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The L*IP Access System

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L*IP Satellite System

- Prototype built for ESA, ARTES-5 contract
- Meshed MF-TDMA, over GEO
- Optimized for IP
- QoS
- DAMA
- MF-TDMA modem supports up to 4 Msymb/s
- QPSK, Turbo codec
- Fade mitigation techniques

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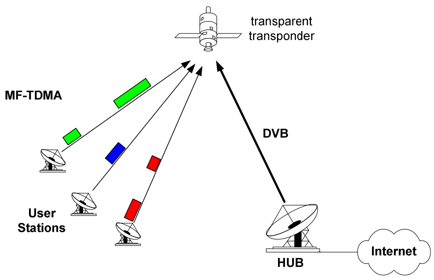
A Star Satellite Network, e.g. DVB/RCS



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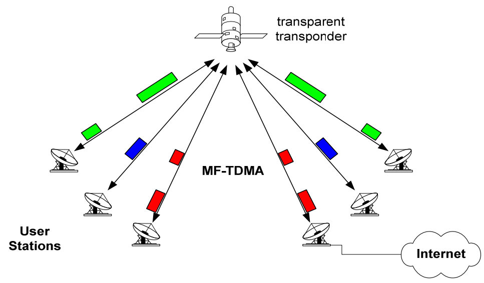
A Satellite Network with Meshed Topology, like L*IP



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Comparison Star versus Meshed Topology in Satellite Networks

Problems of star topology with DVB as forward channel:

- fixed allocation of forward / return bandwidths
- double hop for communication between 2 user terminals
  - → twice the delay and twice the bandwidth
- considerable large minimum bandwidth for DVB
- expensive hub, even for small networks
- but: receiver in terminals are cheap (mass market)

Meshed: flexible bandwidth allocation in forward and return

- single hop between slaves
- but: slaves are more complex

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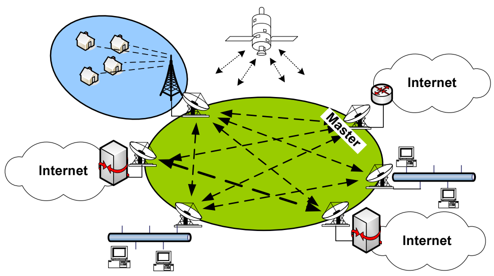
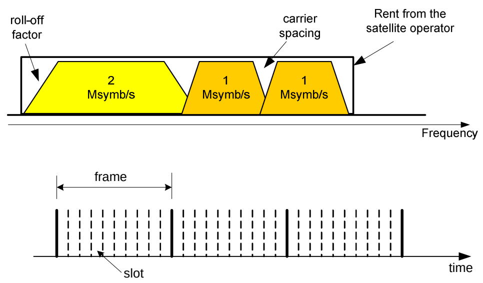
Reference Scenario of the L*IP Meshed Satellite Network



Subdivision of the Satellite Resource in Time and Frequency



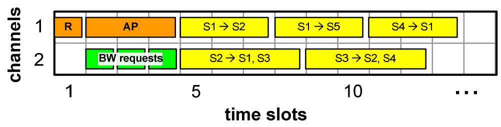
Subdivision of the Satellite Resource in Time and Frequency (2)

- Carriers can have different size: 1, 2 or 4 Msymb/s
- Support of stations with different equipment (antenna, amplifier)
- For example: a low cost station can only transmit on a 1 Msymb/s carrier

Subdivision of the Satellite Resource in Time and Frequency (3)

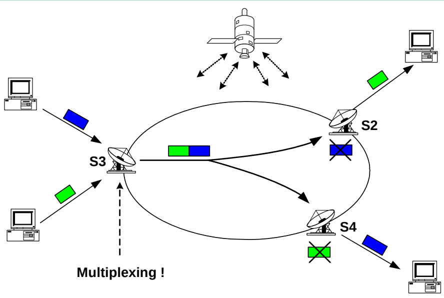
- TDMA frame length: 20ms
- Time slot length 125us
- → 160 slots per frame
- bursts length in integer multiples of the slot length
- Bursts can be 1 to 159 slots long
- Efficiency increases with the size of the burst!

The Allocation Plan



R	reference burst
AP	burst transmitting the allocation plan
BW requests	from the slaves
S1 → S2	data burst from station 1 to station 2

Multiplexing on the Satellite (or: How can we increase the burst size?)



Connection-Oriented Flow Identification

Virtual Connections (VC) = IP Packet Flows

defined unidirectional;

specified by TX+RX station and QoS parameters

Pipes = Burst Flows

multiplexes of VCs

specified by TX station + RX station**S**

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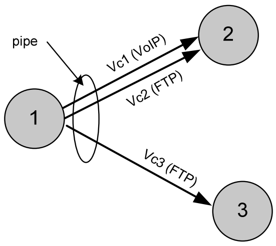
Connection-Oriented Flow Identification (2)

Multiplexing of different kind of traffic to different station into a single burst



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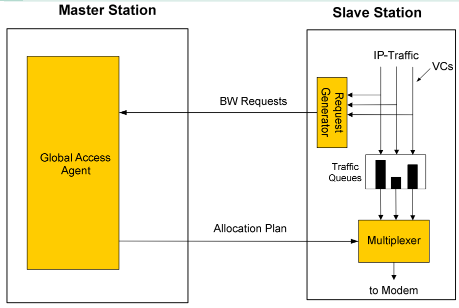
Demand Assignment Multiple Access (DAMA)



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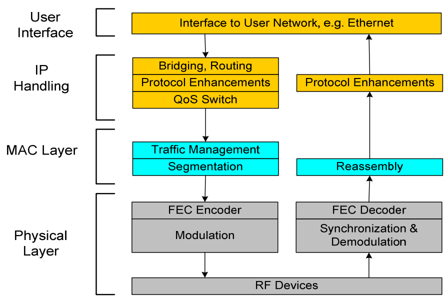
Principle Architecture of a Terminal/Station



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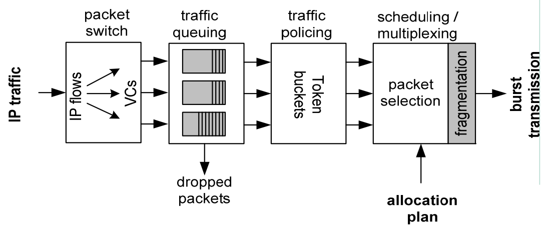
Traffic Handling in a Terminal



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Packet Switching

IP packets are switched to associated VCs, based on
- QoS class
- Routing (receiver station)

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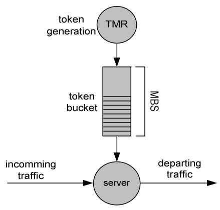
Traffic Queuing

Packets wait in queues until BW is available (DAMA!)

Different queues for different QoS classes,
- High priority traffic may “overtake”

Packets are dropped, if incoming traffic rate is higher than available BW

Traffic Policing with the Token Bucket Algorithm



Execution of QoS parameters

TMR: Traffic mean rate
MBS: Maximum burst size

Incoming packets may pass the server, if enough tokens are available

Traffic bursts up to MBS are accepted
On the average, traffic rate is limited to TMR

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Traffic Scheduling / Multiplexing

Question: Which queue should be served next?

Decision based on QoS parameters of the VC

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Fragmentation & Reassembly (Encapsulation)

Burst length is in most cases different from IP packet length

IP packets have to be fragmented at the transmitter and reassembled at the receiver

Encapsulation introduces additional overhead

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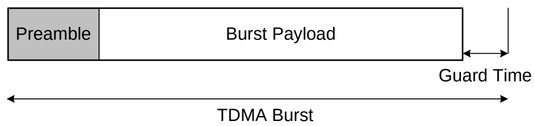
TDMA Burst Format



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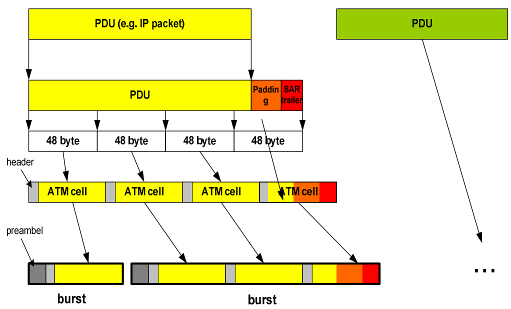
ATM/AAL5 Encapsulation



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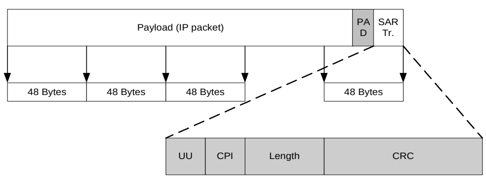
ATM Adaptation Layer 5 (AAL 5)



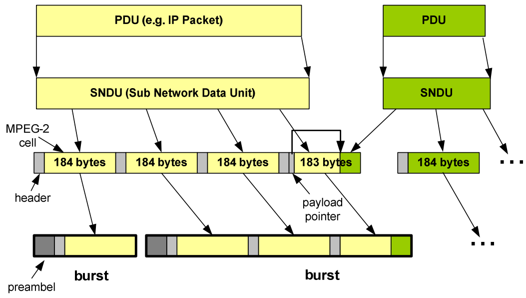
UU	User to user indication	8 bit
CPI	Common part indicator	8 bit
Length	Length of payload	16 bit
CRC	Cyclic Redundancy Check	32 bit

Format of the ATM Cell

5 byte header					48 byte payload
VPI	VCI	PT	CLP	HEC	data
12	16	3	1	8 bit	

VPI	Virtual Path Identifier	12 bit
VCI	Virtual Circuit Identifier	16 bit
PT	Payload Type	3 bit
CLP	Cell Loss Priority	1 bit
HEC	Head Error Control	8 bit

Unidirectional Lightweight Encapsulation (ULE)

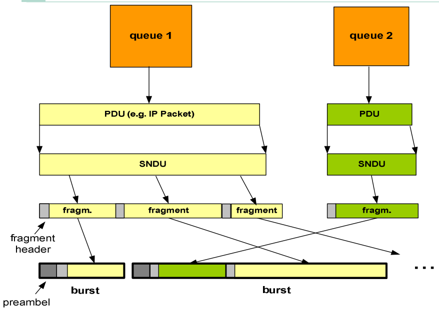


SNDU Format of ULE

D	length	type	PDU	CRC - 32
4 byte			1- 32767 Byte	4 byte

D	Destination address present flag (1 bit)
length	length of the PDU (15 bit)
type	type of the PDU (16 bit IANA EtherType)
PDU	Protocol Data Unit
CRC-32	cyclic redundancy checksum (32 bit)

Low Overhead Encapsulation (LOE)



LOE - SNDU Format

type	PDU	CRC - 32
2 byte		4 byte

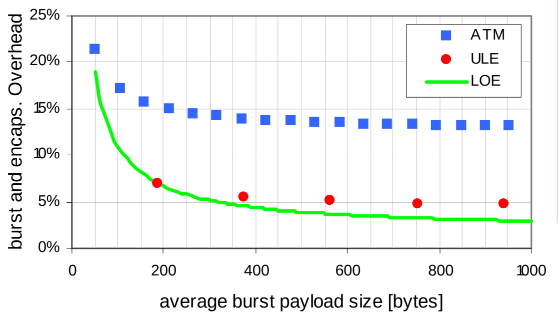
type	Protocol Type (optional)
CRC-32	Cyclic redundancy checksum (32 bit)

LOE - Fragment Format

Fragment Header (4 bytes)					Payload (1-2047 bytes)
VCD	BoS	EoS	LEN	HEC	data
11	1	1	11	8	

VCD	Virtual Connection Descriptor
BoS	Begin of SNDU
EoS	End of SNDU
LEN	Length of payload in Bytes
HEC	Header Error Control

Comparison of ATM, ULE and LOE



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Comparison of ATM, ULE and LOE (2)

ATM is due to its large header compared to its small body inefficient

ULE is nearly as efficient as LOE, but can only support burst sizes that are multiples of the MPEG-2 cell size
→ results in efficiency problems with VoIP traffic

LOE is most efficient and supports any burst size
→ fits into the allocation plan grid with fixed slot sizes

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Calculation of the Total Bandwidth

Calculation of the signaling overhead (ref burst, allocation plan, BW requests)

Calculation of the burst overhead (unique word, guard time)

Calculation of the encapsulation overhead (fragment header, SNDU overhead)

Assumption:

Each active pipe is assigned one burst per frame

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How many pipes do we need ?

N_{St} ________Number of stations

N_{RCVpSt} _______Average number of receivers per station

N_{PpSt} ______Average number of pipes per station

B_{tot} ________Total bandwidth in the satellite network

N_{Chn}________Number of carriers

k ________Rate of over-admission

$$B_{pipe} = \frac{k \cdot B_{tot}}{N_{St} \cdot N_{PpSt}}$$

$$N_{RCVpSt} \cdot B_{pipe} \le \frac{B_{tot}}{N_{chn}}$$

→

$$N_{PpSt} \ge \frac{k \cdot N_{chn} \cdot N_{RCVpSt}}{N_{St}}$$

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How many pipes do we need ? (2)

$N_{St} = 100$

$N_{RCVpSt} = 3$

$N_{Chn} = 10$

$k = 5$

$$N_{PpSt} \ge \frac{k \cdot N_{chn} \cdot N_{RCVpSt}}{N_{St}} \ge 1.5$$

Note that this is a lower bound on the number of pipes

In practice, 2-3 pipes per station are realistic

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Signaling Overhead

L_{ref} ______Length of reference burst

L_{AP} ______Length of AP

L_{BWreq} ______Length of BW request

$L_{ref} = const$

$L_{AP} \sim N_{St} \cdot N_{PpSt}$

$L_{BWreq} \sim N_{PpSt}$

→

$$O_{sig} = \frac{f\left(L_{ref}, L_{AP}, L_{BWreq}\right)}{B_{tot}}$$

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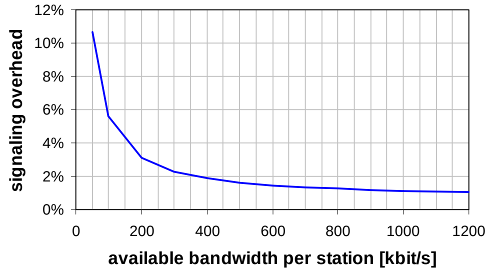
Signaling Overhead



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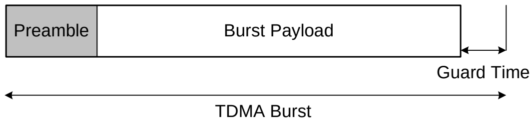
Burst Overhead



L_{burst} ____Average length of Bursts

b_{burst} ____Equivalent overhead bits

$$O_{burst} = \frac{b_{burst}}{L_{burst}}$$

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Burst Overhead (2)

N_{burst} ______Number of bursts per second

N_{Fr} ______Number of frames per second

$\eta_{sig} = 1 - O_{sig}$ ___Signaling efficiency

$$N_{burst} = N_{PpSt} \cdot N_{St} \cdot N_{Fr}$$

$$L_{burst} = \frac{\eta_{sig} \cdot B_{tot}}{N_{burst}}$$

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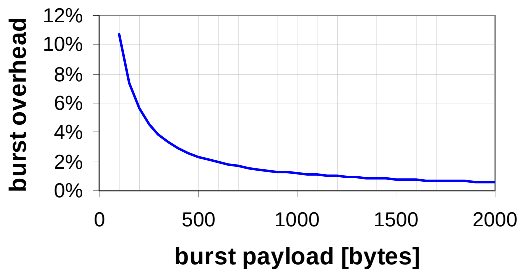
Burst Overhead (3)



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LOE - Overhead Calculation

L_{PDU} ______Average length of PDU

b_{SNDU} ______Number of SNDU overhead bits

n_{frg} ______Average number of fragments per PDU

b_{frg} ______Overhead bits of fragment header

L_{burst} ______Average length of burst

b_{burst} ______Burst overhead bits

$$n_{frg} \approx \frac{L_{PDU} + b_{SNDU}}{L_{burst} - b_{burst}} + 1 \;\rightarrow\; O_{LOE} = 1 - \frac{L_{PDU}}{L_{PDU} + b_{SNDU} + b_{frg} \cdot n_{frg}}$$

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Total Overhead Calculation

$\eta_{sig} = 1 - O_{sig}$ ___Signaling efficiency

$\eta_{burst} = 1 - O_{burst}$ ___Burst efficiency

$\eta_{LOE} = 1 - O_{LOE}$ ___LOE efficiency

$$O_{tot} = 1 - \eta_{sig} \cdot \eta_{burst} \cdot \eta_{LOE}$$

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Total Overhead