Terminal Structures and Air-Interface Protocols

Tho Le-Ngoc, Concordia University

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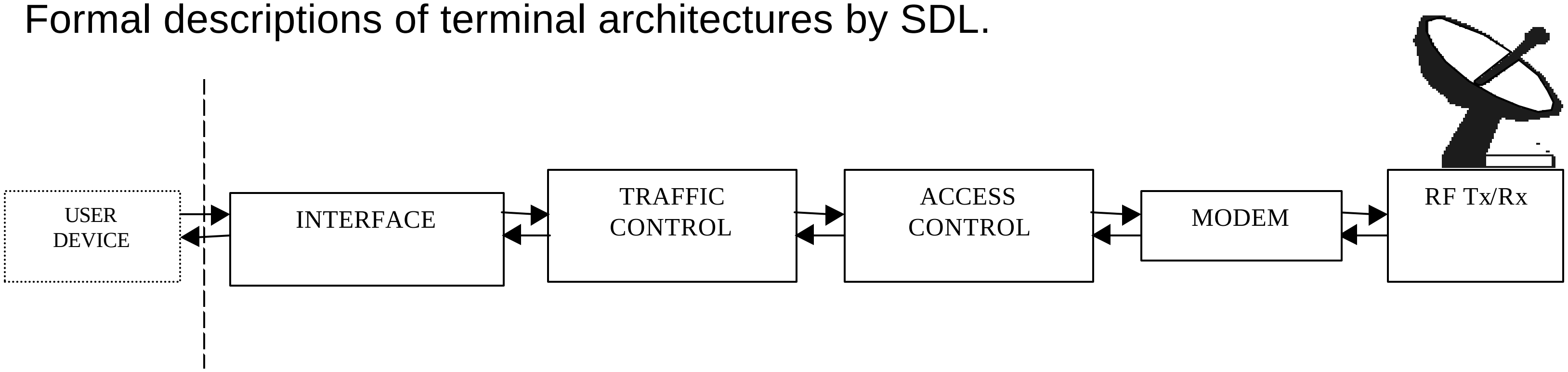
- terminal architectures with appropriate air interface protocols that provide efficient utilization of communications resources in support of voice, video, data and multimedia services.
- flexible multi-access, dynamic allocation, traffic control techniques suitable to the design and implementation of advanced satellite communications systems for broadband multimedia services.
- Formal descriptions of terminal architectures by SDL.



Satellite-Based Systems

Advantages

- Global connectivity
- Multipoint and broadcast transmission
- Quick network configuration/reconfiguration
- Rapid allocation of space segment capacity
- Distance-insensitive costs

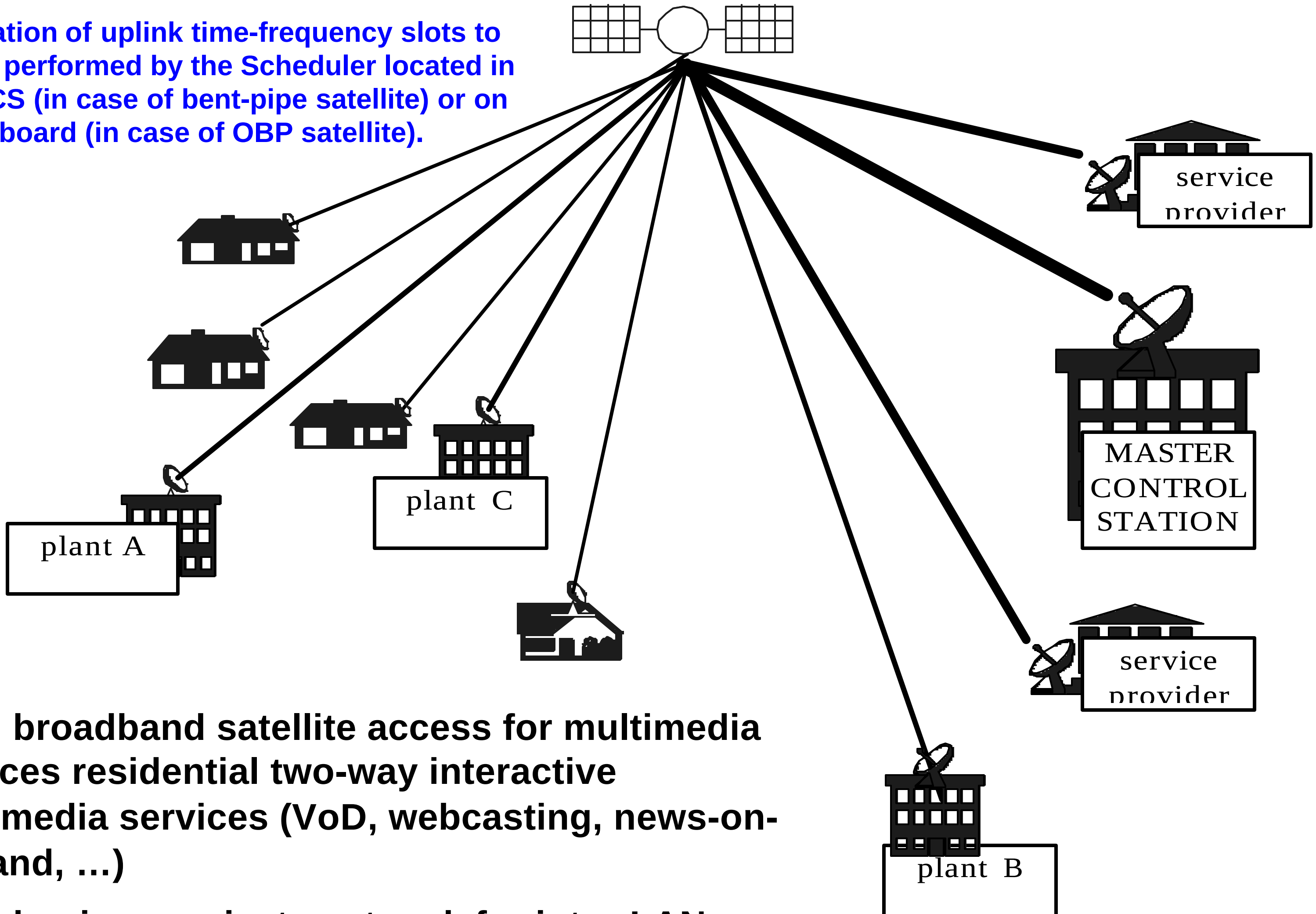
Disadvantages

- Large propagation delay
- Power- and bandwidth-limited environment

Multimedia Satellite Communications System

serving terminals of different sizes

Allocation of uplink time-frequency slots to UT's is performed by the Scheduler located in the MCS (in case of bent-pipe satellite) or on board (in case of OBP satellite).



BSA: broadband satellite access for multimedia services residential two-way interactive multimedia services (VoD, webcasting, news-on-demand, …)

BPN: business private network for inter-LAN

Integrated Uplink Multiple-Access Schemes

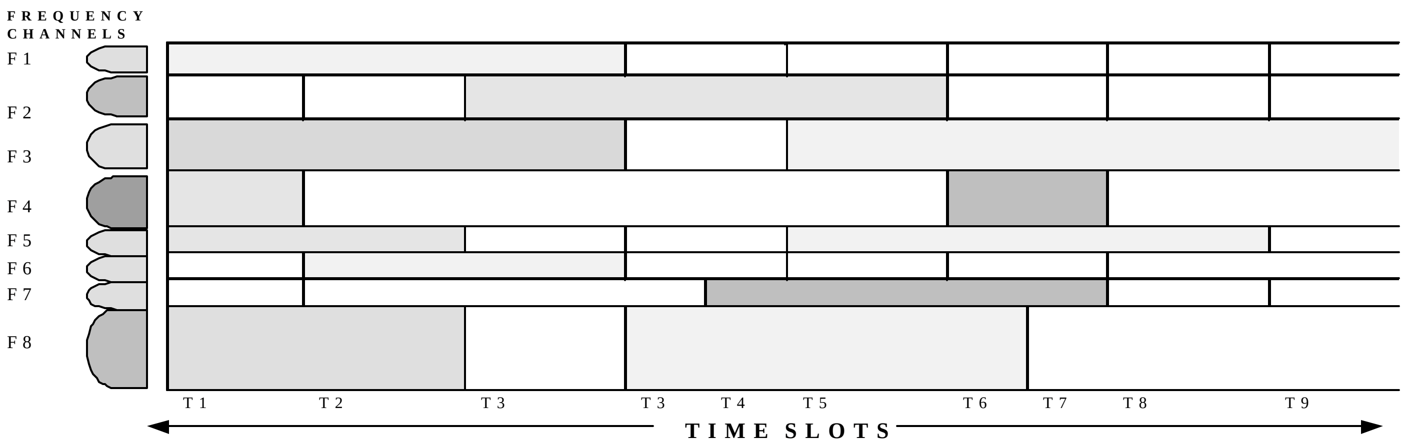


Figure 2: ***Flexible*** **MF-TDMA Structure with** ***variable-size*** **frequency channels and time slots**

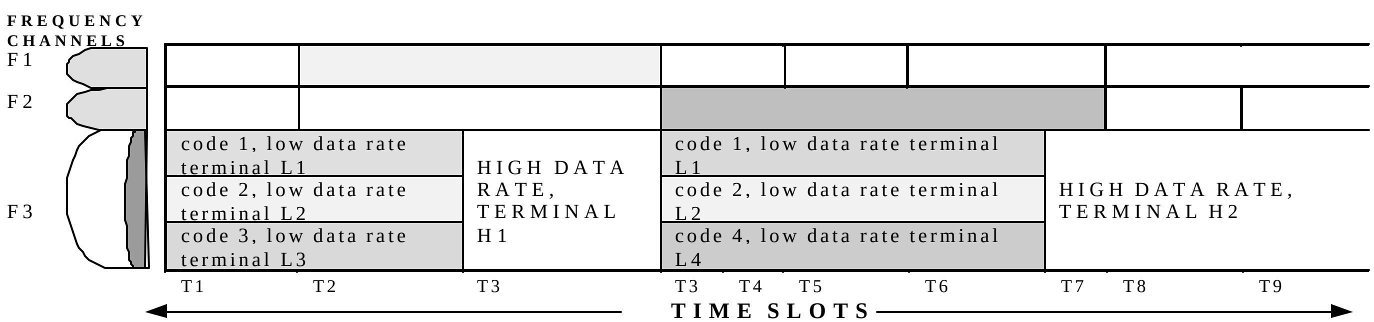


Figure 3: ***Flexible*** **3-dimensional MF-MC-TDMA Structure**

Efficient Uplink Transmission Scheduling & Dynamic Capacity Allocation Techniques in MF-MC-TDMA environment

DCA Issues

BSA

Communication is ***asymmetric***:

- **Downstream:** heavy load and less bursty ➔ constant, steady capacity allocated to BTS
- **Upstream:** low load and bursty ➔ dynamic scheduling to efficiently share uplink bandwidth among the large number of STS

PBN

Communication is ***symmetric***:

- Traffic between UT’s has relatively equal load ➔ dynamic scheduling to efficiently share uplink bandwidth among the large number of UT’s

Traffic Control Issues

To satisfy the different QoS requirements:

- **prioritization:** gives a better performance to traffic with higher priority
- **provisioning:** provides the network with a quantitative measure of the network commitment to support the higher QoS
- **policing:** ensures the conformance of sources to their pre-determined traffic characteristics
- **traffic control:** oversees the proper handling of network resources - admission control, flow control, and congestion control

Challenges and Proposed Solutions

Challenges

- To maintain QoS (packet loss probability, packet transfer delay & delay variance) and to achieve high resource utility
- Long propagation delays in satellite system may introduce long response time
- Efficiency vs. processing time required for DCA and traffic control

Proposed Solutions

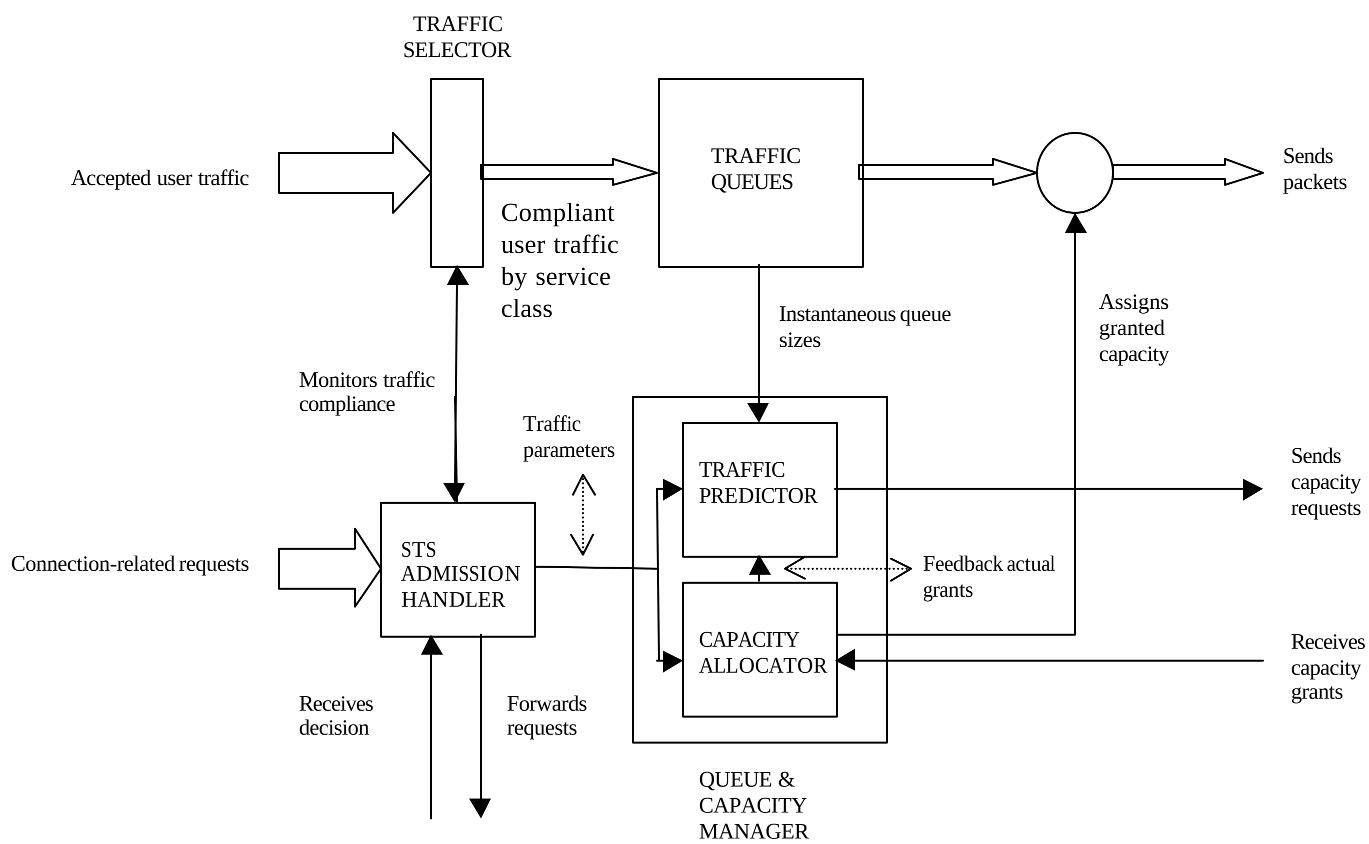
- DCA and traffic control
- Prediction of capacity requirement
- Distributed/cooperative control system

Architecture Design Approach

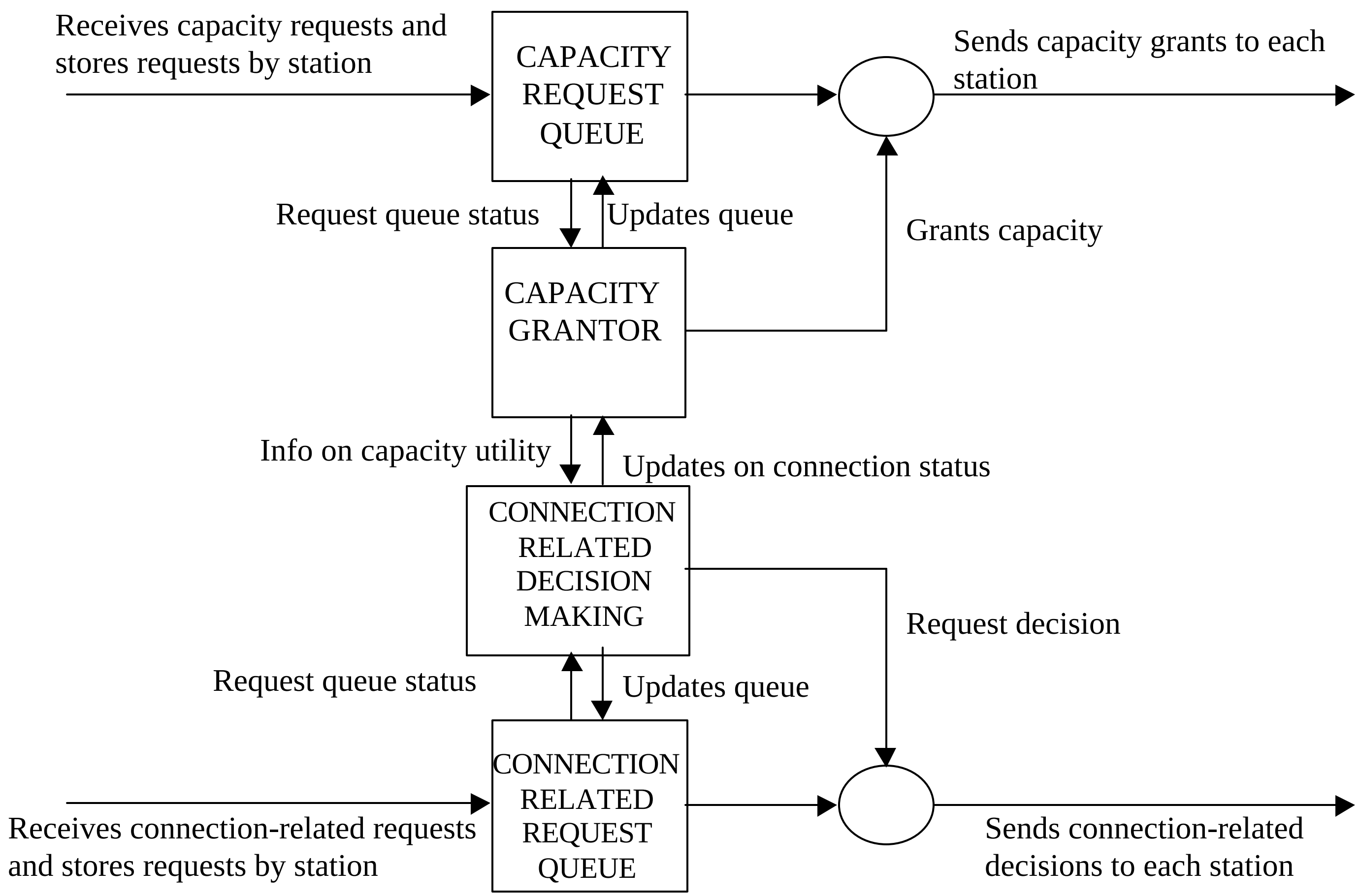
To reduce MCS processing, a distributed control structure is proposed:

- **each station (STS or UT):**
  - **actively polices its user traffic**
  - **requests user capacity from MCS**
  - **allocates granted capacity to user**
  - **assists MCS in admission control**
- **MCS:**
  - **receives capacity requests from all stations**
  - **grants capacity to each station**
  - **makes admission control decisions**

Functional Elements of MAC in STS/UT



Functional Elements of Scheduling in MCS



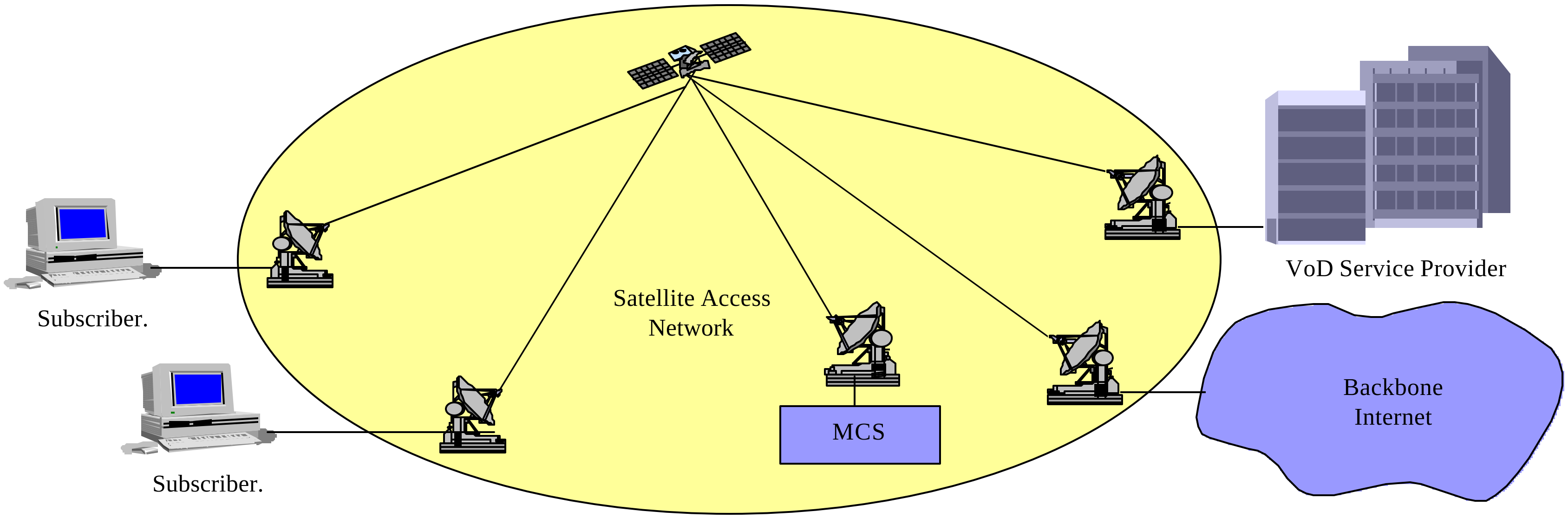
Dynamic Capacity Allocation

- Challenges:
  - bandwidth utilization efficiency
  - bursty traffic with different services and different QoS requirements
  - long propagation delays ➔ at MCS, current station needs can be outdated
- Combined free/demand assignment multiple access (CFDAMA) technique:
  - capacity is first assigned based on terminals demands
  - remaining capacity is *freely* allocated to all terminals
- Free assignment provides fast transmission
- Possible *free assignment* strategies:
  - round-robin: simple but may not be efficient
  - based on prediction using knowledge of traffic characteristics: parameters and indicators

Traffic Measures for Prediction

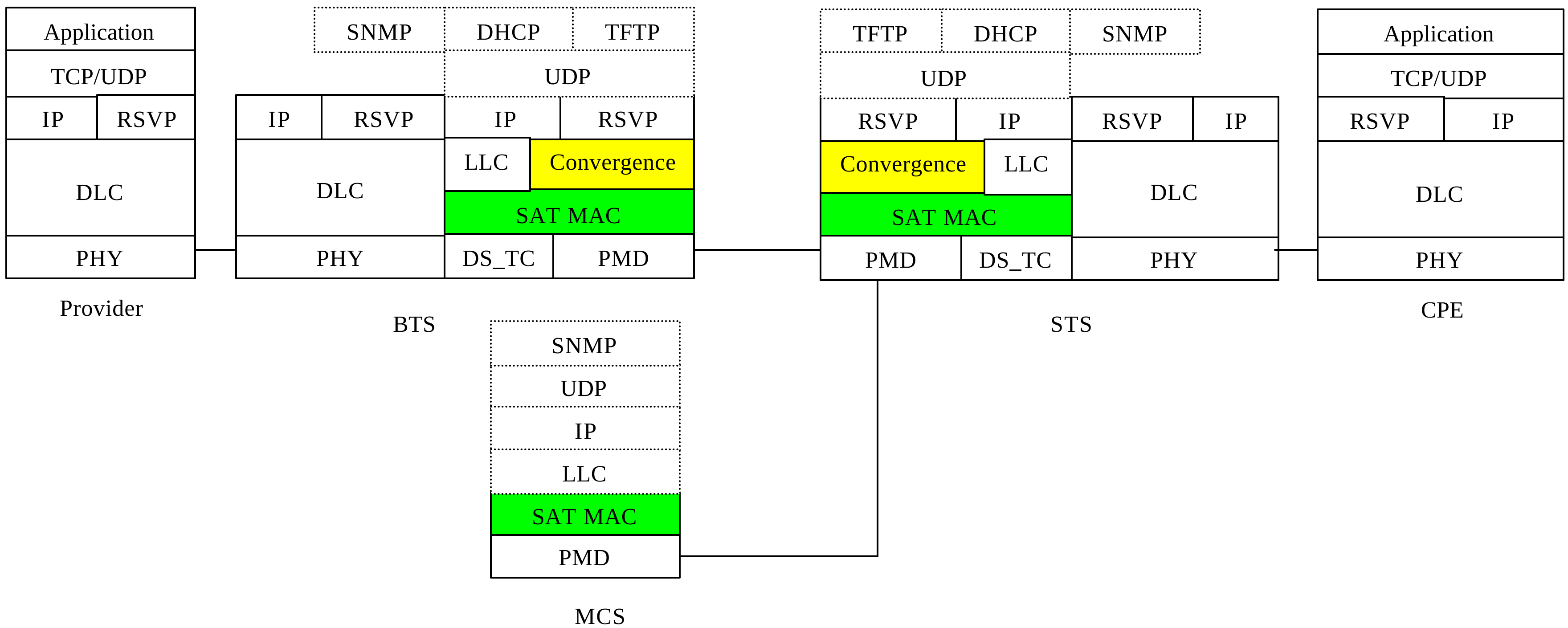
- **Traffic parameters:** constitute an agreement between the station (STS or UT) and the MCS on the characteristics of the traffic. These are clearly defined in RSVP and DOCSIS. The relevant parameters for prediction are:
  - average rate
  - peak rate
  - burst length
- **Traffic indicators:** are traffic characteristics that can be monitored during a connection. The relevant indicators for prediction are:
  - queue lengths
  - packet arrivals

BSA (Broadband Satellite Access)



- Addresses the same markets and services as other access technologies (BWA, DSL, etc.).
- Advantages:
  - Global connectivity.
  - Transmissions are broadcast in nature. This provides a cost-effective environment for deploying the broadcast/multi-point services.
  - Reaching remote inaccessible areas where there is no backbone.
  - Cost-effective in low population rural areas.
  - Distance insensitive.

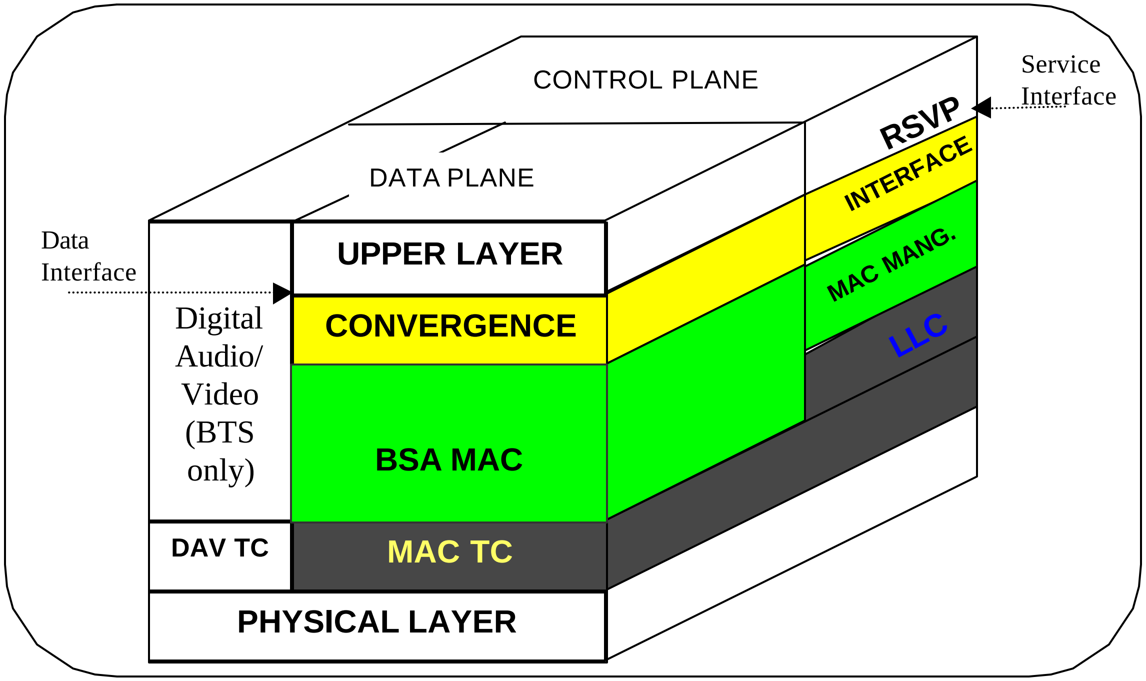
Overall Protocol Stacks for BSA System



The STS and BTS may operate as
forwarding agents (bridging or at the network level as shown above)
and also as end-systems (hosts).

Protocol Stacks

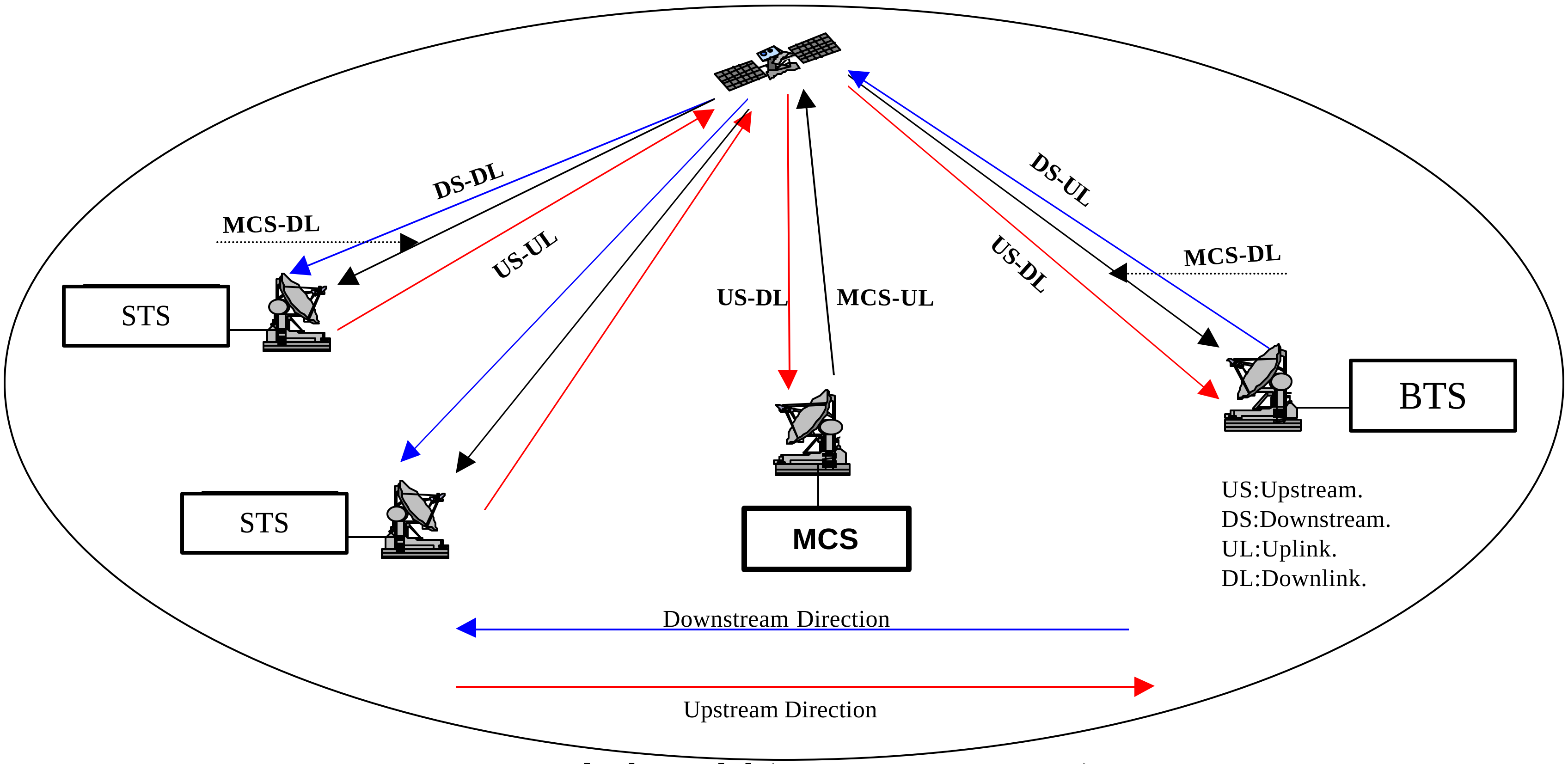
- Upper layers
  - The proposed MAC may independently support internet protocol service and ATM cell relay service (circuit-based).
  - The efficiency of IP over ATM is a current research issue.
- Convergence Layer
  - Encapsulates PDU framing of upper layers into the native BSA MAC/PHY PDUs.



BTS and STS as Forwarders at the Network Layer.

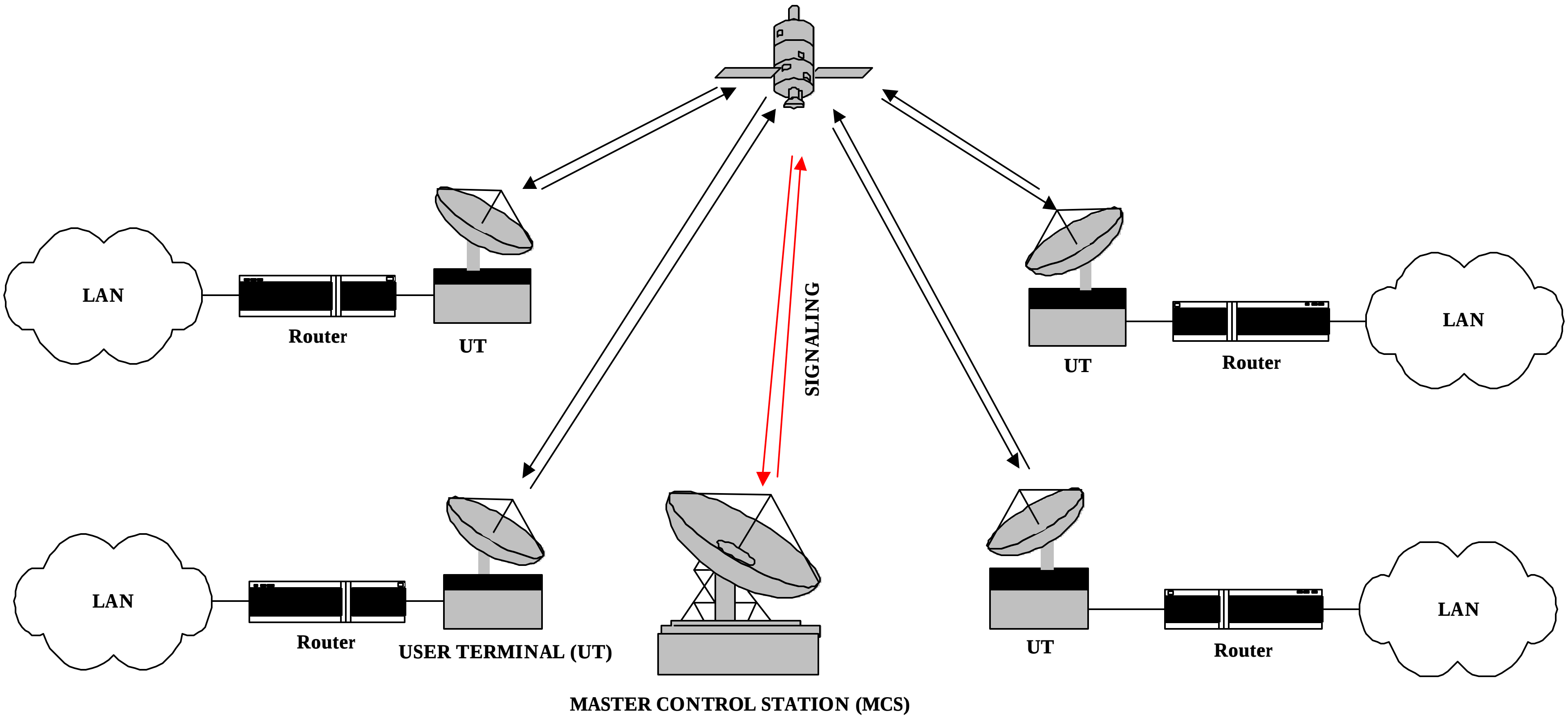
  - Maps upper layer's addresses into BSA addresses.
  - Translates upper layer QoS parameters into BSA MAC constructs.
- MAC Layer
  - Guarantees efficient data transmission over the satellite medium.
- PMD
  - Responsible for physical transmission of bit stream bursts over satellite channel.

BSA Block Model



BSA Block Model (One Access Domain)

Satellite-based business private network for Inter-LAN connections



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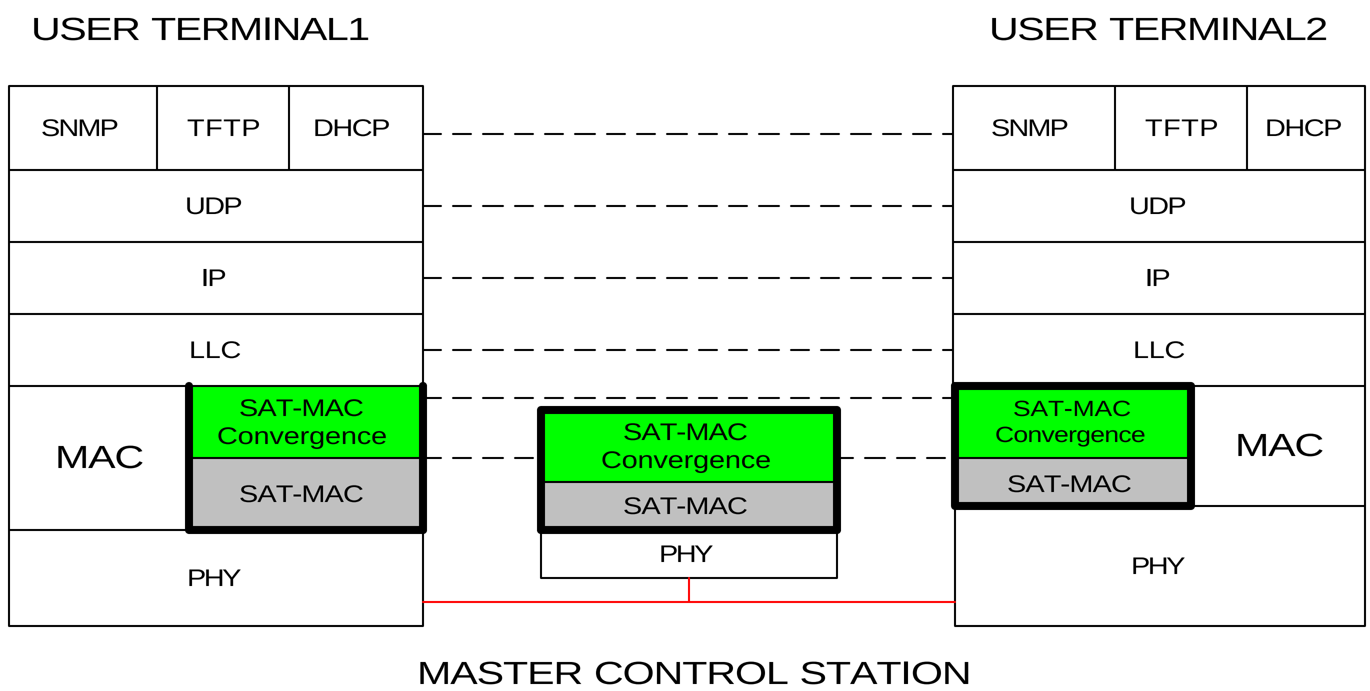
Protocol Stack for BPN



•**SAT-MAC:** responsible for power-on initialization, synchronizing, scanning, ranging, registration, SAT-MAC PDU handling, data transmission

• **SAT-MAC Convergence:** responsible for interaction with upper-layer protocols **to provide**

•dynamic capacity allocation, scheduling of the traffic

• QoS support, translation of QoS parameters to service categories