An Access Protocol for Mobile Satellite Users with Reduced Link Margins and Contention Probability

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An Access Protocol for Mobile Satellite Users with Reduced Link Margins and Contention Probability

Marc Emmelmann(*)
Hartmut Brandt

Fraunhofer Institute Fokus

Hermann Bischl
Sandro Scalise

German Aerospace Agency (DLR)

ASMS 2003
July 10-11, 2003
Frascati, Italy

(*) corresponding Author: emmelmann@ieee.org

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Outline

Introduction	- Project Framework - System Architecture
Protocol Design & Error Control	- Medium Access Control - Rain Attenuation & Link Availability - Link Availability with Adaptive Coding - Efficiency of Adaptive FEC Schemes - Adaptive FEC and Modulation Schemes
Protocol Implementation	- Prototyping & Simulation Environment
Measurements	- Link Level Delay - Application Level Error Rates - Shadowing Effects
Conclusion	

Introduction
Project Framework

ATM-Sat

- ATM-based Multimedia Communication via LEO Satellites
- Design of entire system architecture
- Development of proof-of-concept demonstrator

Technical Aspects

- Support of mobile, fixed, and portable terminals
- Guaranteed QoS
- Switching and Routing in the sky (ATM switch as payload)
- Adaptive MAC and FEC schemes

Partner

- German Aerospace Agency (DLR)
- Fraunhofer Instititute Fokus (competence center CATS)
- Tesat-Spacecom
- Financed by: German Ministry for Education and Research

Introduction
System Architecture

Satellite Constellation

- LEO orbit (1350 km)
- Walker 72 satellites, 12 planes, 47° inclined
- Optical ISLs
- 20° min. elevation angle

Link Parameters

- Ka-Band
- approx. 2 Mbit/s in the uplink
- approx. 32 Mbit/s in the downlink
- 16 kbit/s adjustment steps
- QPSK modulation (if not other mentioned)

Protocol Design & Error Control
Medium Access Control

On-board XS control & scheduling

FDD in the up- & downlink

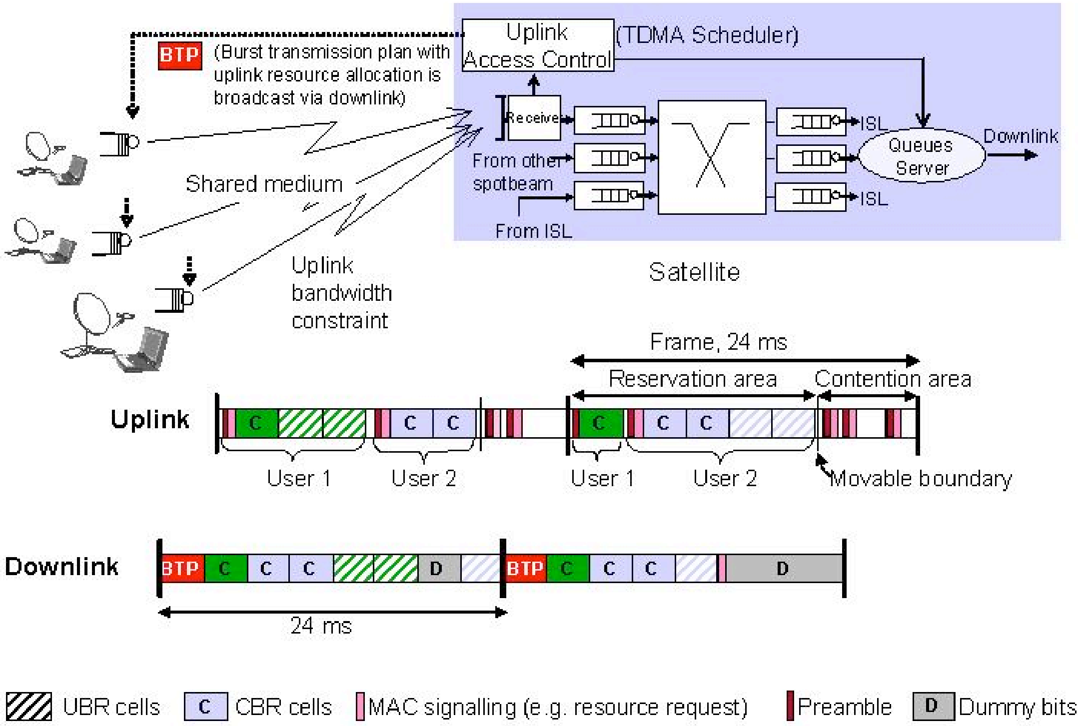
MF-TDMA scheme in the uplink

Frame length 24ms --> 16kbit/s band-width granularity with ATM cells

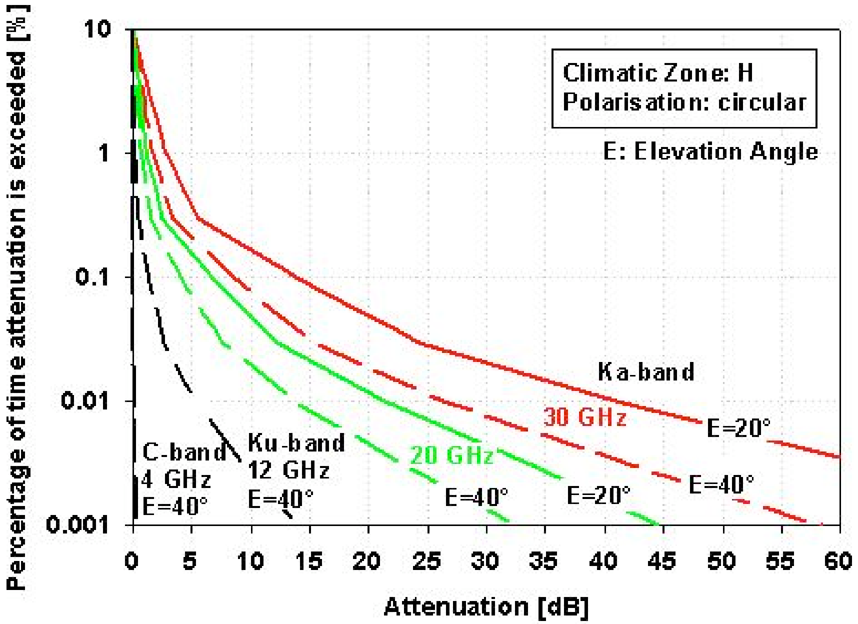
Reservation and Contention area with movable boundary

BTP contains resource assignment for next uplink frame

Usage of extended VPI/VCIs



Protocol Design & Error Control
Rain Attenuation & Link Availability



Attenuation in Ka-Band dominated by rain effects

Directional antennas eliminate multi-path fading

Rain attenuation appears only from time to time

→ Adaptive FEC and modulation most efficiently use the available bandwidth

Goal: Cell Error Rate ≤ 10^{-6}

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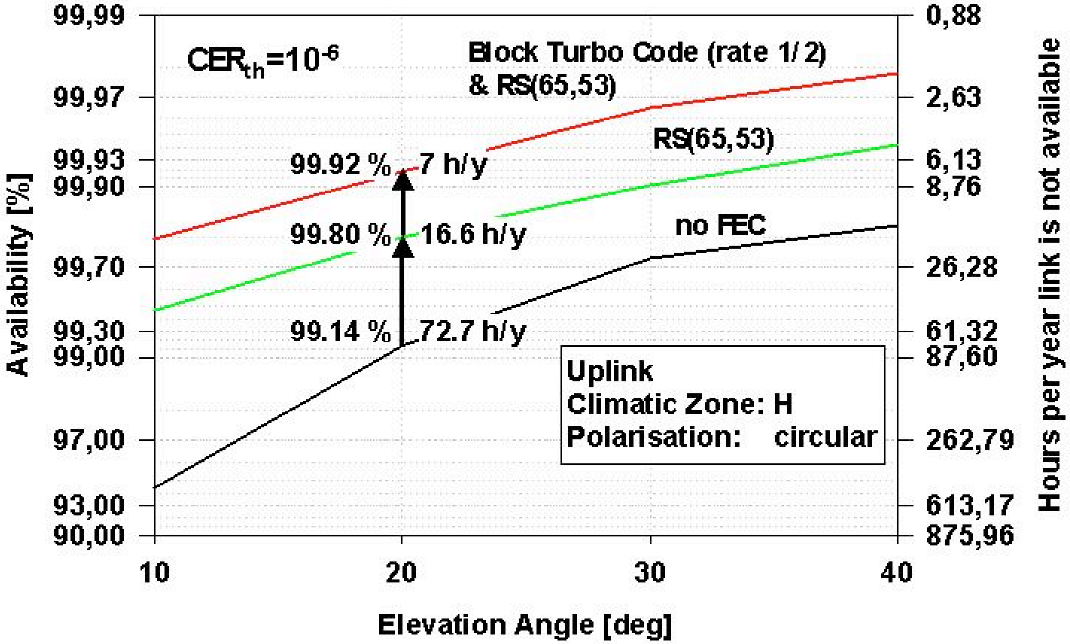
Protocol Design & Error Control
Link Availability with Adaptive Coding

Adaptive Coding:

- 4-byte CRC only
- RS(65,53)
- RS(65,53) & Rate 1/2 Turbo Code

Worst case: guarantee CER_{th} of 10^{-6} at min. elevation angle

- without FEC --> 99.14%
- RS(65/53) --> 99.80%
- convolutional code --> 99.92%



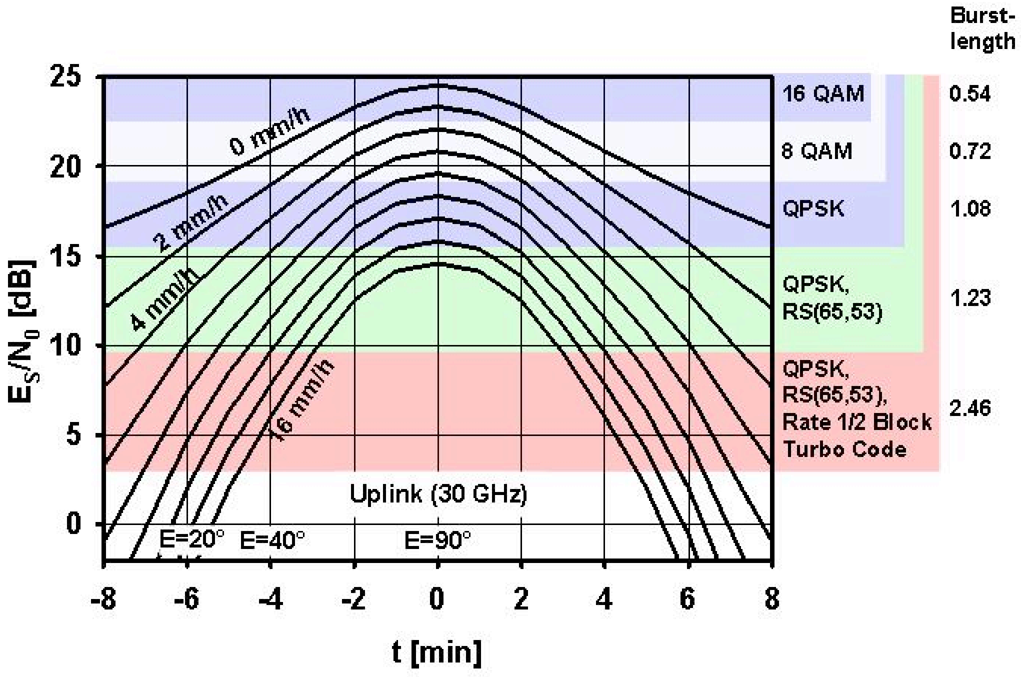
Protocol Design & Error Control
Efficiency of Adaptive FEC Schemes

ABLP = Availability BurstLength Product

Constant RS(65/53) Coding	ABLP	=	99.8% * 65/53	
		=	1.22	
Adaptive Coding	ABLP	=	99.14% * 57/53	(4-byte CRC)
			+ 0.66% * 65/53	(RS-Code)
			+ 0.12% * 130/53	(RS & Turbo)
		=	1.08	

Adaptive Coding Scheme guarantees higher link availability for the given CER_{th} with an even better bandwidth utilization.

Protocol Design & Error Control
Adaptive FEC and Modulation Schemes



Rain attenuation occurs only occasionally

→Rainless periods with a rather good S/N_0 allow to switch modulation schemes

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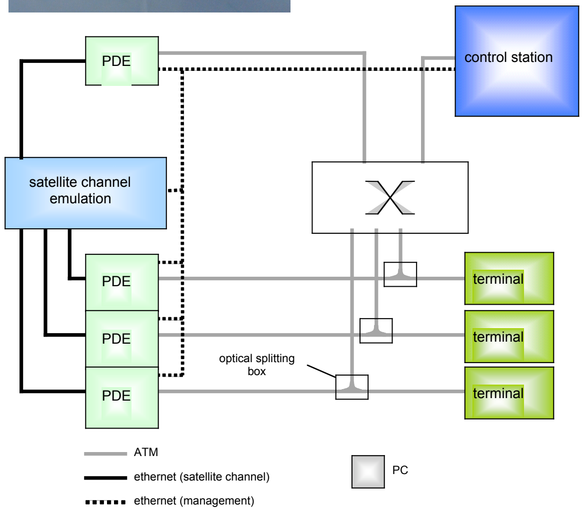
Protocol Implementation
Prototyping & Simulation Environment



Key Features:
- Std. COTS components
- Focus on target system
- FreeBSD 5 current-version

Core Units:

Sat. channel emulator	Configurable via SNMP Adds variable delay Packet corruptions Shadowing
Protocol Dev. Entity	"External VSAT System" Netgraph used for devel.
Control Station	Initializes SCE & PDE

Measurements
Link Level Delay

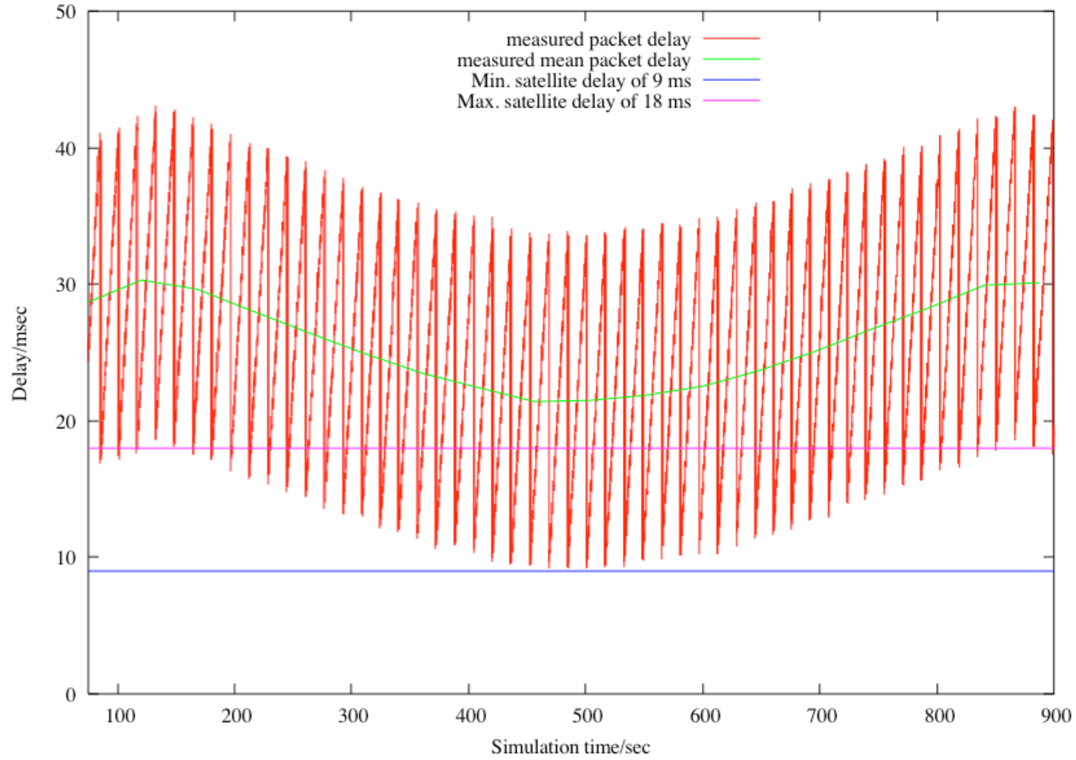
Sender cell rate: 1/24ms (one cell/frame)

Application and MAC not synchronized

Application computes time to send with regard to the start time of application, DLC starts a new 24-ms timer after every frame

→Jitter in clock may cause application to send cells at different times wrt. the beginning of a MAC Frame (cell may have to wait for next MAC frame)

→Measured mean delay 1/2 framelength larger than theory



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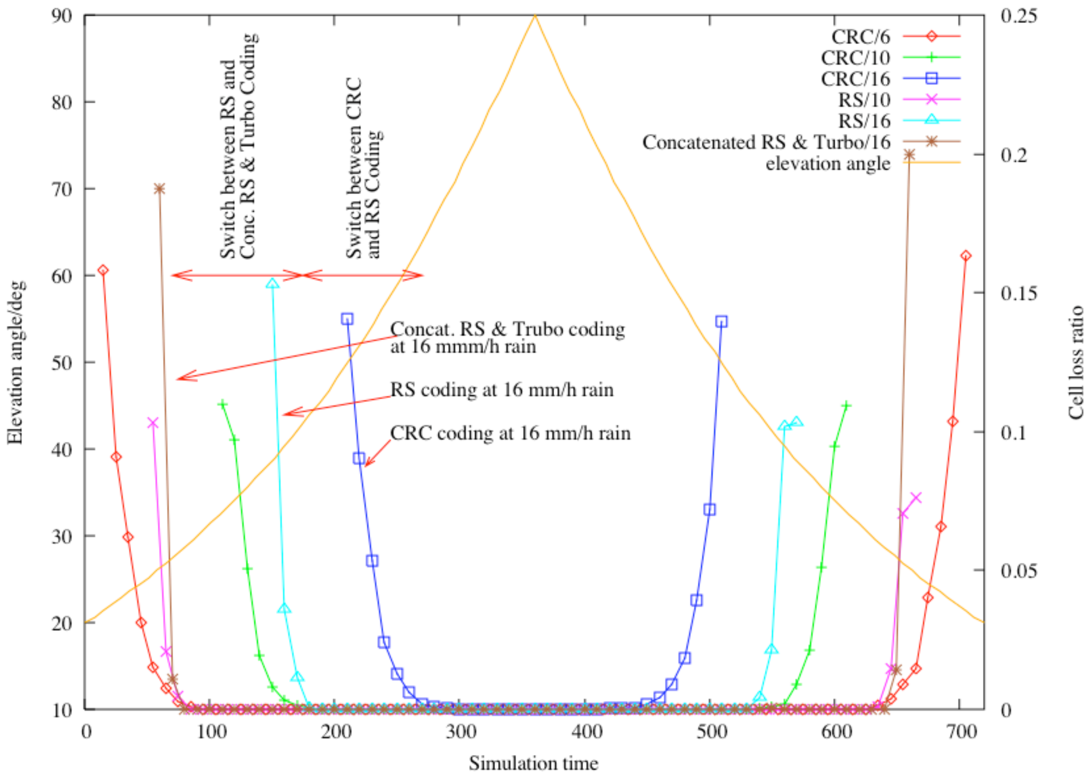
Measurements
Application Level Error Rates

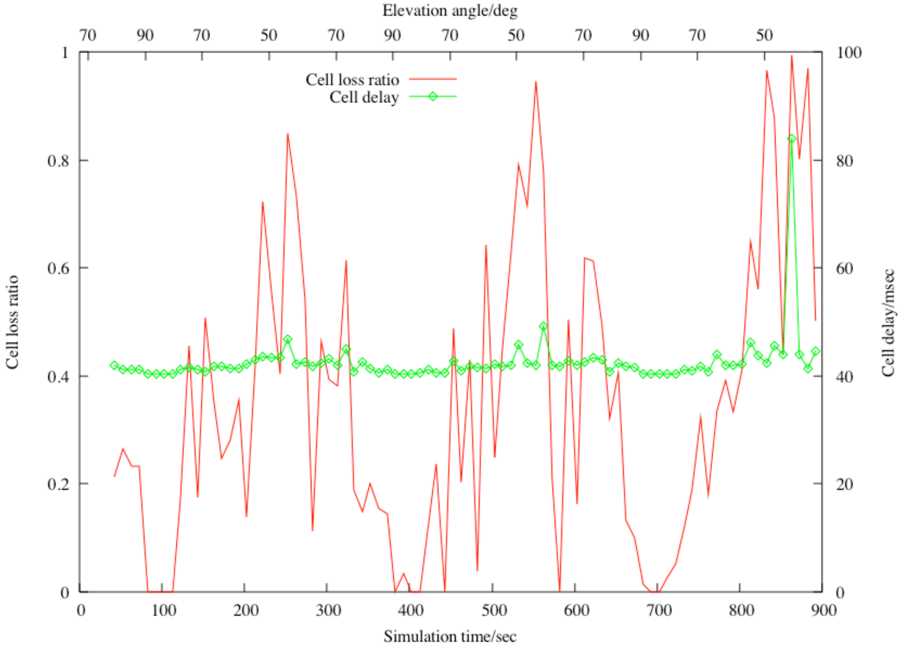
Graph shows measured cell loss ratio for a given rain intensity (in mm/h) and coding scheme (CRC, RS, or Concatenated RS & Turbo)

Sophisticated coding schemes significantly improve availability at the cost of bandwidth

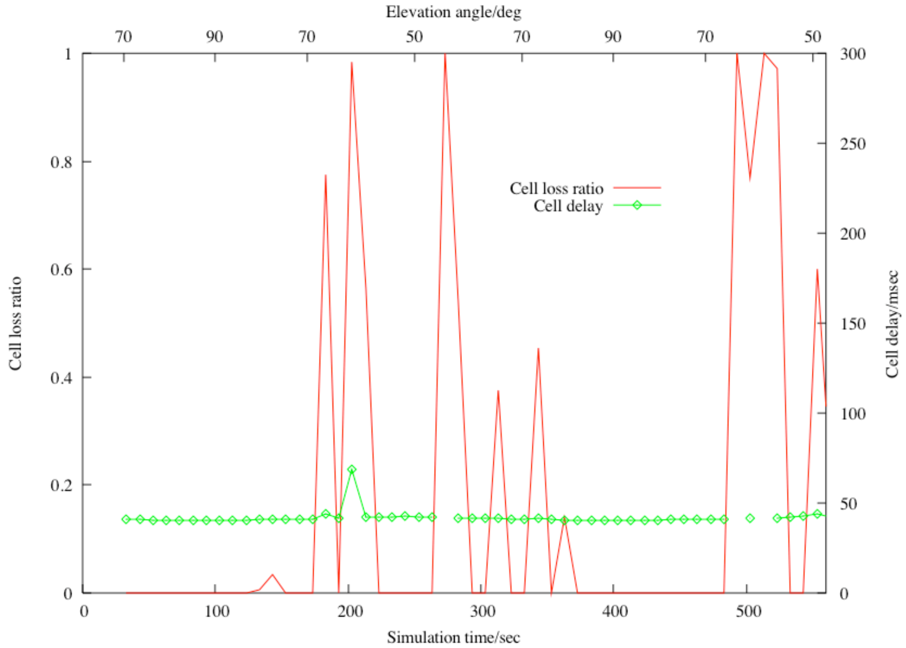
Simple CRC efficient for rainless periods and low rain intensities at high elevation angles.



Measurements
Shadowing Effects



Slow car (50km/h)



Pedestrian

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Conclusion

MAC protocol
- Adapts its coding and modulation scheme according to the experienced SNR and CER
- Increases the availability of the link for a given cell loss threshold
- Optimizes the bandwidth utilization

Measurements
- Proof of concept implementation used (available for FreeBSD)
- Show correct timing behavior
- Illustrate advantages of adapting coding scheme according to rain intensity and elevation angle

Further Information
- Corresponding author: emmelmann@ieee.org
- http://www.fokus.fraunhofer.de/cats/satellite
- http://www.dlr.de