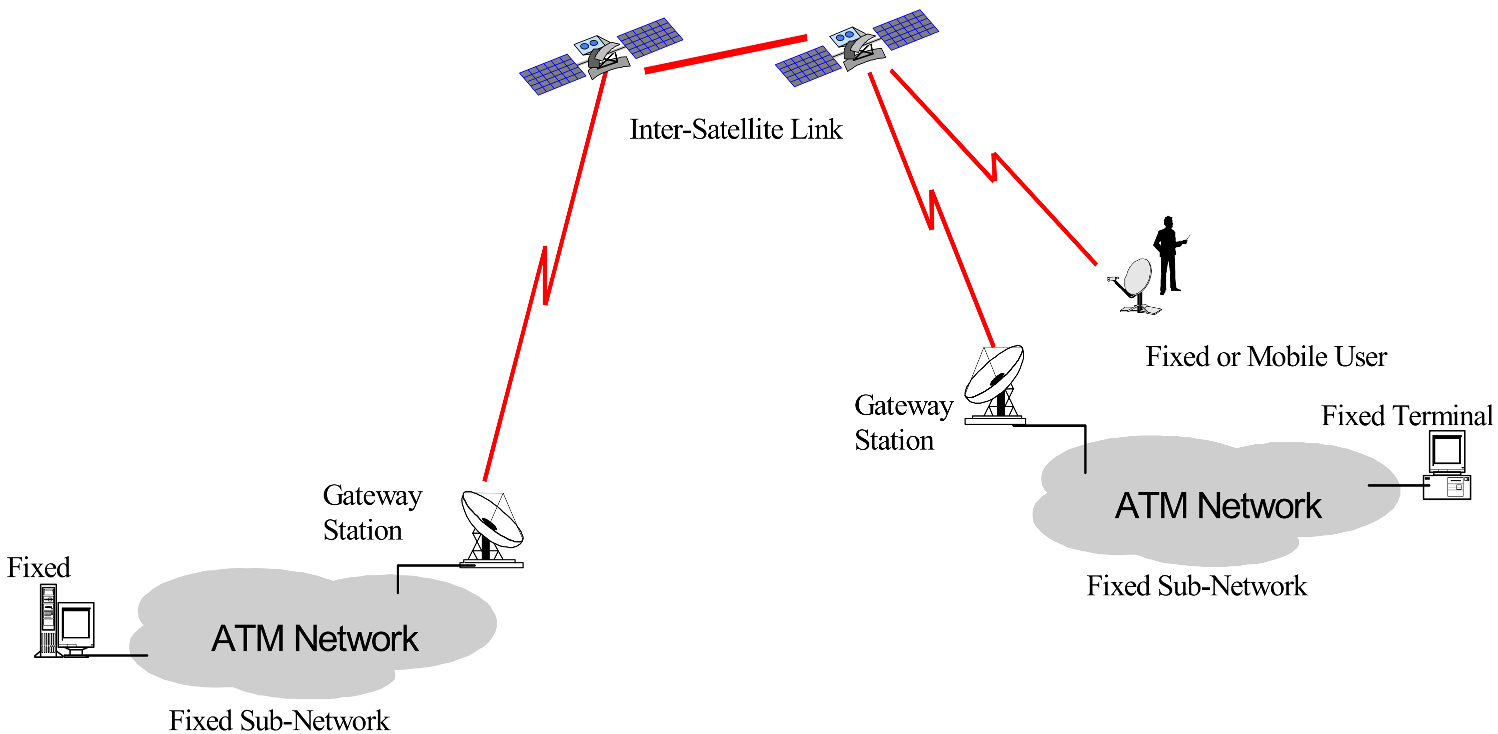
LEO satellite networks

- Offer a number of benefits:
  - wide area coverage
  - unique broadcast capability
  - ability to meet different QoS requirements
  - ability to communicate with mobile users

- Support of sophisticated PCS, including multimedia services

- On-board switching

Interconnection between fixed and mobile networks and terminals



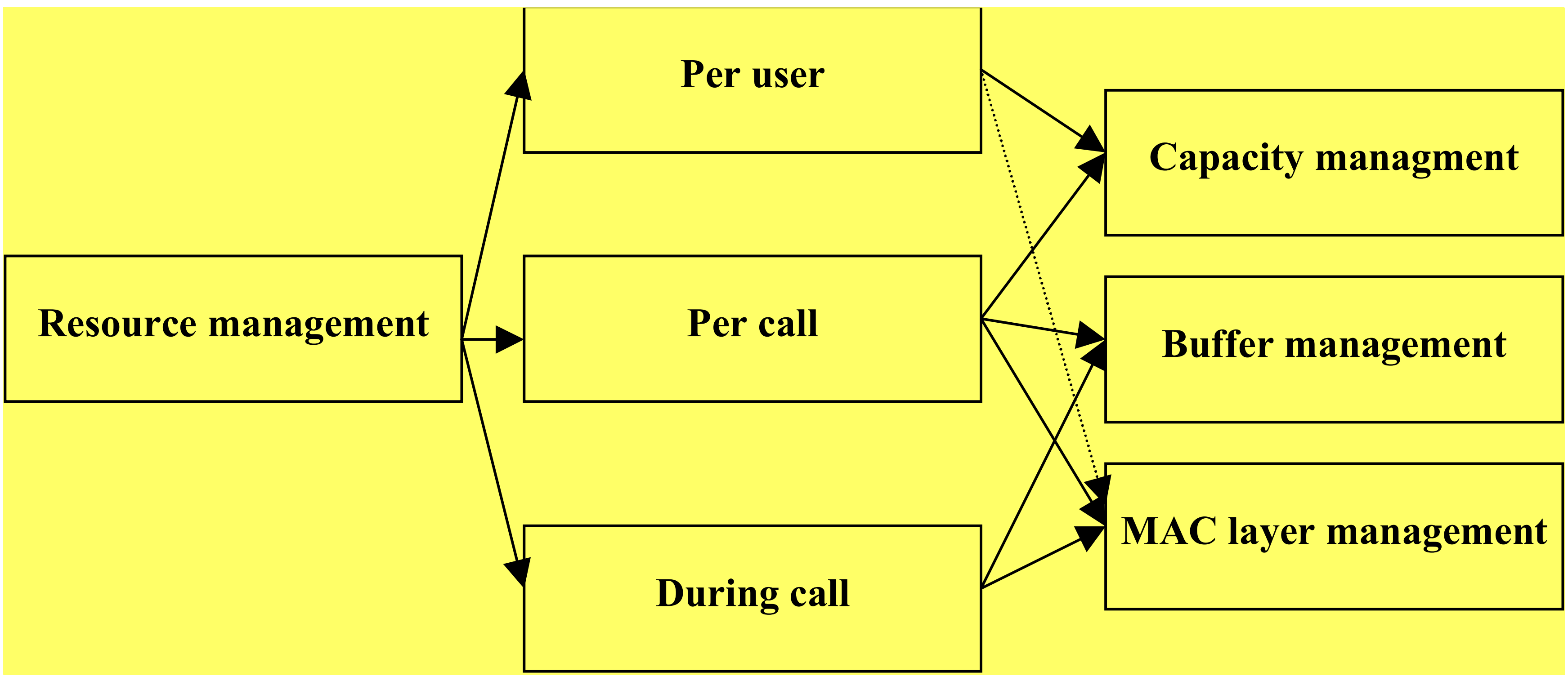
Why resource management?

- Limited bandwidth of the satellite channel
- The satellite channel capacity must be shared by a large number of users
- Limited buffer capacity of the on-board ATM switch
- LEO satellites rotate around the Earth at constant speed
- Mobile users change their access points several times
- Fair sharing of bandwidth between handoff connections and new connections is required
- Call admission, resource allocation and handoff management are becoming important areas of research

Resource management functions

- Resource Management aims to guarantee the fair distribution of the resources available among the users as well as to fulfil certain pre-negotiated QoS requirements for the lifetime of the connection
- *ATM Resource Management functions* related to flow control, congestion control and traffic control of the satellite network, and
- *Radio Resource Management functions* related to the allocation of radio resources like bandwidth, codes, frequency, etc.

Resource Management Functions(cont'd)



Connection Admission Control (CAC)

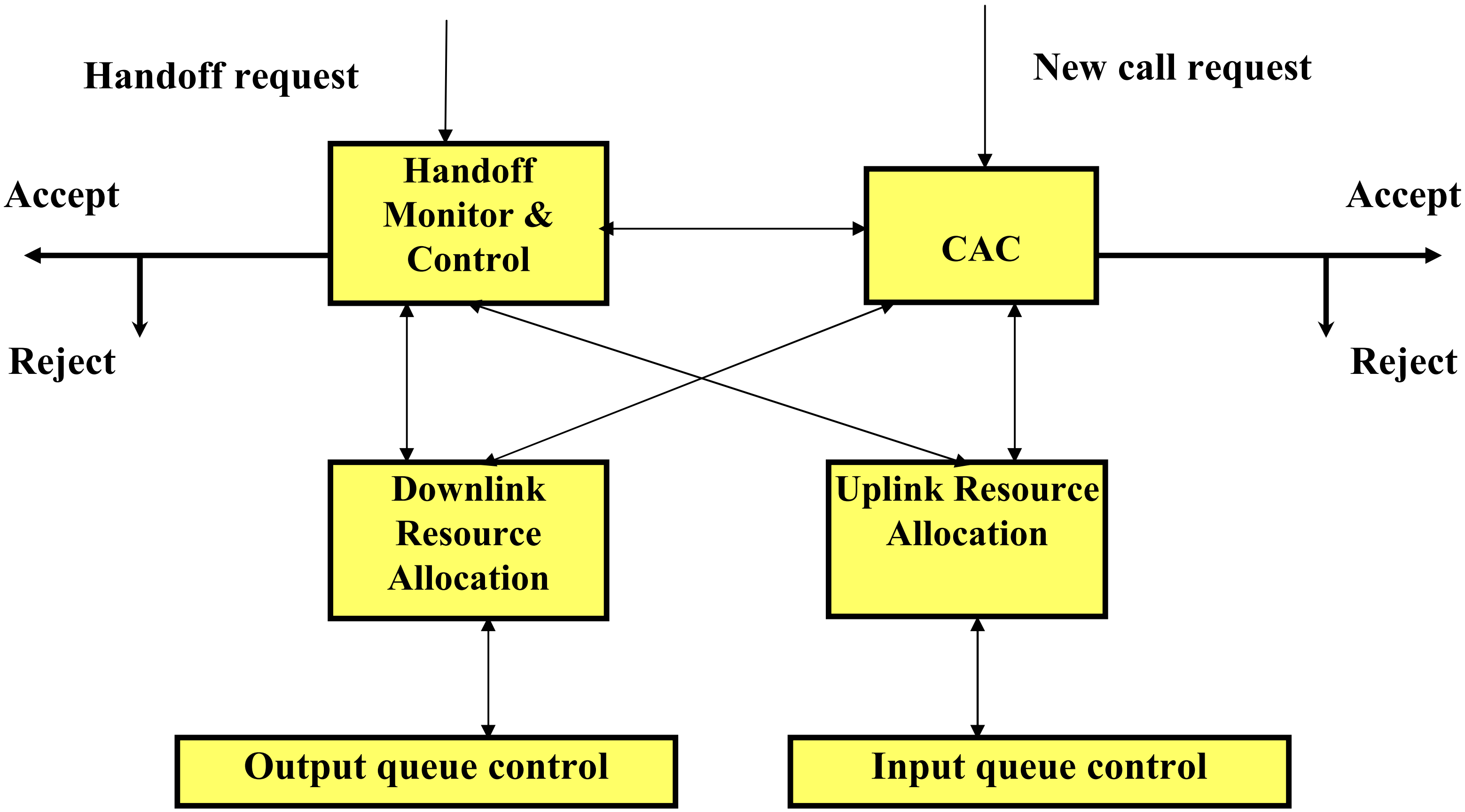
- Most important ATM Resource Management function is *Connection Admission Control (CAC)*
- CAC algorithm operates on the call level. It defines a procedure taken by the network during the call set-up phase in order to determine if the connection request can be accepted or not
- The user describes the connection in terms of network parameters and the network then uses a CAC scheme to calculate if the connection can be admitted to the network or not

On-Board Resource Management

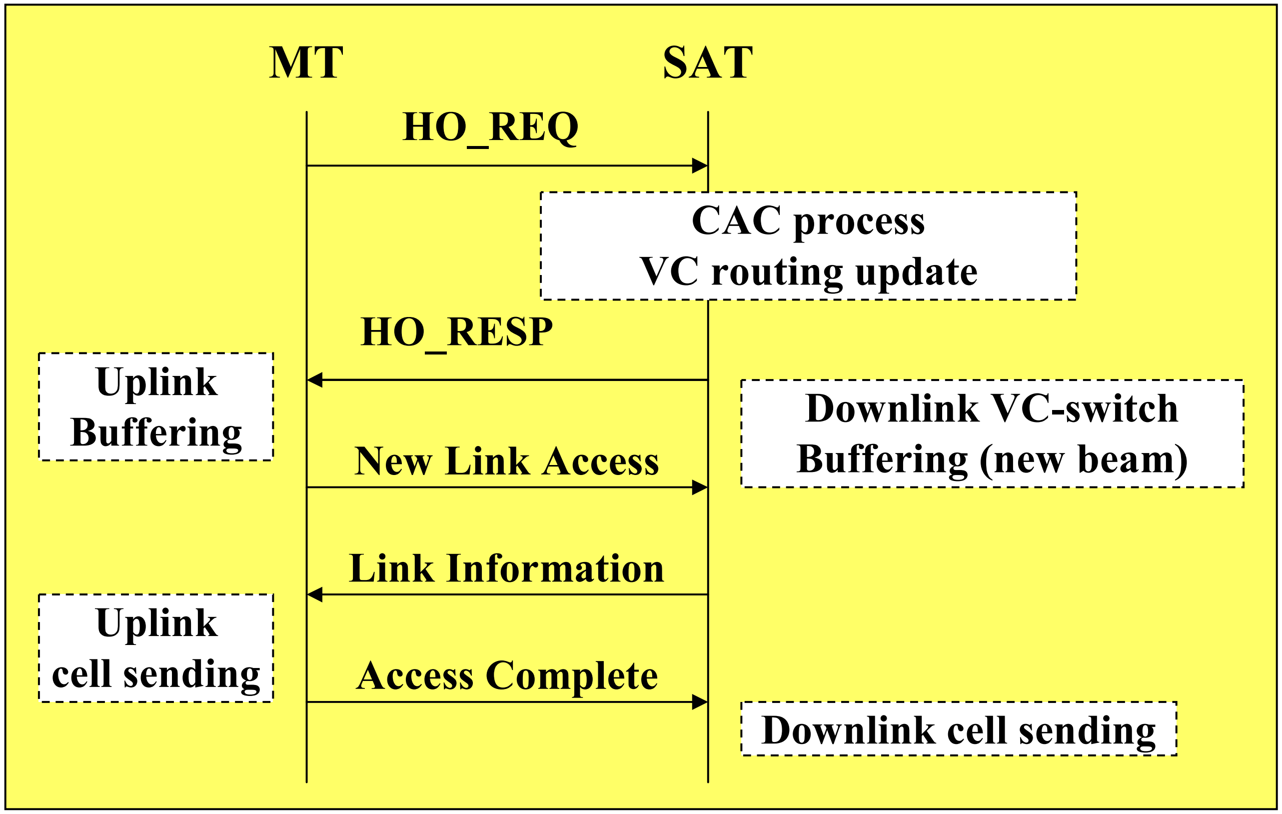
- Let us consider ATM Resource Management in terms of resource allocation implemented in the on-board ATM switch
- We address *intra-satellite handoff* focusing on the on-board ATM switch buffer architecture
- We introduce a simple CAC priority policy based on the *delay and cell loss requirements* for the investigated types of traffic: handoff CBR, new CBR, rt-VBR and UBR
- We propose an on-board input/output buffer architecture with separated buffers for *new calls* and *intra-satellite handoff calls*

S-ATM Node

- **CAC Control Module**



Intra-satellite handoff procedure

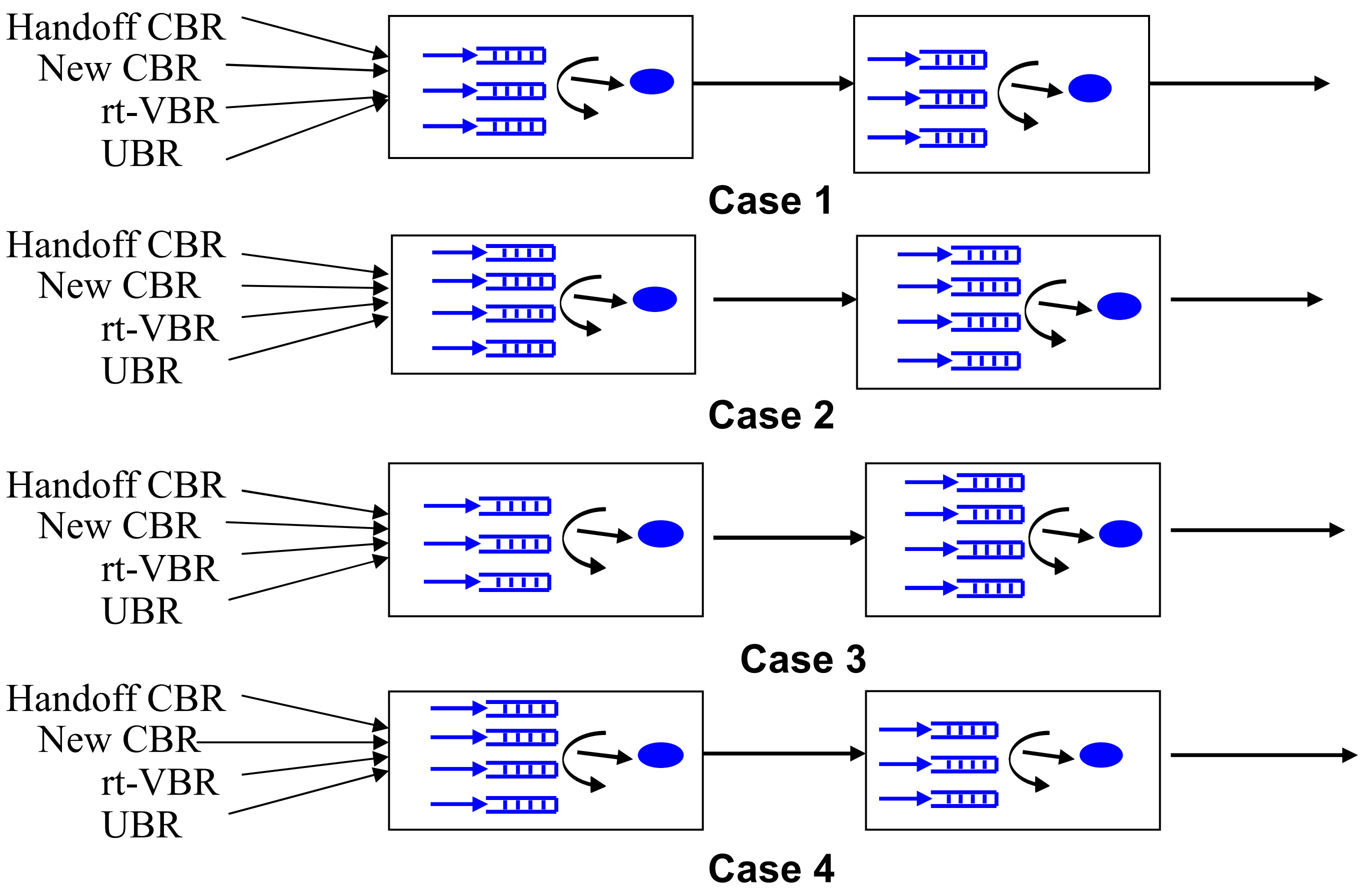


Intra-satellite handoff procedure (cont'd)

- MT will initiate intra-satellite handoff indicating the new beam ID and QoS requirements
- CAC decides if the request is accepted
- Uplink/Downlink buffering is proposed to reduce the number of cell losses
- On-board buffer architecture offering separate buffers for new and intra-satellite handoff calls

On-board buffer architecture schemes

- **Simulation Cases**



The simulation model - parameters

- ✓ Handoff and CBR traffic: Poisson distribution
- ✓ rt-VBR traffic: on-off model, on-time and off-time durations are exponential distributed
- ✓ On-time mean value is 100ms.
  Burstiness = Peak cell rate / Mean cell rate
- ✓ UBR traffic: on-off model, on-time and off-time durations are exponential distributed

The simulation model - parameters (cont'd)

- ✓ On-time mean value is 60ms, off-time mean value is 60 ms. Cells are generated as Poisson distribution during on-time duration
- ✓ Output link capacity is 45Mbit/s i.e. 100000 cells/sec. modeled as deterministic distribution
- ✓ Input serving time is 5 time shorter than that of the output

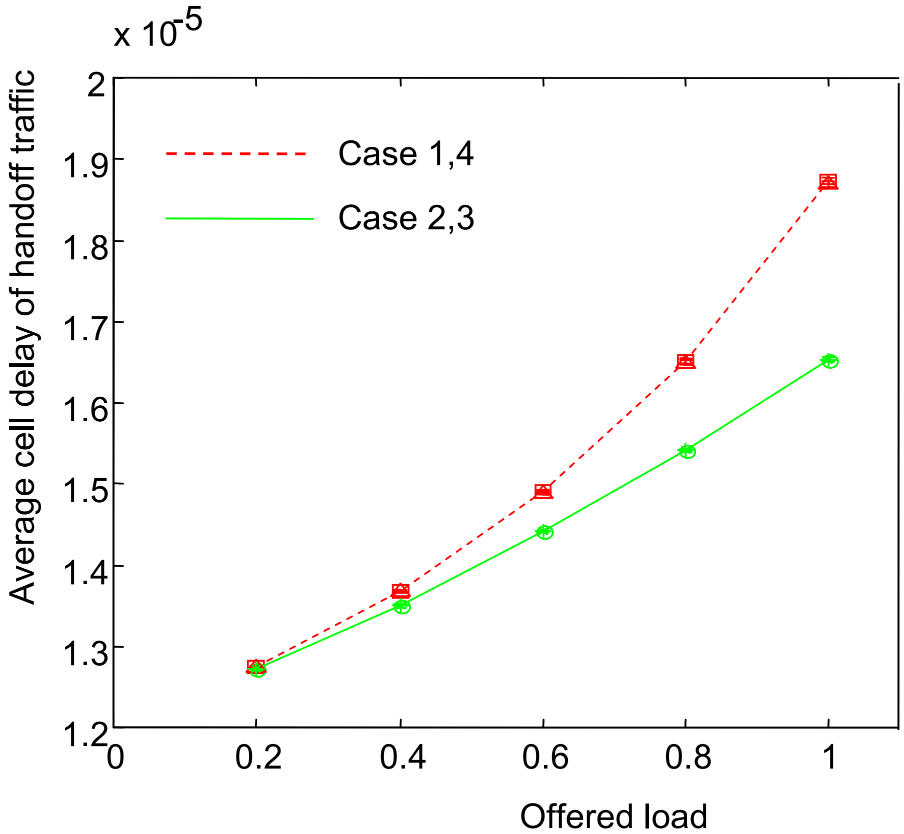
Additional parameters

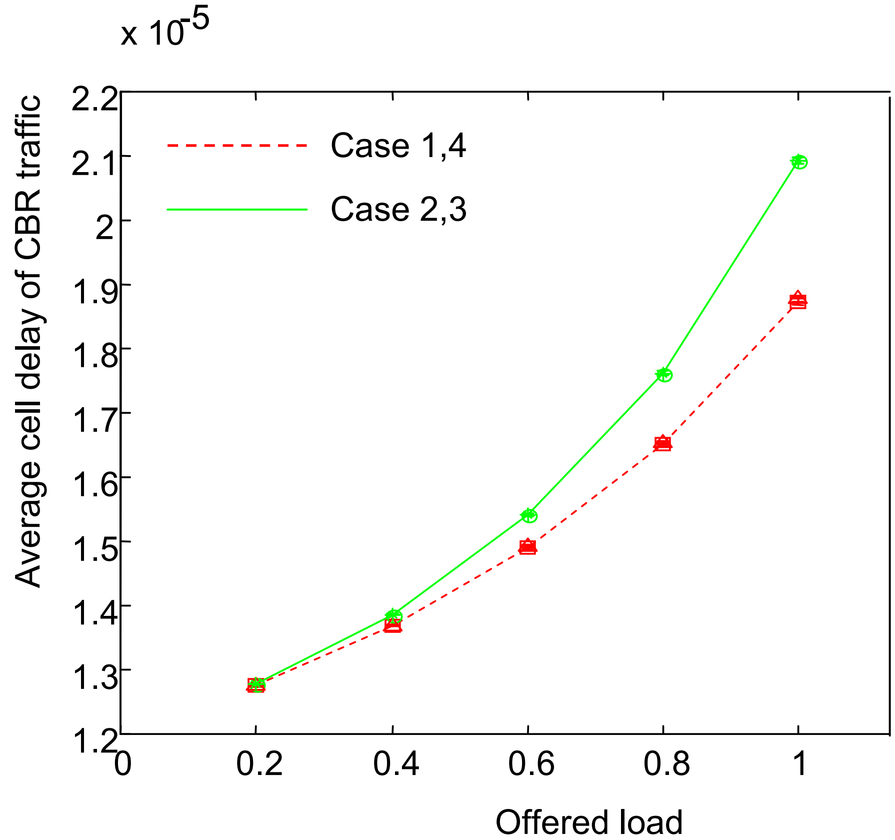
- In the case of handoff, the handoff source will buffer its cells (to avoid loss cells) and transmit them when handoff finishes
- We only simulate the ATM layer i.e. assume that radio resource is available. Handoff radio access interruption is assumed 30ms.
- In case of four buffers, handoff CBR call has highest priority, and then priority assignment is as follows: new - CBR call, rt-VBR and UBR call
- In case of three buffers, handoff CBR and new CBR have same priorities and are served as FIFO in the CBR buffer
- We define: Offered load = Peak input rate / Output rate

Simulation results

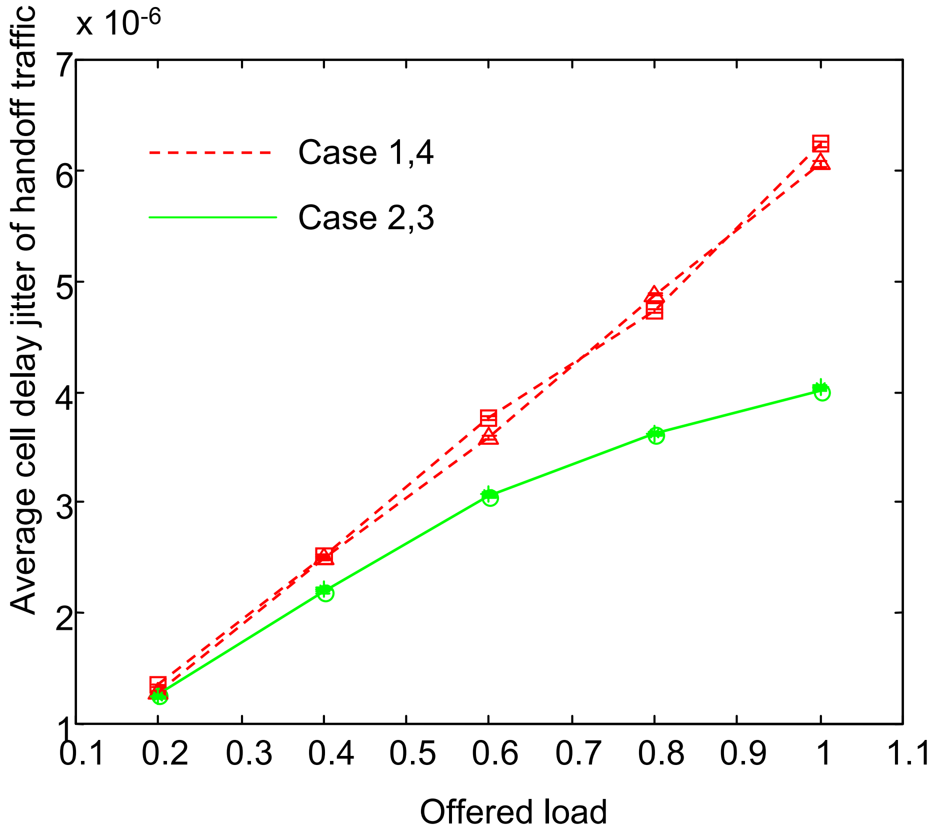
- **Goal**:
  - Validate our on-board buffer architecture in terms of keeping Average Delay and Average Delay Jitter low
  - Optimize buffer space in terms of keeping the Cell Loss Probability (CLP) equal to 3.10^{-7}

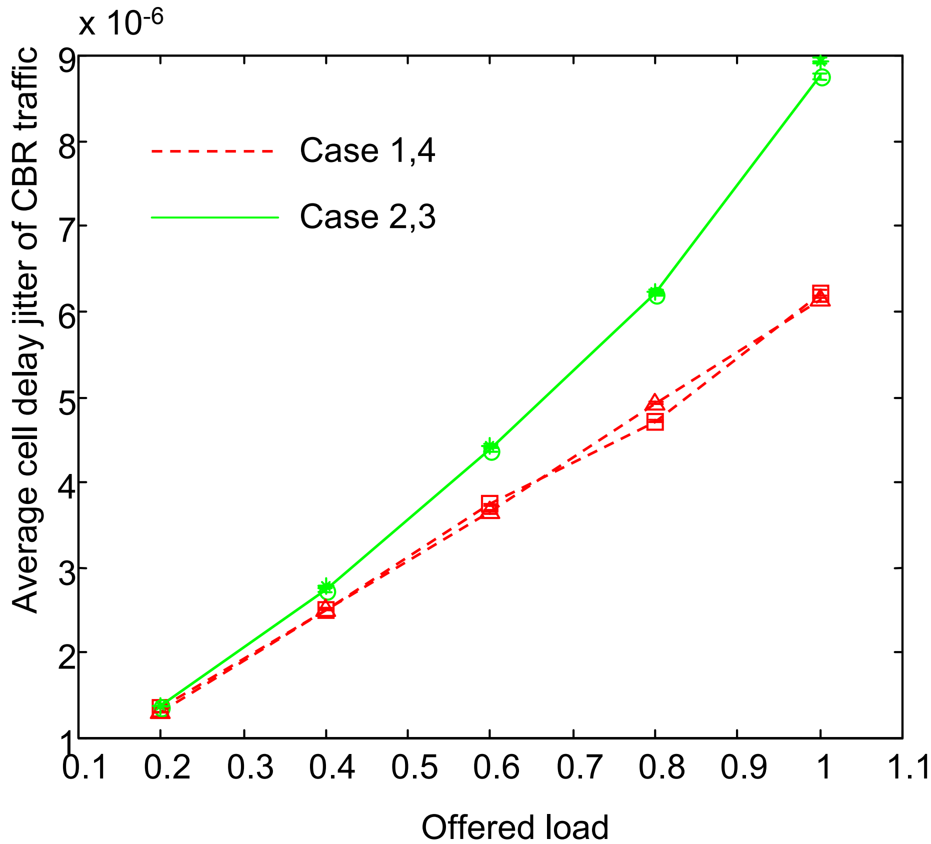
Cell Delay of Handoff and new CBR traffic



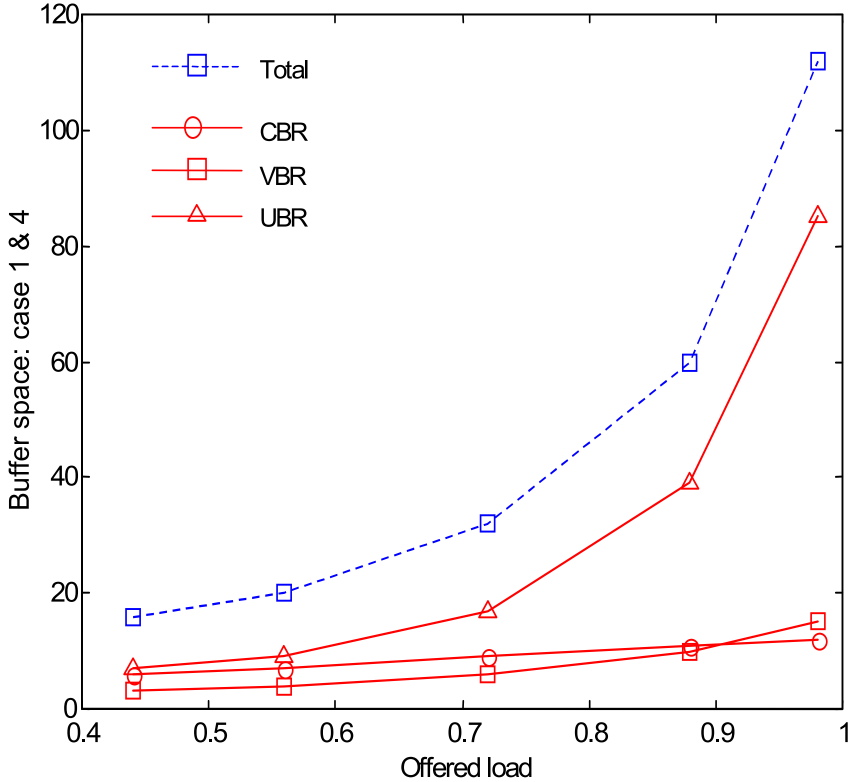


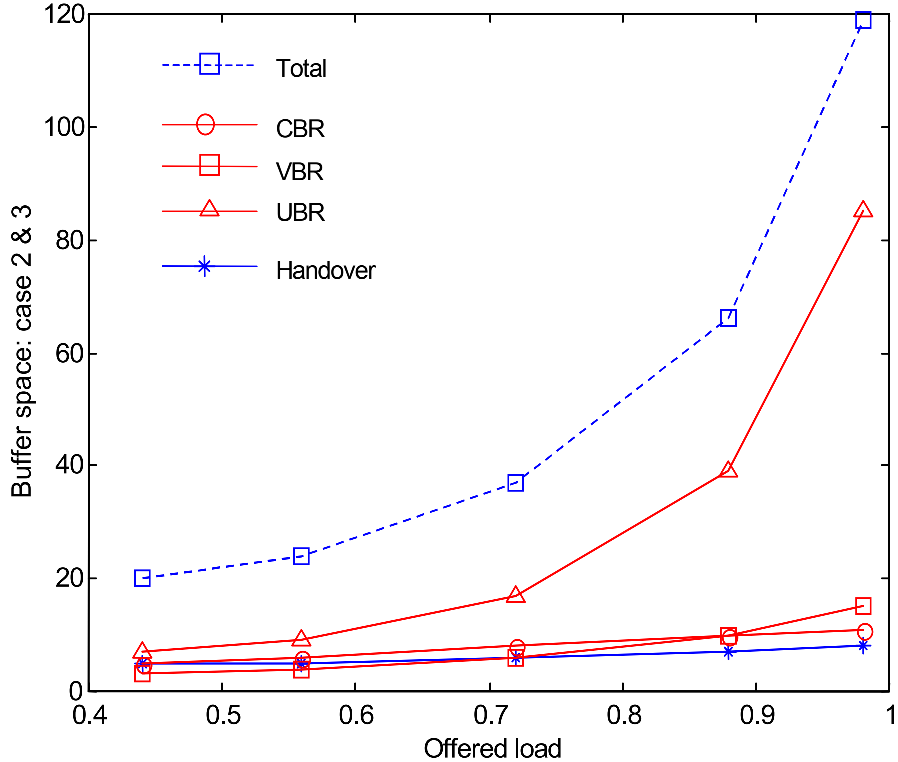
Average Cell Delay Jitter of Handoff and new CBR traffic





Output buffer space optimization





Concluding remarks

- Different buffer architectures cause different Delay/Delay Jitter to handoff CBR and new CBR traffic but NOT to rt-VBR and UBR traffic
- Case 1 and Case 4 show same simulation results: (introduction of a separate queue for handoff traffic at the input ONLY does not influence the Delay /Delay Jitter performance)
- Introduction of separate queue for handoff traffic at the output with the highest priority significantly improves performance

Concluding remarks (cont'd)

- The buffer architecture in Case 2 and Case 3 reduces significantly the Delay/ Delay Jitter of handoff and new CBR traffic when load increases
- A very small buffer space at the input port is sufficient to ensure the desired CLP in all proposed cases
- In Case 2 and Case 3 the amount of total buffer space increases slightly
- Our CAC rules are easy to implement and evaluate and lead to fair utilization of buffer memory in the presence of handoff traffic