Evaluating the Benefits of Using HiperAccess as a Backhauling Solution for 2G and 3G Mobile Networks

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Overview

- ETSI Project BRAN HiperAccess (HA)
- Main technical features
- ETSI approach for testing
- UMTS backhauling
- Marconi‘s HiperAccess-compliant system

ETSI BRAN Interoperable Standards

ETSI Project BRAN
(Broadband Radio Access Network)

Chairman: Prof. Dr. Bernd Friedrichs (Marconi)

HiperLan/2
(High Performance LAN)

Wireless LAN at 5 GHz, connection-based, 54 Mbps, QoS

HiperAccess
(High Performance Access)

Fixed broadband wireless PMP system above 11 GHz, based on single carrier

HiperMan
(High Performance MAN)

Fixed broadband wireless PMP system below 11 GHz, based on OFDM

HiperAccess:

- **PHY** physical layer
- **DLC** data link control layer
- **CL** convergence layers
- **Testing** radio & protocols (EC-funded)

BRAN HiperAccess Standardization

Status of HiperAccess

- **Technical Specifications for all layers (PHY, DLC, CL) and testing (radio, protocol) were published in 2002**
- **Ongoing activities: fine-tuning of specifications**

Interest in HA from

- **<u>Manufacturers:</u> Alcatel, Ensemble, Ericsson, Marconi, Nokia, Siemens, ...**
- **<u>Operators</u>: France Telecom, Omnitel Vodafone, Sonera, Telecom Italia, Telekom Austria, Telenor, Telia, ...**

Why Do We Need a Standard ?

- Active participation of many operators
  ➔ Optimized for important applications
  (UMTS backhaul, SME, SOHO, ...)

- Active participation of many manufacturers
  ➔ Low-cost and high performance
  (both for IP and ATM core networks)

- Low cost is critical for competiton with wireline access

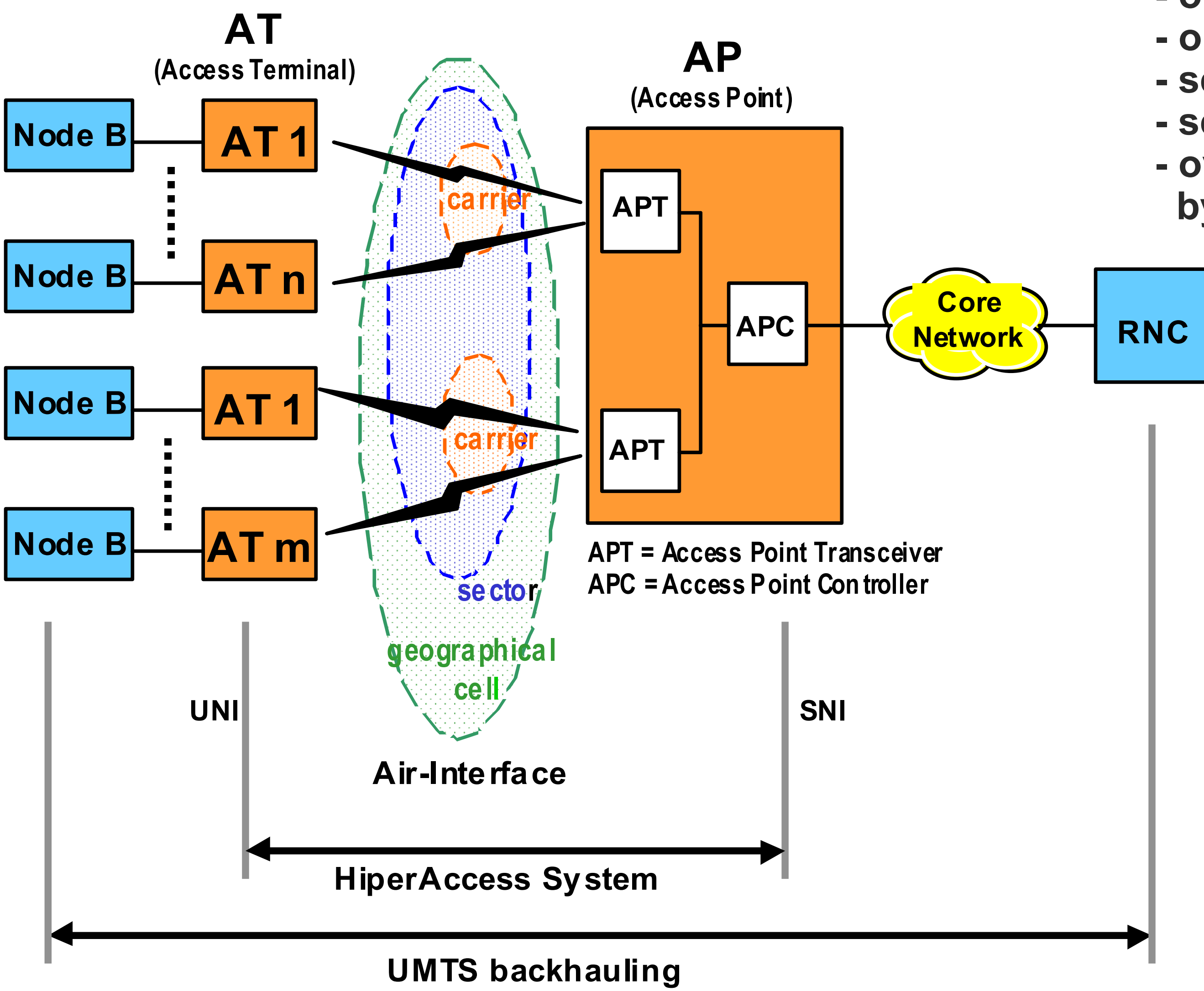
- Interoperable standard ➔ large volume ➔ low cost

- Other advantages of an interoperable standard
  - easy for customers to compare
  - flexibility for customers
  - increased competition ➔ low cost

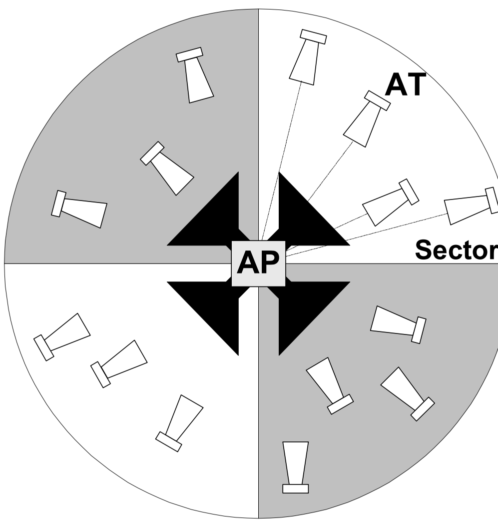
Main Technical Features

- **Point-to-Multipoint (PMP)** topology
- **Interoperability** (testing is normative part of standard)
- Standard allows for **vendor-differentiated** products, e.g.,
  - management,
  - core network interfaces,
  - ARQ,
  - broad range of cellular constellations
  - security,
  - bandwidth allocation strategies, ...
- **Spectrum efficient** (both for IP and ATM core networks)

Network Topology Model



- one APT per carrier
- one APC per cell
- several sectors per cell
- several carriers per sector
- overlapping cells (separated by frequency or polarization)



Cell with four sectors

Frequency Bands and Channel Sizes

Focus on frequency bands

- 40.5 - 43.5 GHz
- 31.8 - 33.4 GHz

Other important bands

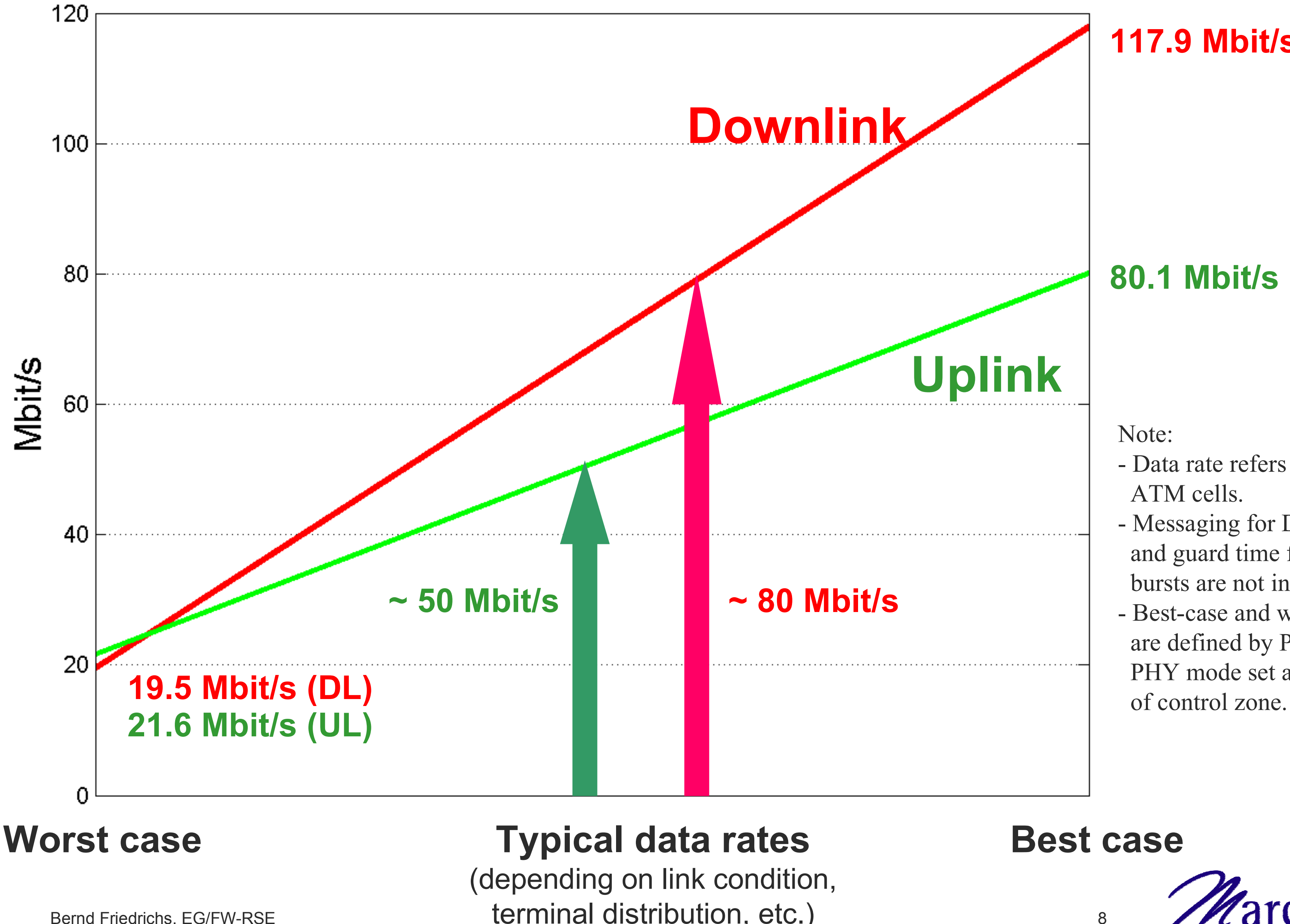
- 27.5 - 29.5 GHz
- 24.5 - 26.5 GHz

Channel size = 28 MHz, Baudrate = 22.4 MBaud

- Paired bands (FDD mode, fixed asymmetric rates)
- Unpaired bands (TDD mode, adaptive asymmetric rates)
- Fits into CEPT raster
- Optimum trade-off between costs, peak data rate and statistical multiplex gain

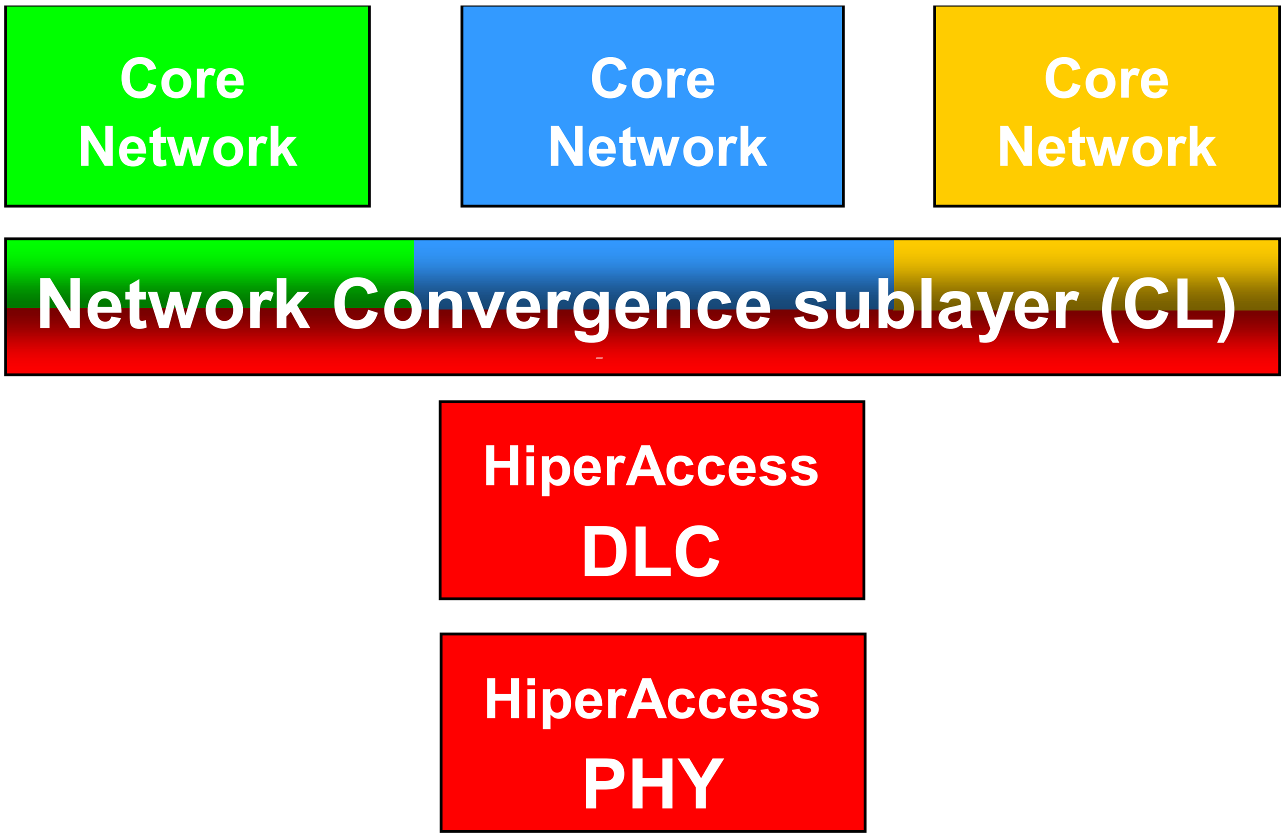
Data Rates of HiperAccess

(worst-case, best-case, typical case)



Note:
- Data rate refers to 53-byte ATM cells.
- Messaging for DL and UL and guard time for UL bursts are not included.
- Best-case and worst-case are defined by PHY mode, PHY mode set and length of control zone.

Interworking Approach



Core Networks:
ATM, IP, ISDN, PSTN,...

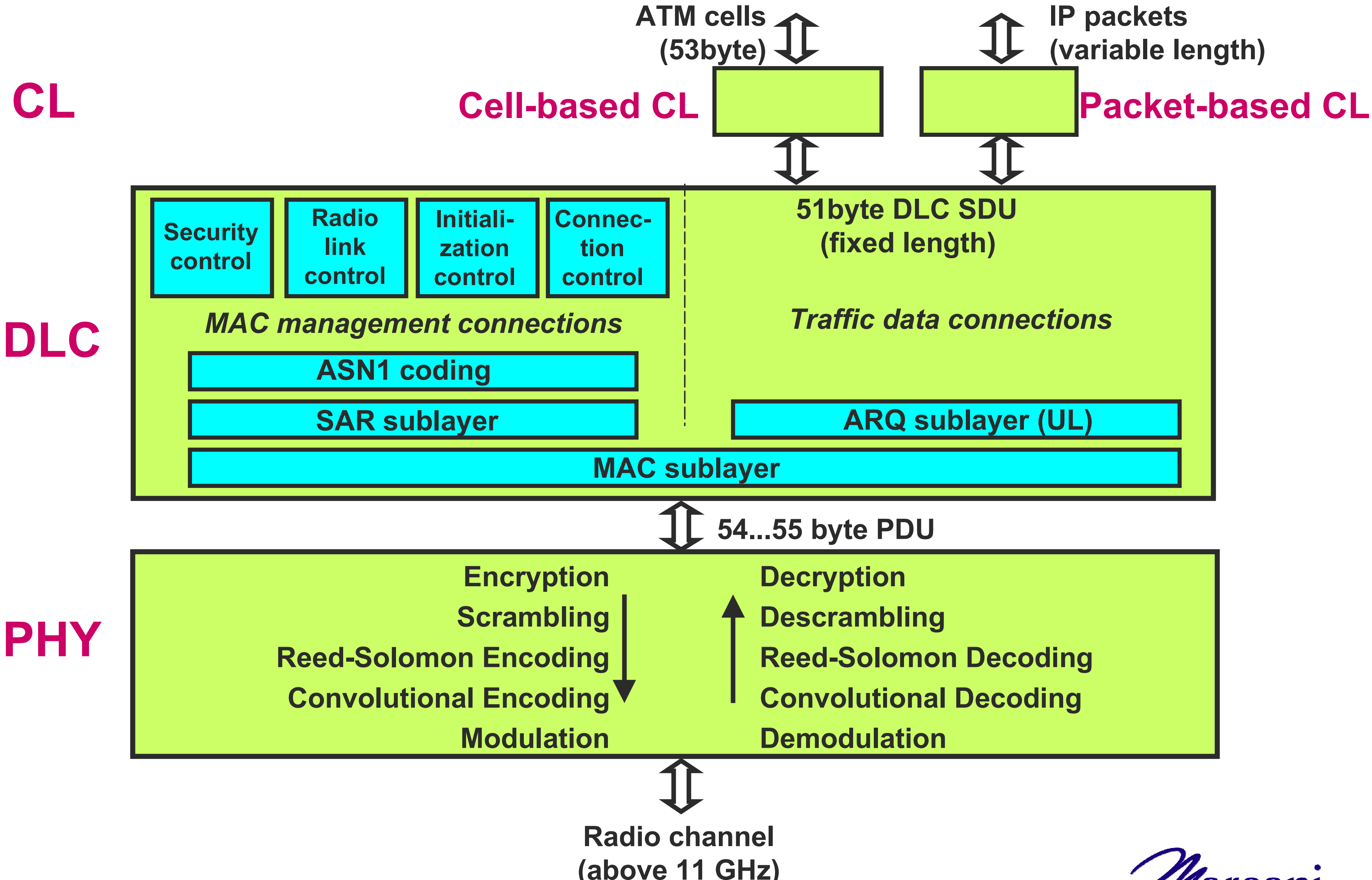
Removes differences between core networks

Matched to the requirements for supporting ATM and IP

Ensure cost-effective implementation and spectral efficiency

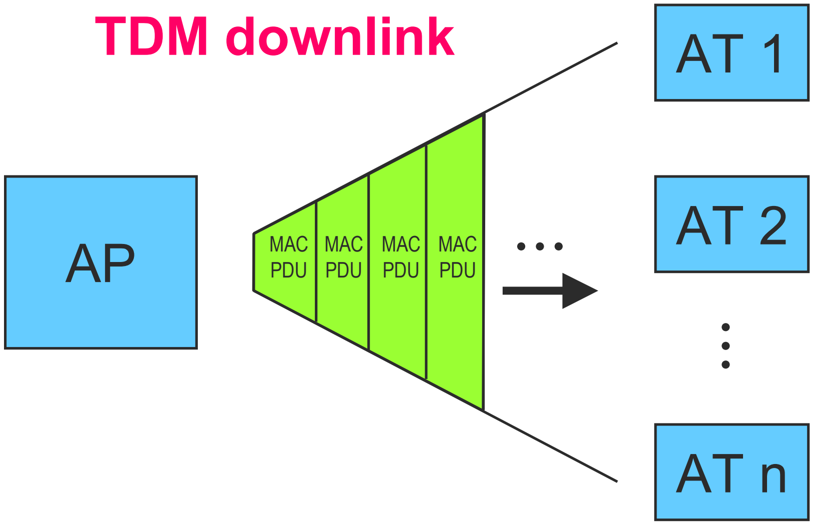
DLC and PHY layers are independent of the core network

Detailed Layer Structure

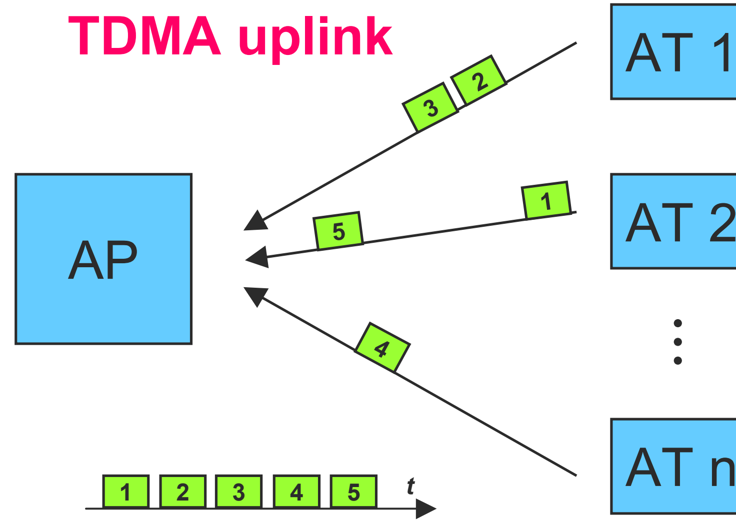


Overview of Downlink (TDM) and Uplink (TDMA)

TDM downlink



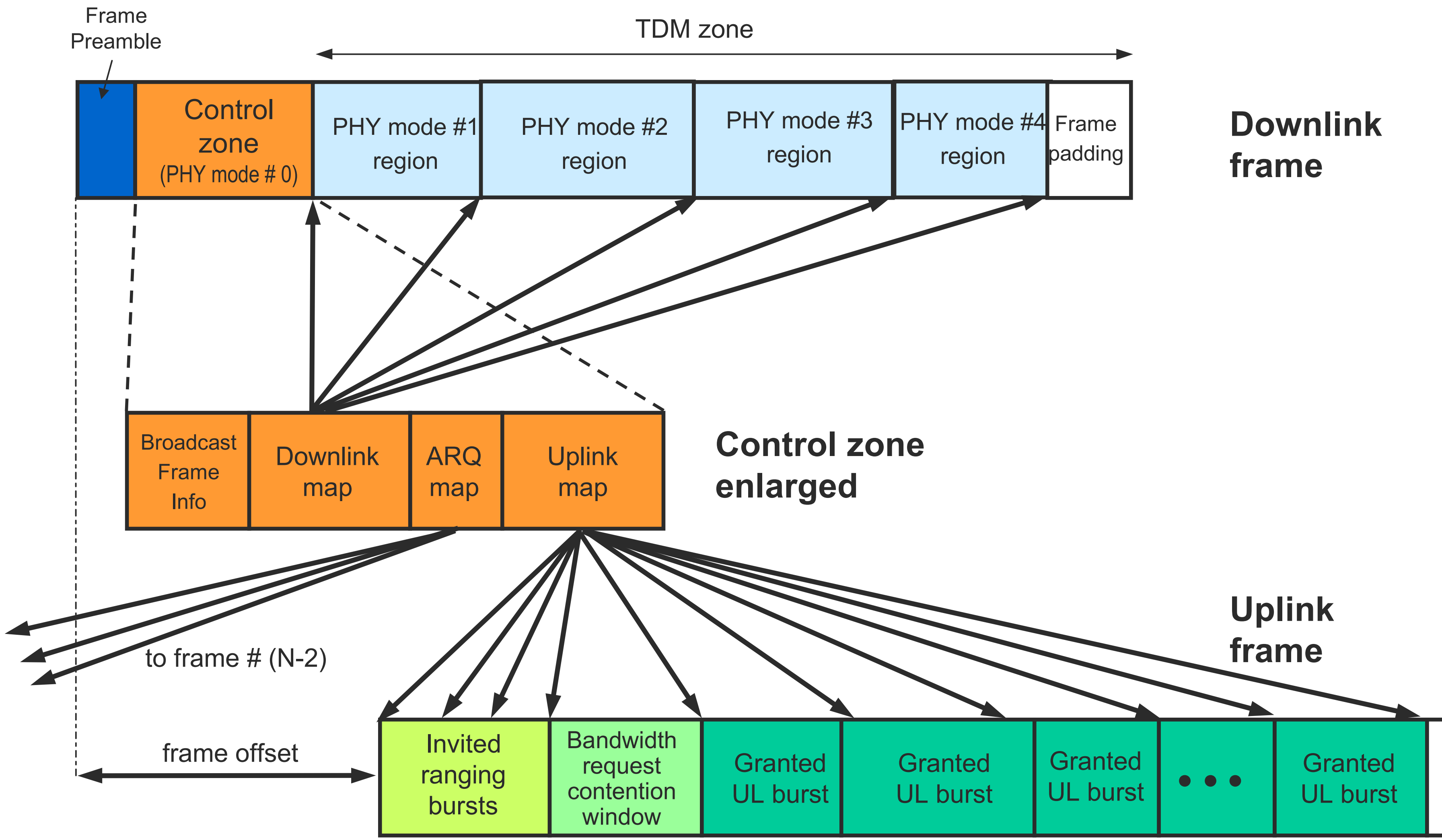
TDMA uplink



Further important properties of downlink and uplink

	Downlink	Uplink
Link budget & rain fading & multipath propagation	approx. identical	
Co-channel interference	time-invariant from other APs	time-variant from other ATs
Transmit power (same bandwidth)	constant for all ATs	individual per AT (distance, modulation, fading) for constant RX power

Frame Structure



Order of ranging burst and
contention window is just an example

Main Technical Features of DLC Layer

Frame based

- 1 ms frame duration
- Optional adaptive TDD mode (unpaired bands)
- Optional H-FDD terminals (paired bands, separated TX and RX)
- Optional ARQ

Fixed length PDUs

- Efficient support of ATM and IP, robust, high QoS, allows ARQ

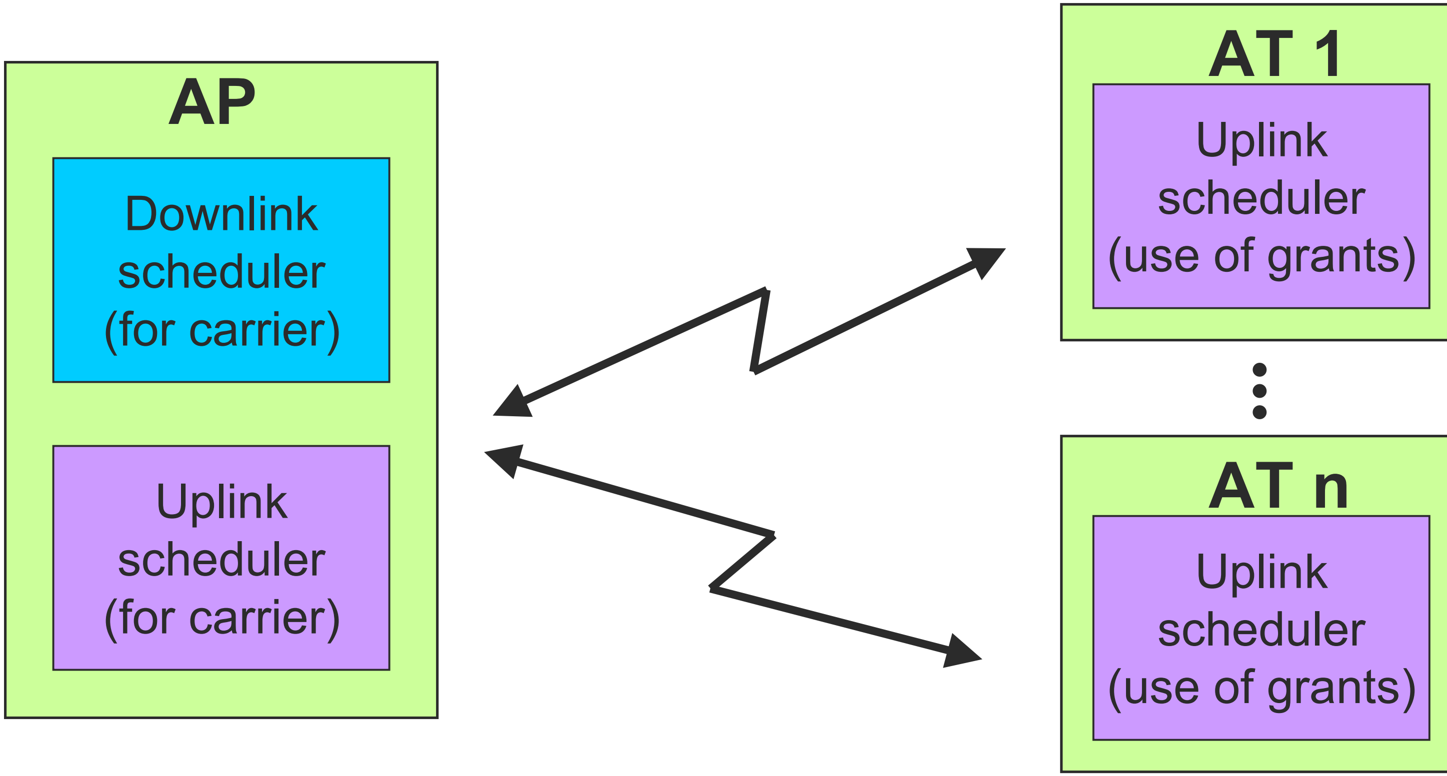
QoS Classes

- Constant bit-rate,
- Real-time variable bit rate
- Non-real time variable bit rate
- Best effort

Resource allocation mechanisms

- Continuous grant, polling, piggybacking, random access

Bandwidth Allocation



Uplink allocation

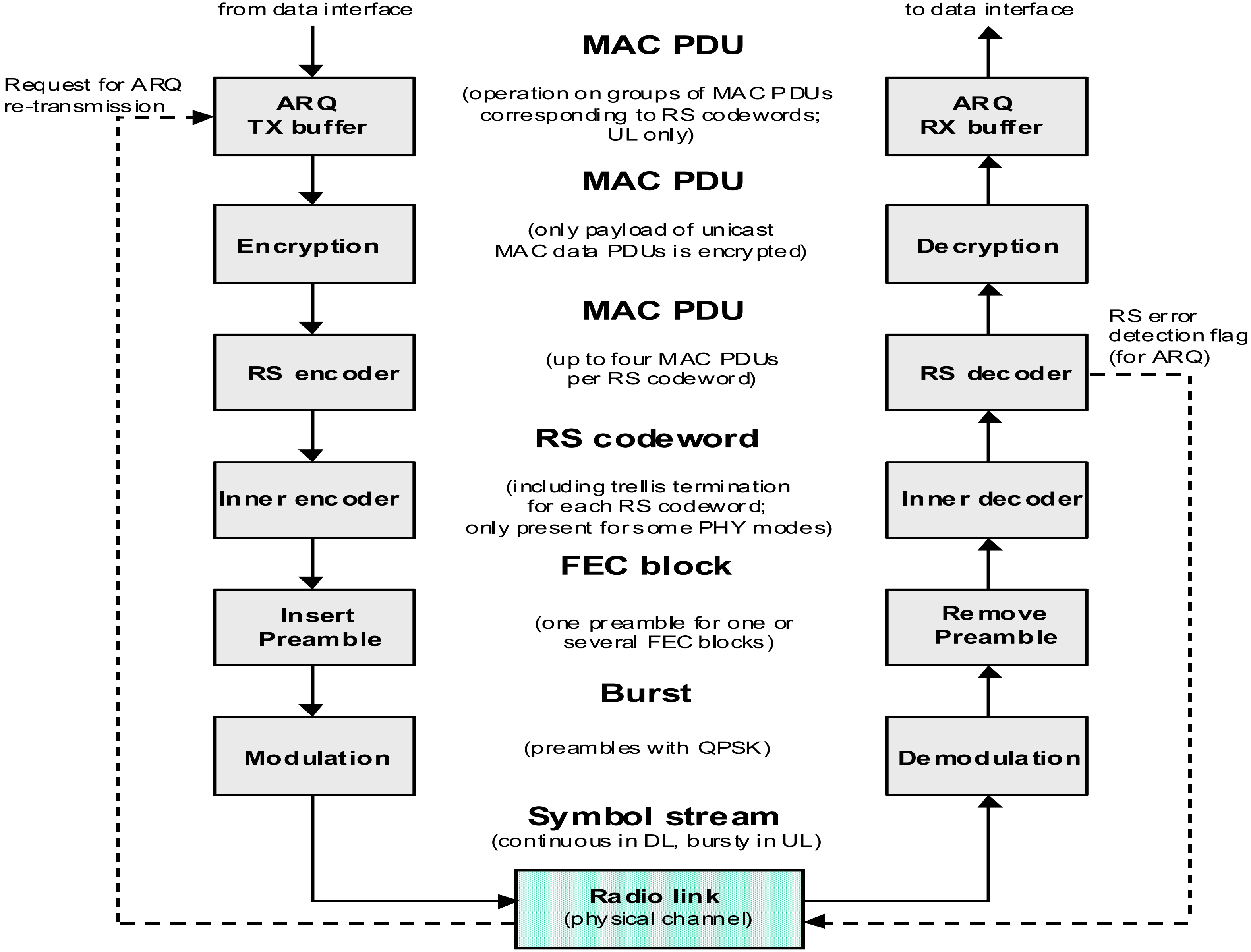
Requests per connection aggregate (various mechanisms)

Grants per terminal via UL map

Downlink allocation

via DL map (no action from AT)

Transceiver Architecture



Adaptive Coding and Modulation (PHY Layer)

Adaptation

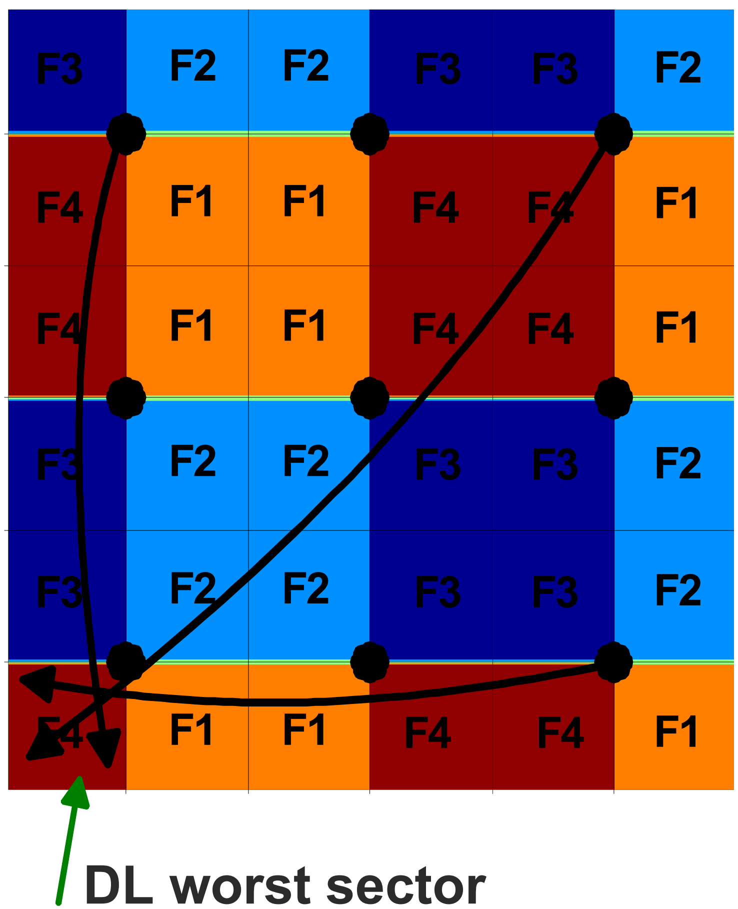
- according to distance
- according to interference
- according to rain fading (20 dB/s)
- per terminal
- per frame
- combined with ATPC (Adaptive Transmit Power Control)

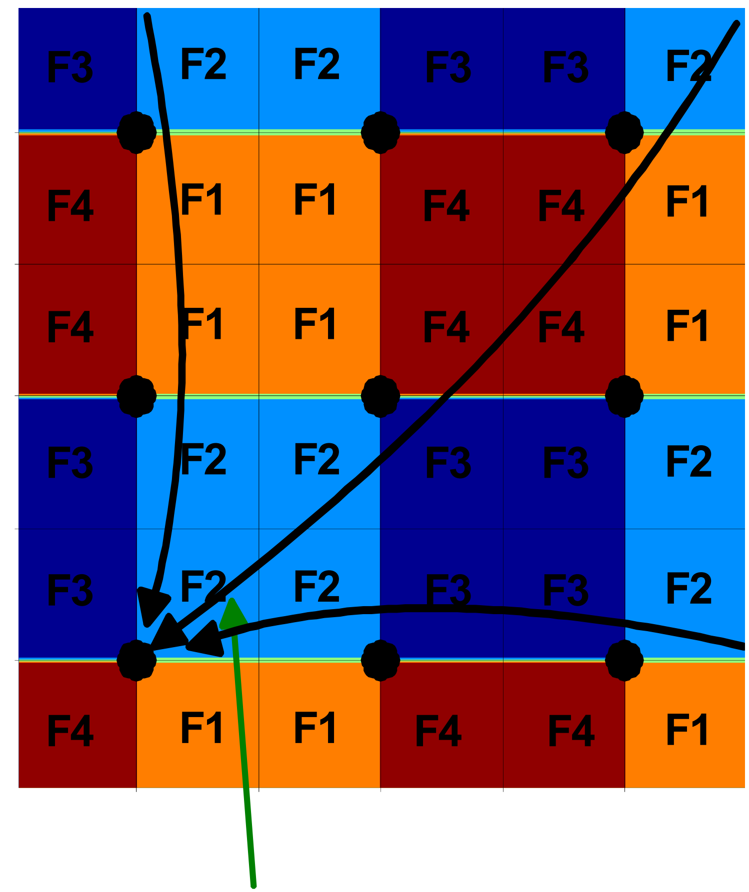
PHY mode defined by modulation and concatenated coding

Mode	Modulation	Outer Block Code	Inner Convolutional Code	Information word length	Spectral efficiency	Required C/(N+I)
0 (CZ)	QPSK	RS(t=8)	R=1/2	30 byte	from ~ 0.5 bit/s/Hz to ~ 3.8 bit/s/Hz	7 dB
1	QPSK	RS(t=8)	R=2/3	1...4 PDU		8 dB
2	QPSK	RS(t=8)	-	1...4 PDU		12 dB
3	16-QAM	RS(t=8)	R=7/8	1...4 PDU		18 dB
4	64-QAM	RS(t=8)	R=5/6	1...4 PDU		25 dB

PHY mode set 1

Interference in Downlink and Uplink





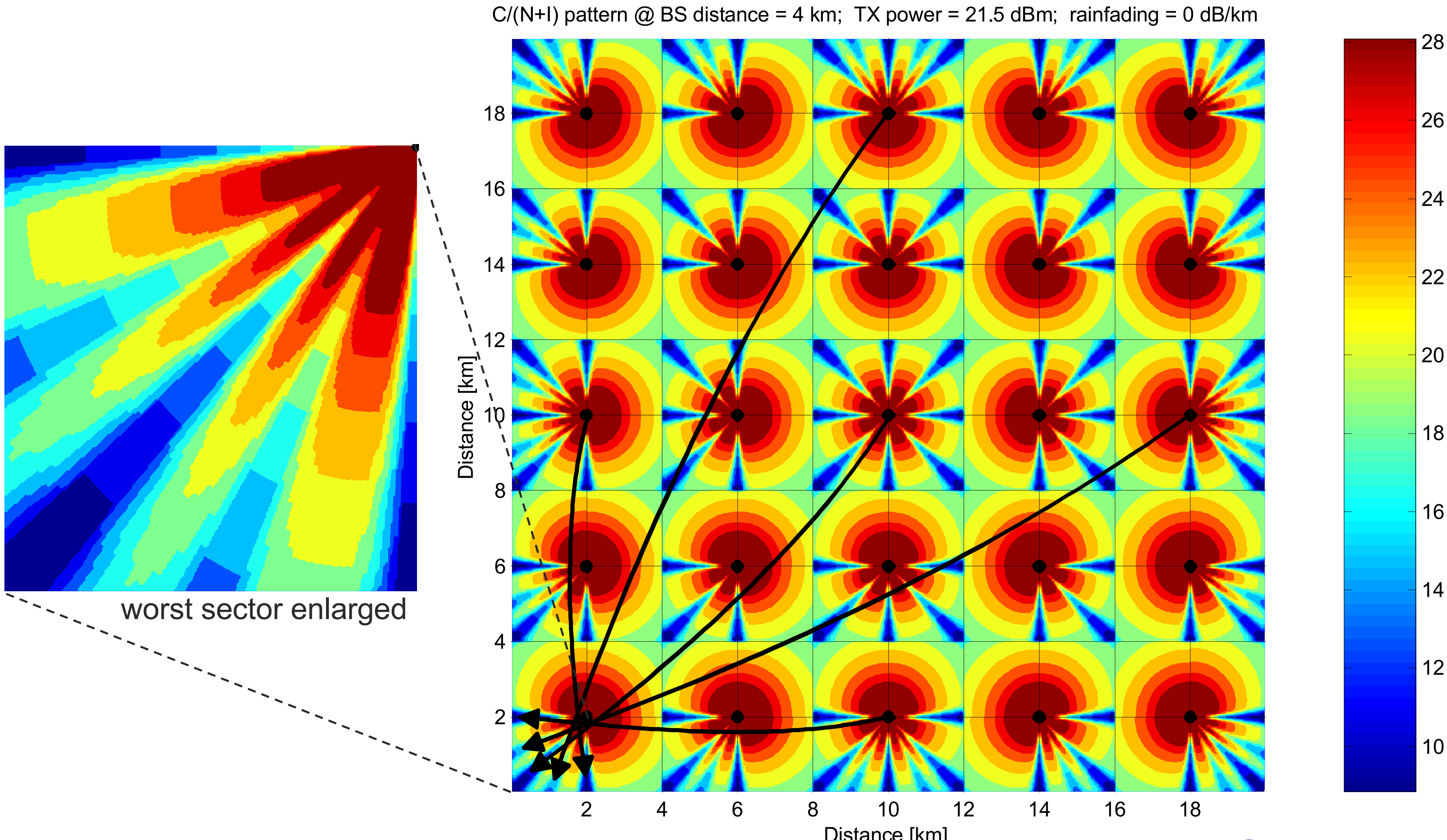
DL worst sector

$(C/I)_{min}$ = 20*log(5) = 14.0 dB

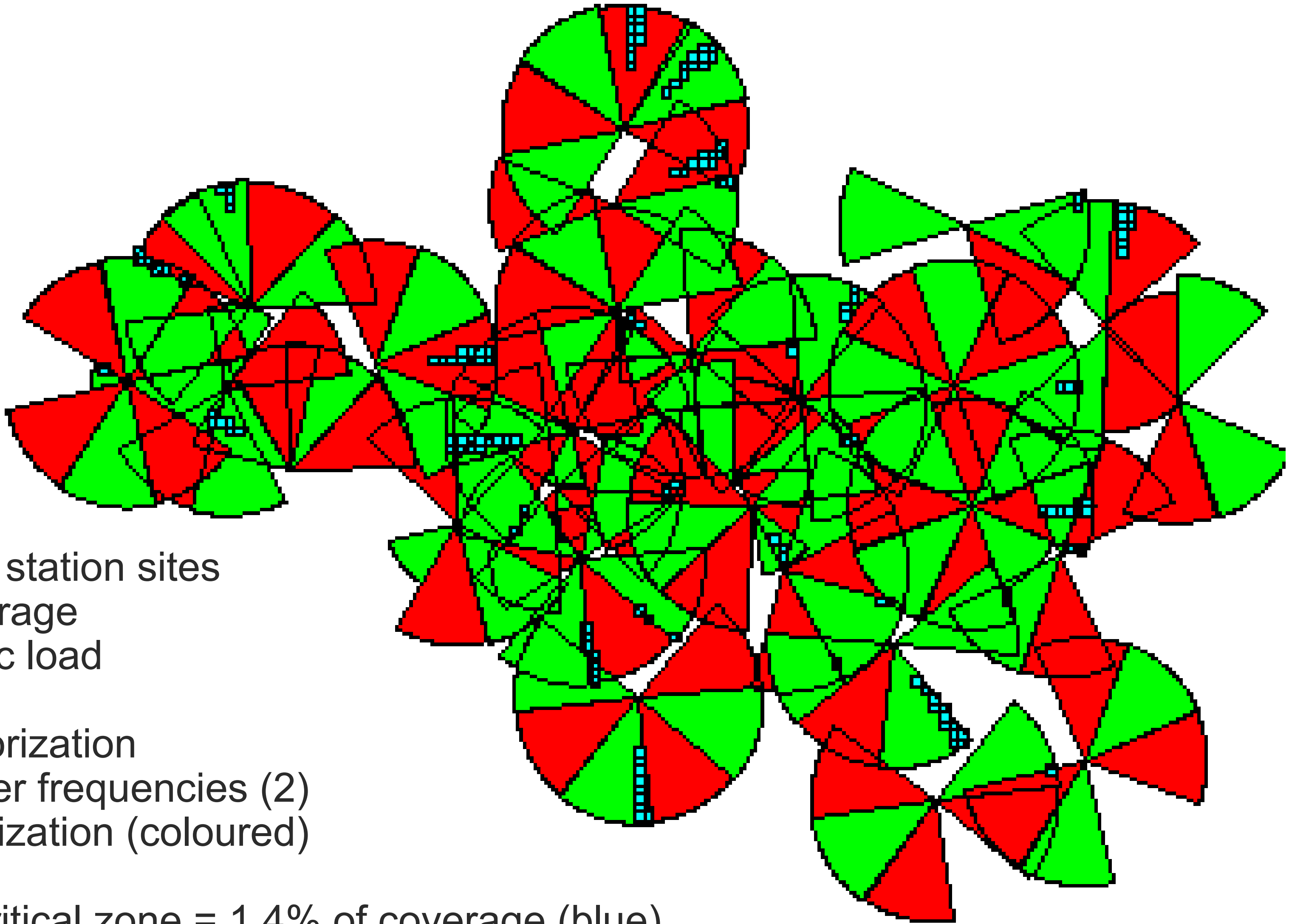
UL worst sector

Interference degradation per sector is typically different for DL and UL

C/(N+I) Pattern in a 5x5 Rectangular Constellation (Downlink, ClearSky, Re-use=4)



Marconi's Radio Network Planning Tool
(Realistic Constellation with 142 Sectors)



Input: Base station sites
Coverage
Traffic load

Output: Sectorization
Carrier frequencies (2)
Polarization (coloured)

Interference critical zone = 1.4% of coverage (blue)

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Statistical Multiplex Gain (1 of 2)

A PMP system performs like a virtual multiplexer:

Statistical multiplexing with a small CLR (cell loss rate) allows higher total data rates than fixed allocation guaranteeing peak data rates. Formally,

$$G = \frac{\text{throughput with statistical multiplex}}{\text{throughput with static collision-free multiplex}}$$

The multiplex gain of a PMP system <u>increases</u> with

- **larger bandwidth**
- **larger number of terminals**
- **higher burstiness (e.g., VBR, UBR)**
- **tighter delay constraints (e.g., CBR, rt-VBR)**
- **smaller CLR**

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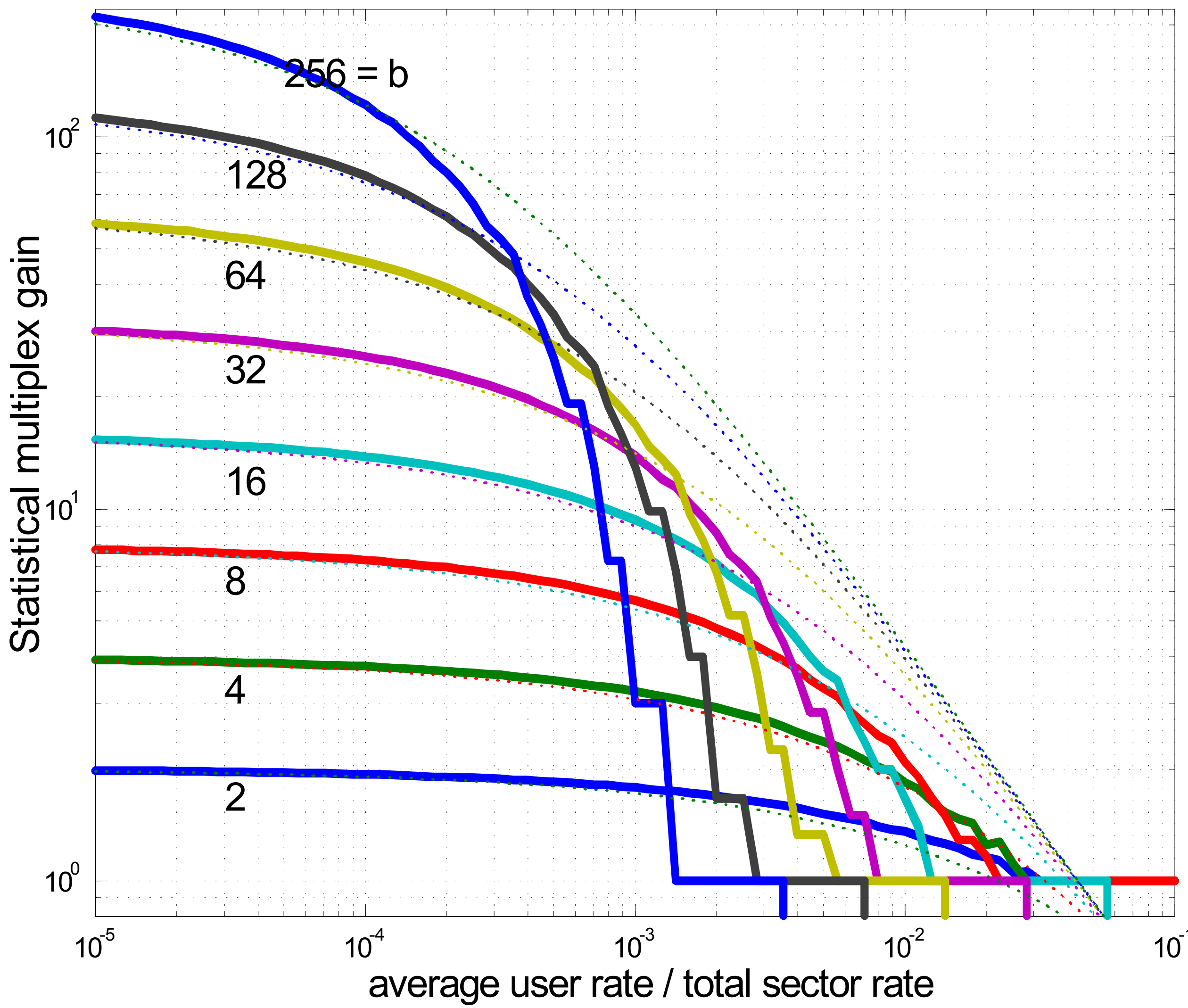
Statistical Multiplex Gain (2 of 2)



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Security (Privacy, Authentication)

Phased approach

- Phase 1: Fixed keys (to relax management requirements)
- Phase 2: Authentication and frequent key exchanges for high-level security
- Phase 3: Privacy for multicast

Algorithms

- Block ciphers: DES, 3DES, AES, CBC mode
- Hash functions: SHA-1
- Certificates: X.509
- Asymmetric keys: RSA (PKCS)

ETSI Approach for Normative Testing
→ Interoperable Standard

Basic protocol standard development

- **Abstract Syntax Notation (ASN.1) message structure specification, ITU-T X.680**
- **Packed encoding rules (PER) for transfer encoding, ITU-T X.691**
- **Message Sequence Charts (MSC) for message flow description, ITU-T Z.120,**
- **Specification and Description Language (SDL) specification, ITU-T Z.100**

  - SDL models used to precisely define the protocol behaviour.
  - Simulations and validations to early remove ambiguities and erroneous protocol behaviour.

Protocol test specifications (ITU-T X.291...296, ISO/IEC 9646)

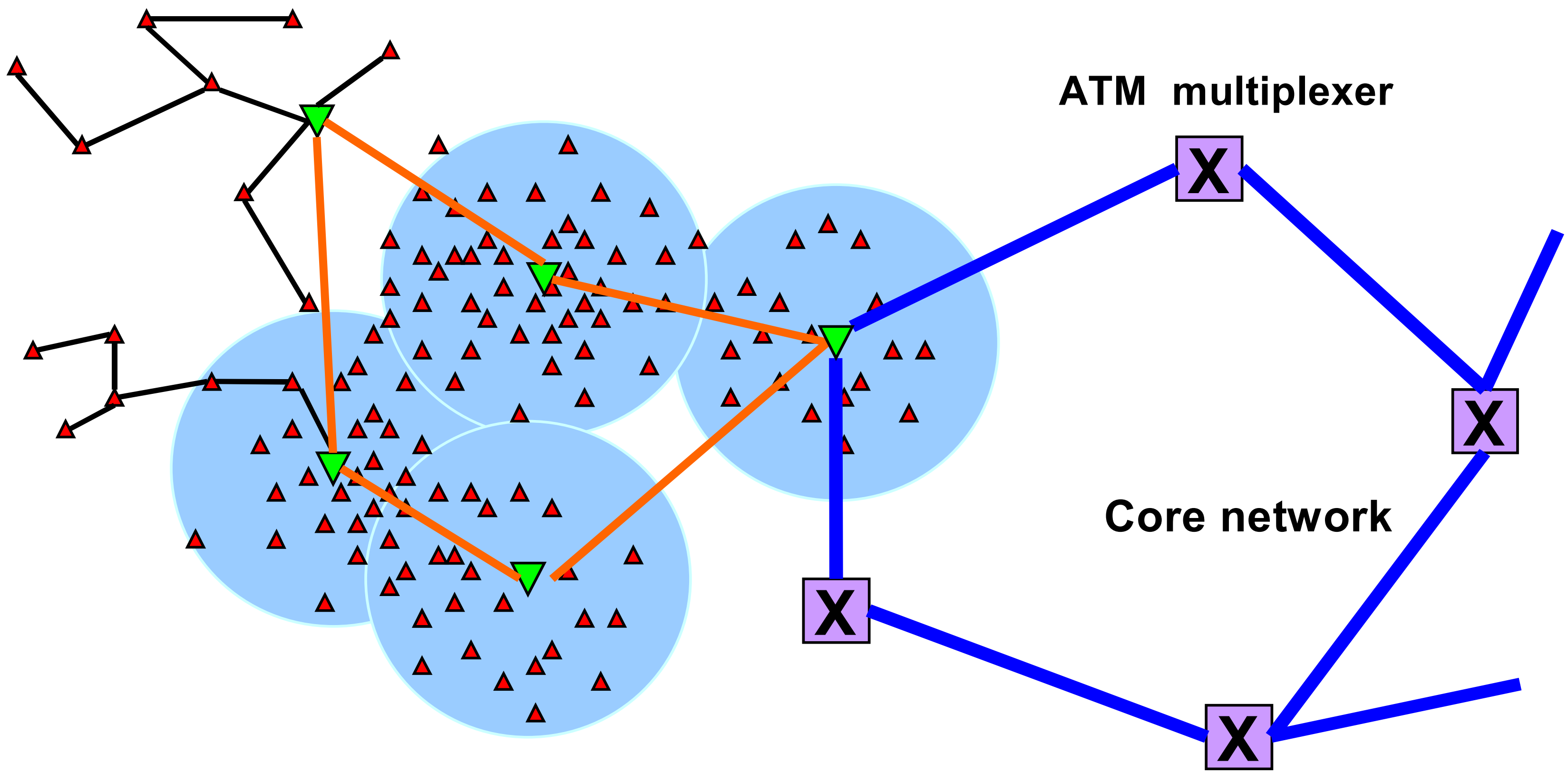
- **PICS** **Protocol Implementation Conformance Statement**
- **TSS & TP** **Test Suite Structure and Test Purposes**
- **ATS** **Abstract Test Suite (TTCN)**

  - Significant effort was spent (30 man month of funded expert work plus voluntary contribution by member companies and ETSI PTCC work)

Radio test specifications

- **RCT** **Radio Conformance Test**
- **EN** **Harmonized Standard (European Norm)**, covering the essential requirements of article 3.2 of the EC R&TTE Directives

Marconi's PMP / PTP Network Solution for UMTS Backhauling



RNC

Node B

Access network

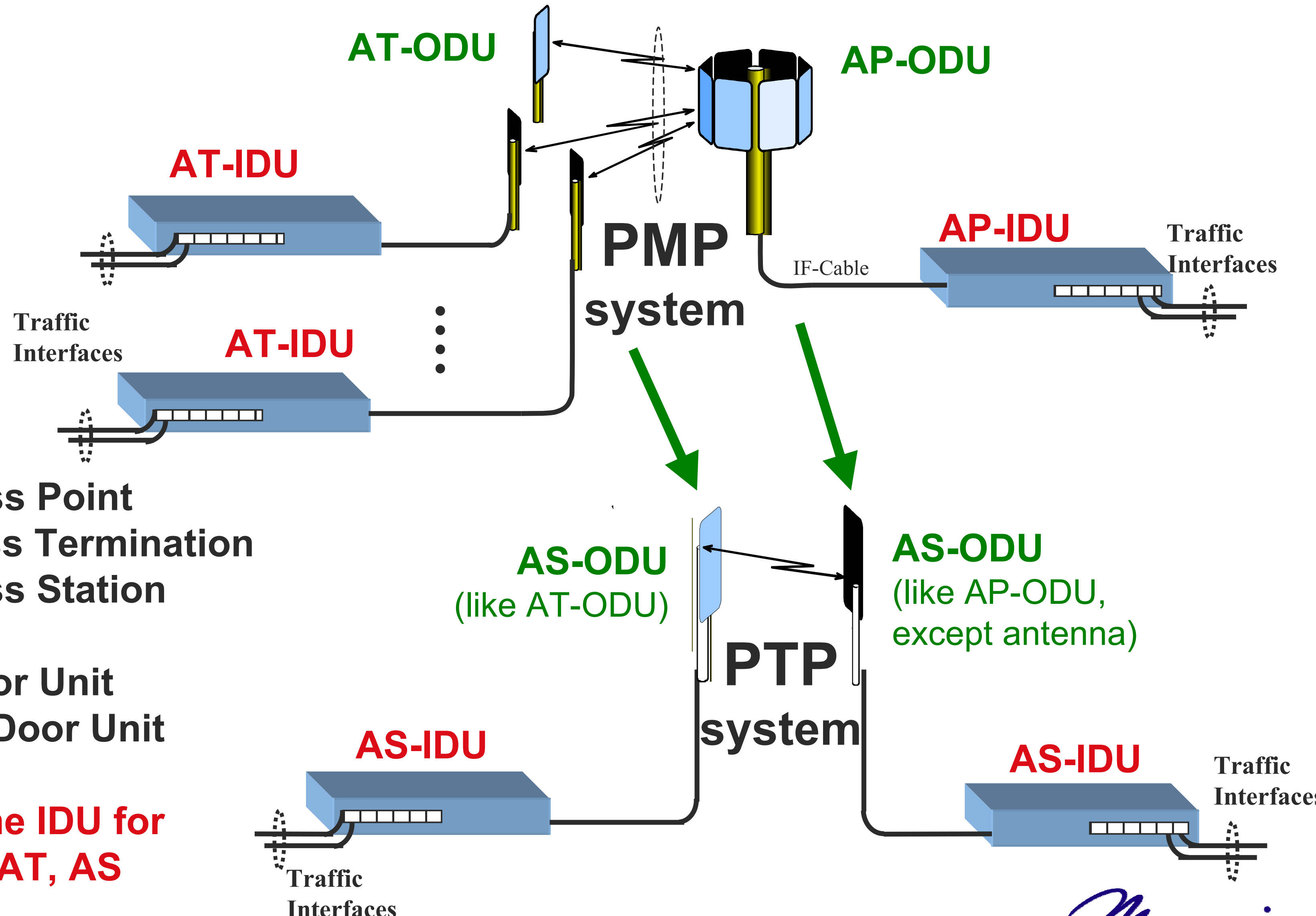
PTP: MDMS (ATM)

PTP: MDMS (ATM) / MDRS(SDH)

PMP: MDMS (ATM)

Future access network IP-based

Marconi's Components for PMP and PTP



AP: Access Point
AT: Access Termination
AS: Access Station

IDU: InDoor Unit
ODU: OutDoor Unit

Note: Same IDU for AP, AT, AS

Marconi's IDU
for HA-compliant-PMP and PTP systems

Protection (Redundancy)

Power

EDI (External Device Interface)

4 x E1-IMA-ATM
4 x E1-CES
2 x 100BaseT

2 x STM1 (optical)

2 x Management (local and remote)

ODU (IF cable)

Conclusions

Requirement		HiperAccess solution
Interoperability	→	Few well-controlled options, ASN.1-based message encoding, detailed test specifications.
Spectral efficiency	→	Adaptive modulation & coding, adaptive power control.
High QoS	→	Centralized radio link control, centralized scheduling, robust messaging.
Low cost design	→	Large network-independent part option for TDD, support of H-FDD.
Future proof	→	Several further options, „hooks“ for future evolution, phased roll-out: 1st ATM, 2nd IP

For more information ...

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