ETSI BRAN (Broadband Radio Access Networks) Standardisierung für breitbandige drahtlose PMP Systeme

Bernd Friedrichs
- Marconi Communications, Germany
- ETSI BRAN Chairman

Overview

- ETSI BRAN HiperAccess
- PHY layer (link budget, adaptive operation & coding)
- DLC layer, multiplex gain
- ETSI testing (radio, protocols)
- Marconi‘s HA-compliant system

About ETSI BRAN

- ETSI Project (EP) BRAN established in 1997
- In response to growing market pressure for low-cost, high-capacity broadband radio systems
- Fixed Wireless Access (FWA) systems as competitive alternatives to wireline access systems with
  - high performance (QoS, spectral efficiency)
  - flexibility
  - easy to set up
- Interoperable standards
- BRAN assists (via ETSI ERM RM) regulatory bodies to define spectrum requirements and radio conformance specifications for new broadband radio networks

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

PHY
physical layer

DLC
data link control layer

CL
convergence layers

EC-funded

Testing
radio & protocols

BRAN Relationship with Other Bodies and Forums

- IEEE 802.xx
  - IEEE 802.11a ~ BRAN HL (same PHY layer)
  - IEEE 802.16+ ~ BRAN HA (harmonization under discusion)
  - IEEE 802.16a ~ BRAN HM (close co-operation)
- HiperLAN2 Gobal Forum
- ATM Forum
- CEPT
- 3GPP
- IETF (Internet Engineering Task Force)
- MMAC-PC (Multimedia Mobile Access Communication Systems - Promotion Council)
- ITU-R, ITU-T
- ETSI OCG, ETSI TM4, ETSI ERM

Why Do We Need Standards ?

- Active participation of many operators
  ➔ Optimized for important applications
  (Cellular 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

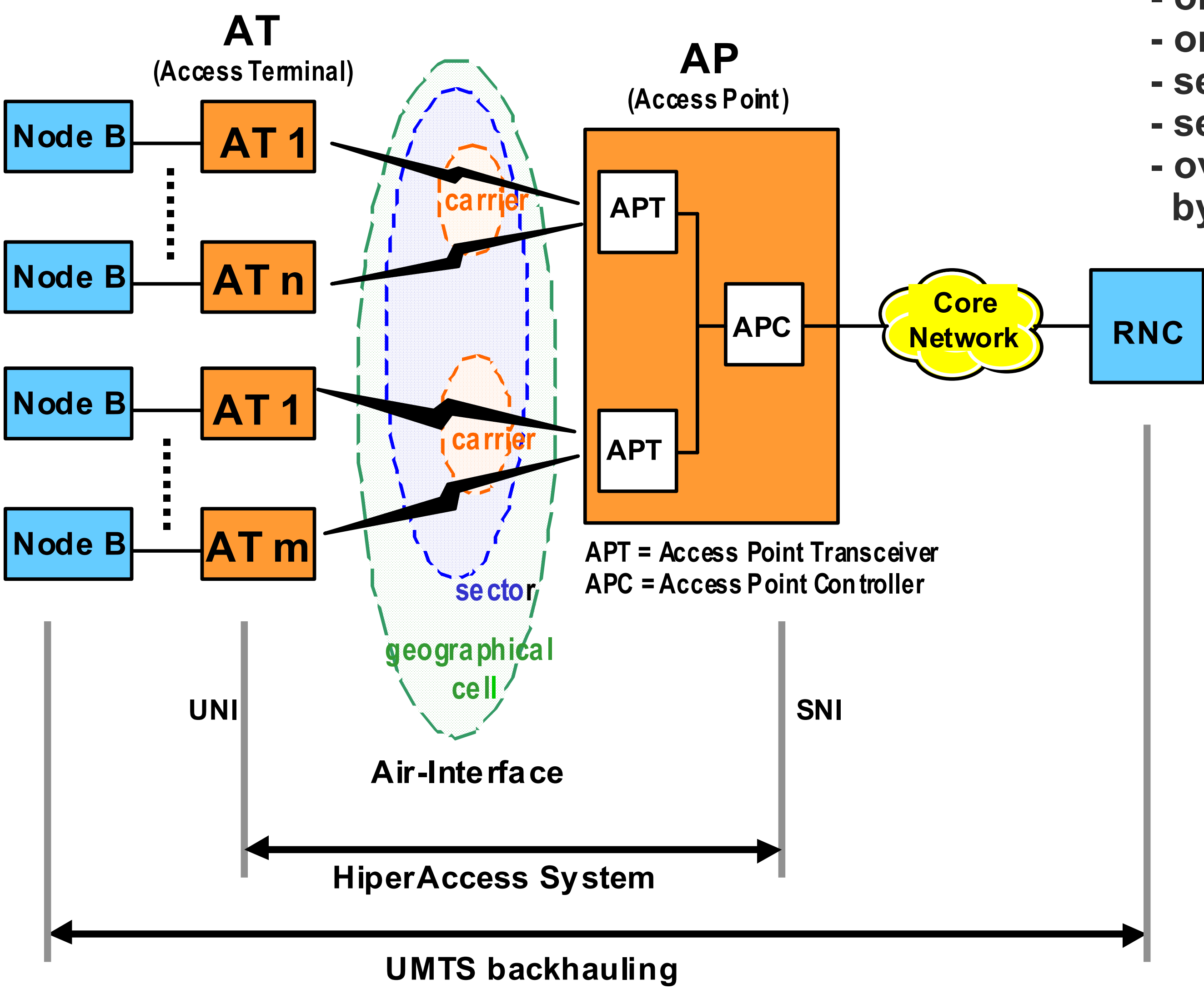
- Other advantages of an interoperable standard
  - easy for customers to compare
  - flexibility for customers
  - increased competition ➔ low cost

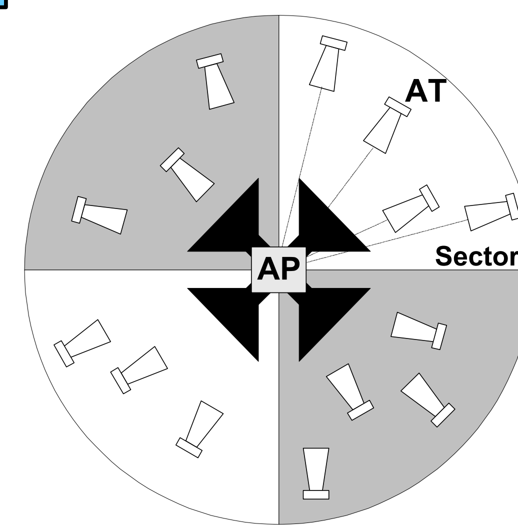
HiperAccess: Overview

- **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)
- **Interest in HA from**
  - Manufacturers: Alcatel, Ensemble, Ericsson, Marconi, Nokia, Siemens, ...
  - Operators: France Telecom, Omnitel Vodafone, Sonera, Telecom Italia, Telekom Austria, Telenor, Telia, ...

HiperAccess: Network Topology Model

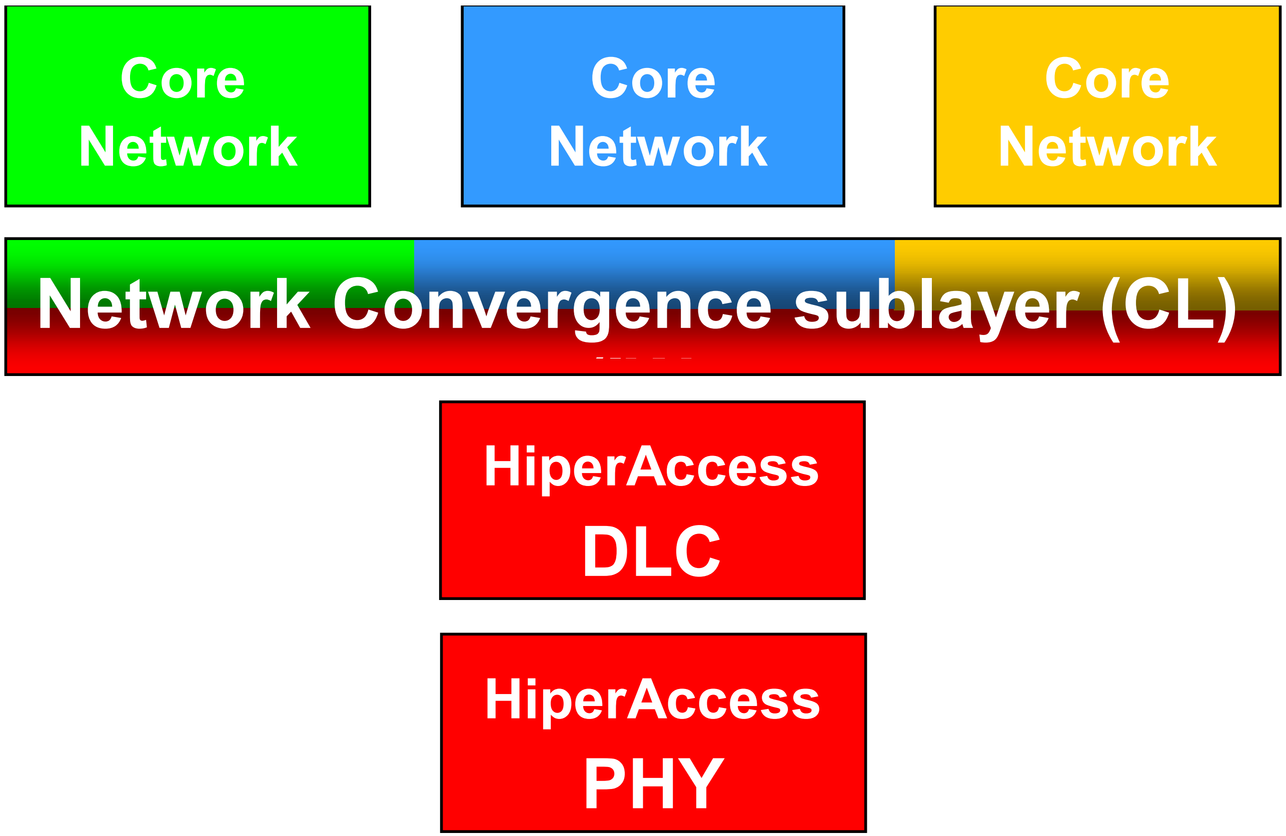
- one APT per carrier
- one APC per cell
- several sectors per cell
- several carriers per sector
- overlapping cells (separated by frequency or polarization)





Cell with four sectors

Interworking Approach



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

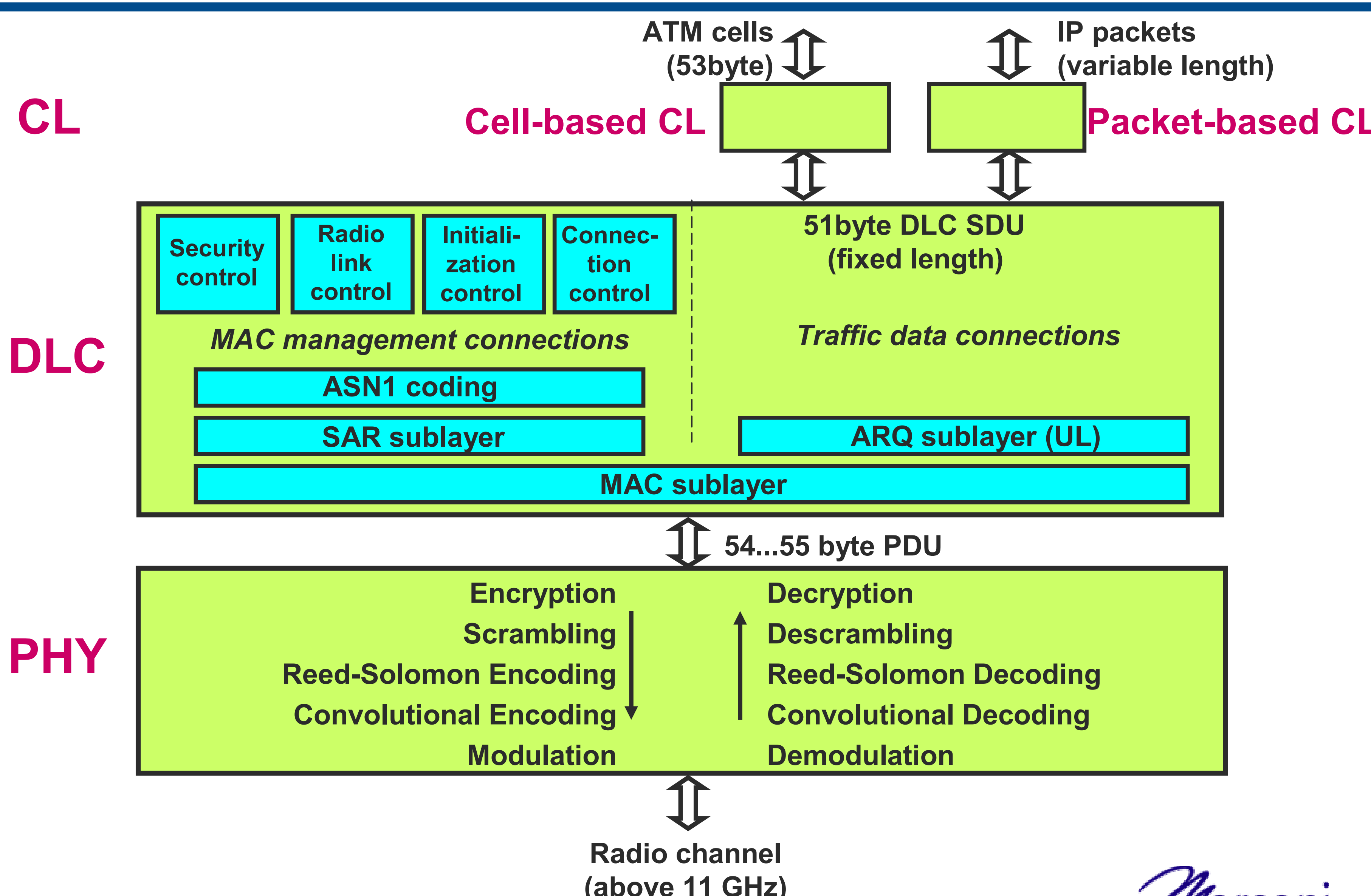
Removes differences between core networks

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

HiperAccess: Detailed Layer Structure



HiperAccess: Basic Features

Focus on frequency bands

- 40.5 - 43.5 GHz
- 31.8 - 33.4 GHz
- 27.5 - 29.5 GHz
- 24.5 - 26.5 GHz
- other lower frequencies

Channel size = 28 MHz, Baudrate = 22.4 MBaud

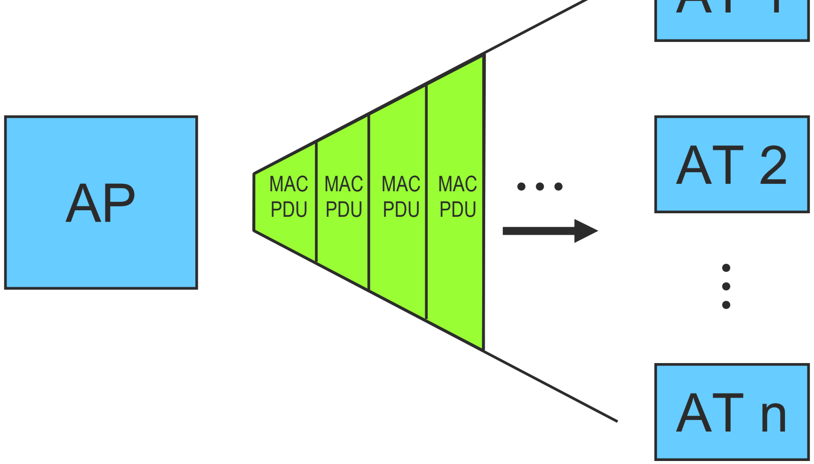
- Paired bands (FDD mode, fixed asymmetric rates)
- Unpaired bands (TDD mode, adaptive asymmetric rates)
- Optimum trade-off between costs, peak data rate and statistical multiplex gain

Important parameters

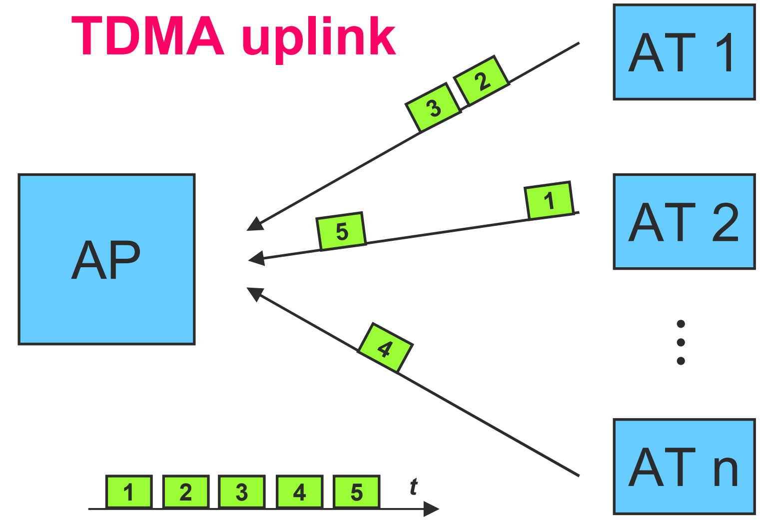
	Downlink (AP → AT)	Uplink (AT → AP)
Data rates (Mbit/s)	20...120 (typically 80)	20...80 (typically 50)
Transmit power	15 dBm	14 dBm
Range	up to 12 km (hard limit from ranging, effectively depending on availability and rain zone)	

HiperAccess: TDM in Downlink, TDMA in Uplink

TDM downlink



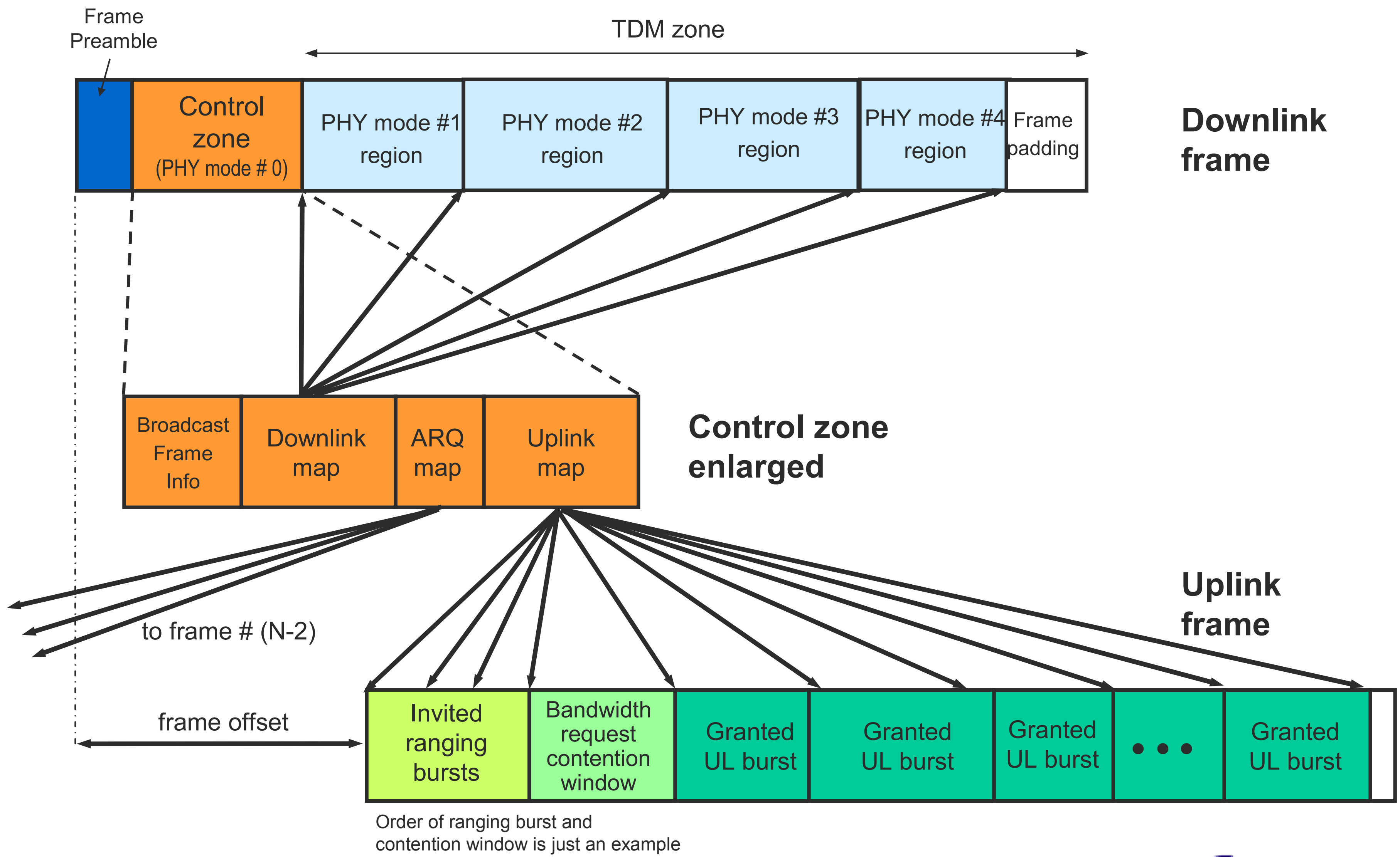
TDMA uplink



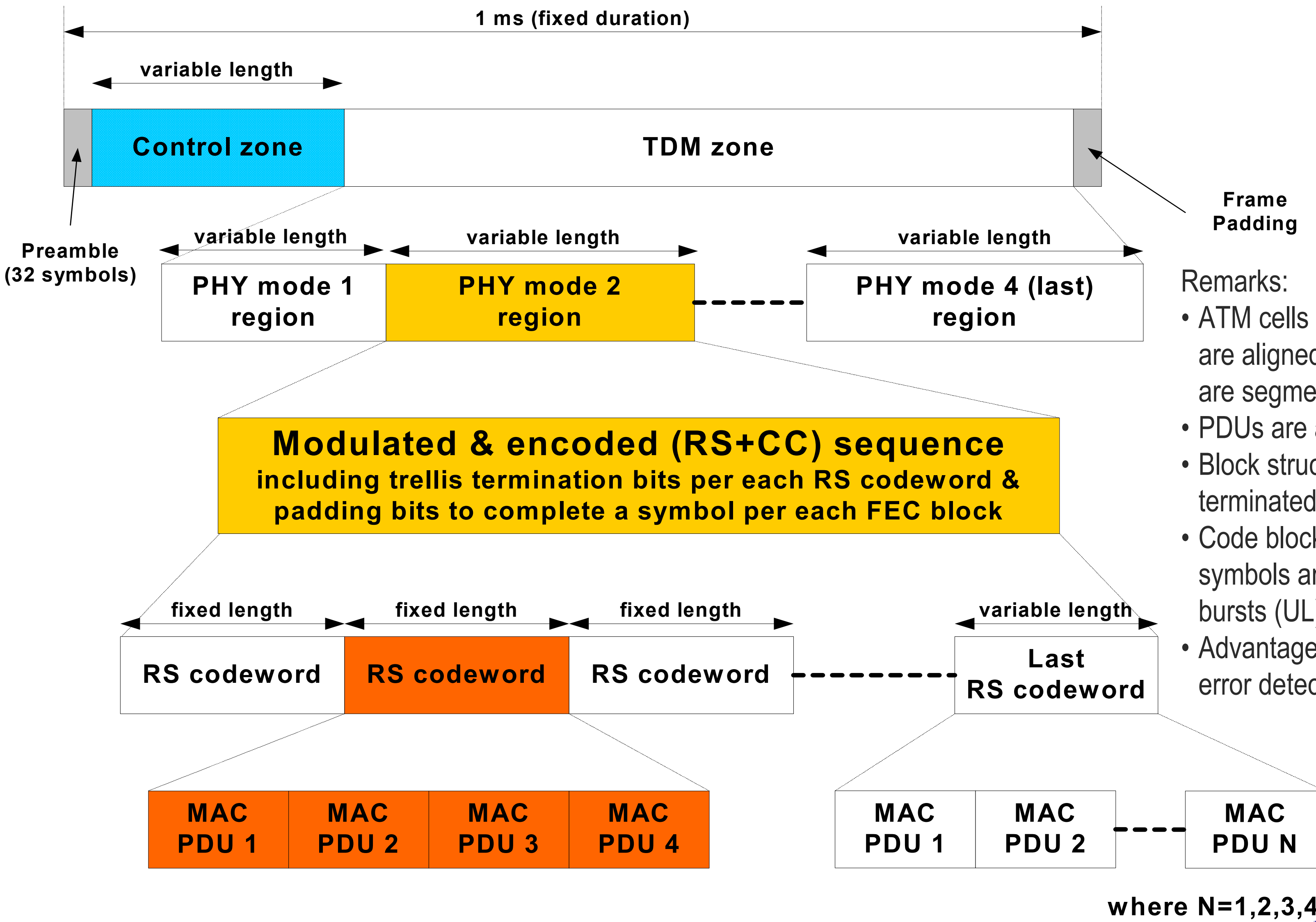
Further important properties of downlink and uplink

	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

HiperAccess: Frame Structure



HiperAccess: Concatenated Coding



Remarks:

- ATM cells and DLC messages are aligned to PDUs, IP packets are segmented to PDUs
- PDUs are aligned to RS blocks
- Block structure preserved by terminated convolutional coding
- Code blocks are aligned to symbols and regions (DL) and bursts (UL)
- Advantages:
  error detection and ARQ

HiperAccess: Adaptive Coding and Modulation

Adaptation

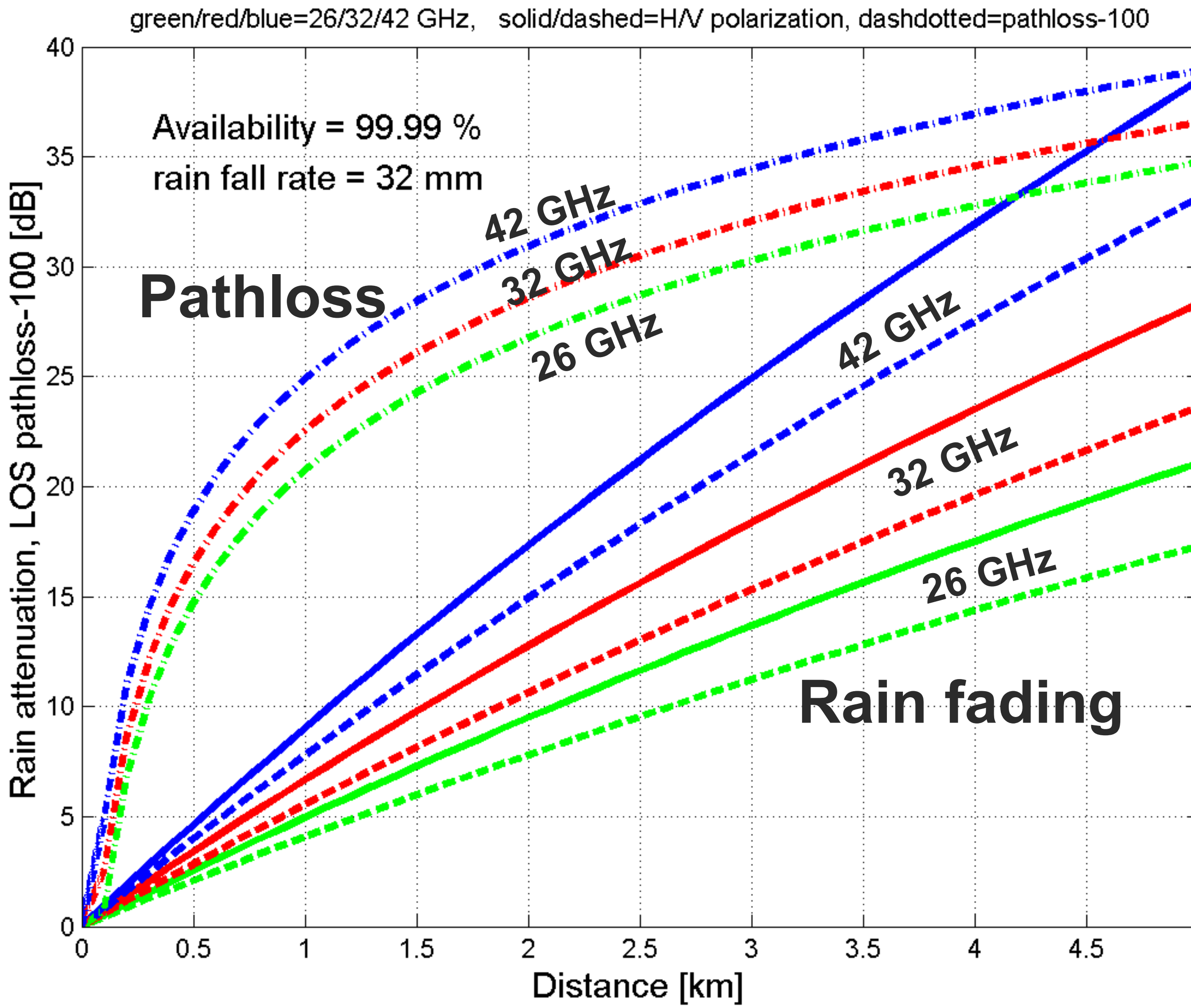
- according to distance
- according to interference
- according to rain fading (20 dB/s)
- per terminal
- per frame
- combined with ATPC (Adaptive Transmit Power Control)

PHY mode defined by modulation and concatenated coding

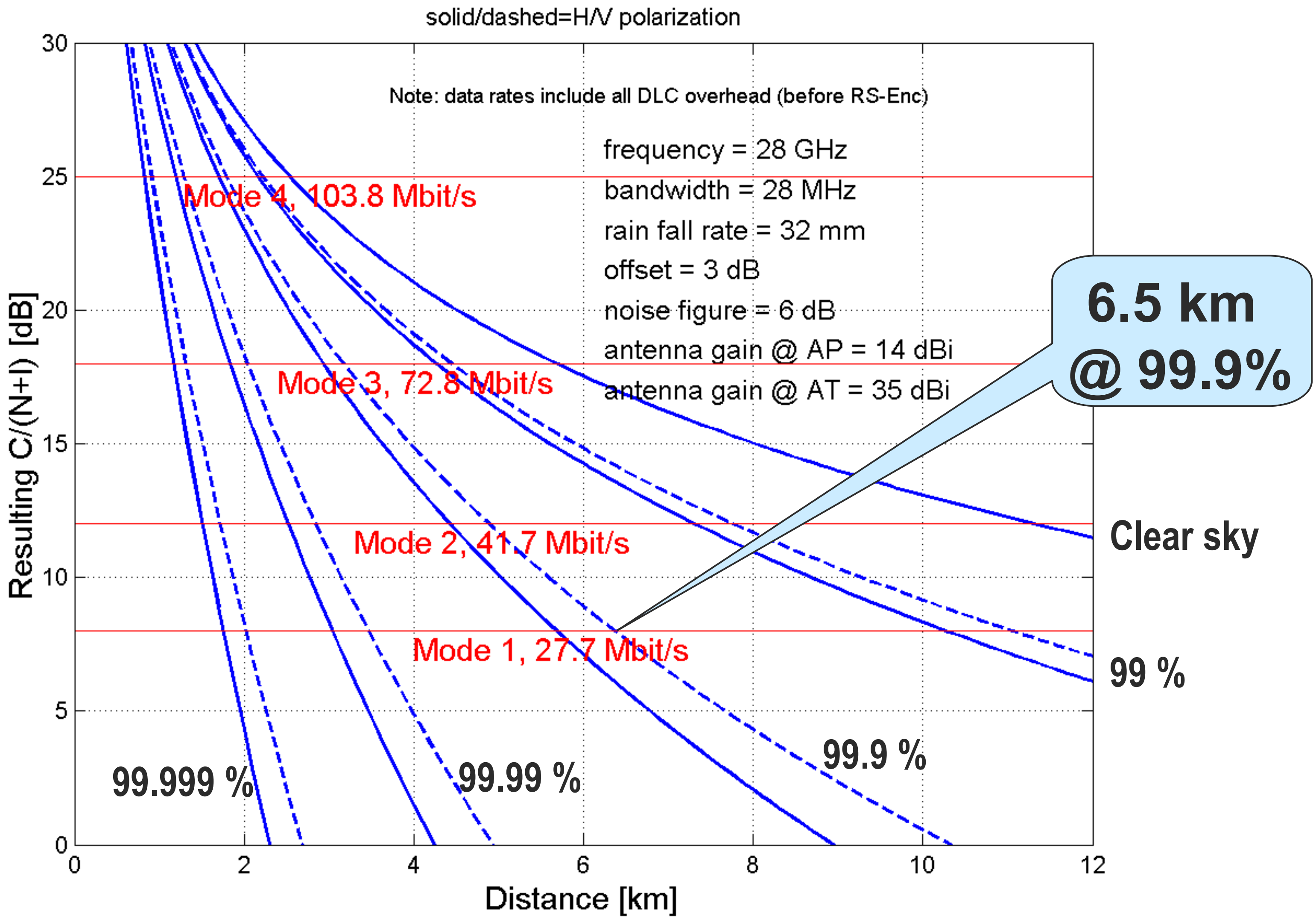
Mode	Modulation	Outer Block Code	Inner Convolutional Code	Information word length	Spectral efficiency	Required C/(N+I)
0 (CZ)	QPSK	RS(t=8)	R=1/2	30 byte	from ~ 0.5 bit/s/Hz to ~ 3.8 bit/s/Hz	7 dB
1	QPSK	RS(t=8)	R=2/3	1...4 PDU		8 dB
2	QPSK	RS(t=8)	-	1...4 PDU		12 dB
3	16-QAM	RS(t=8)	R=7/8	1...4 PDU	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

PHY mode set 1

Link Budget: Free-Space Loss and Rain Fading



Range and Throughput for PMP @ 28 GHz for various availabilities



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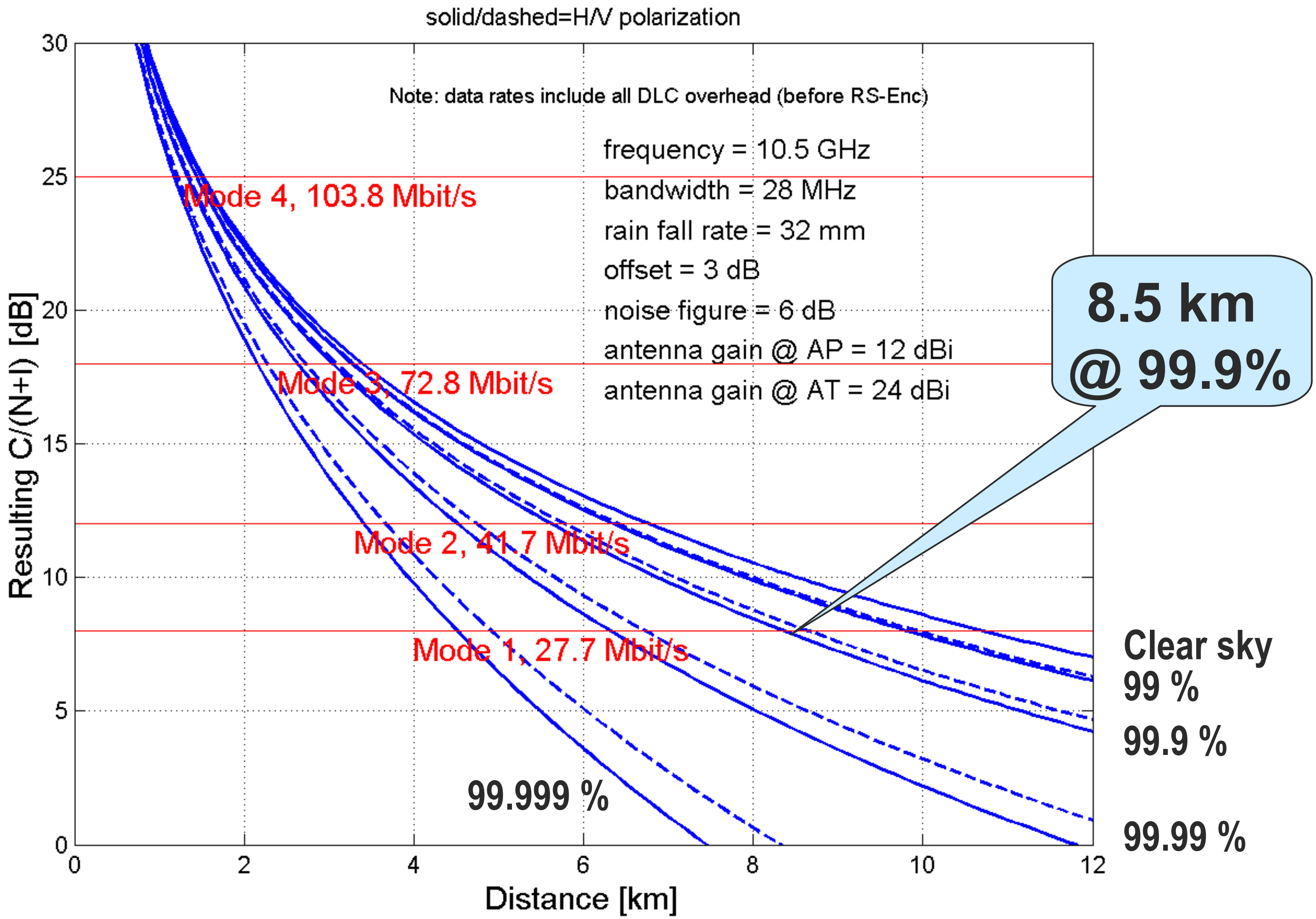
Range and Throughput for PMP @ 10.5 GHz for various availabilities



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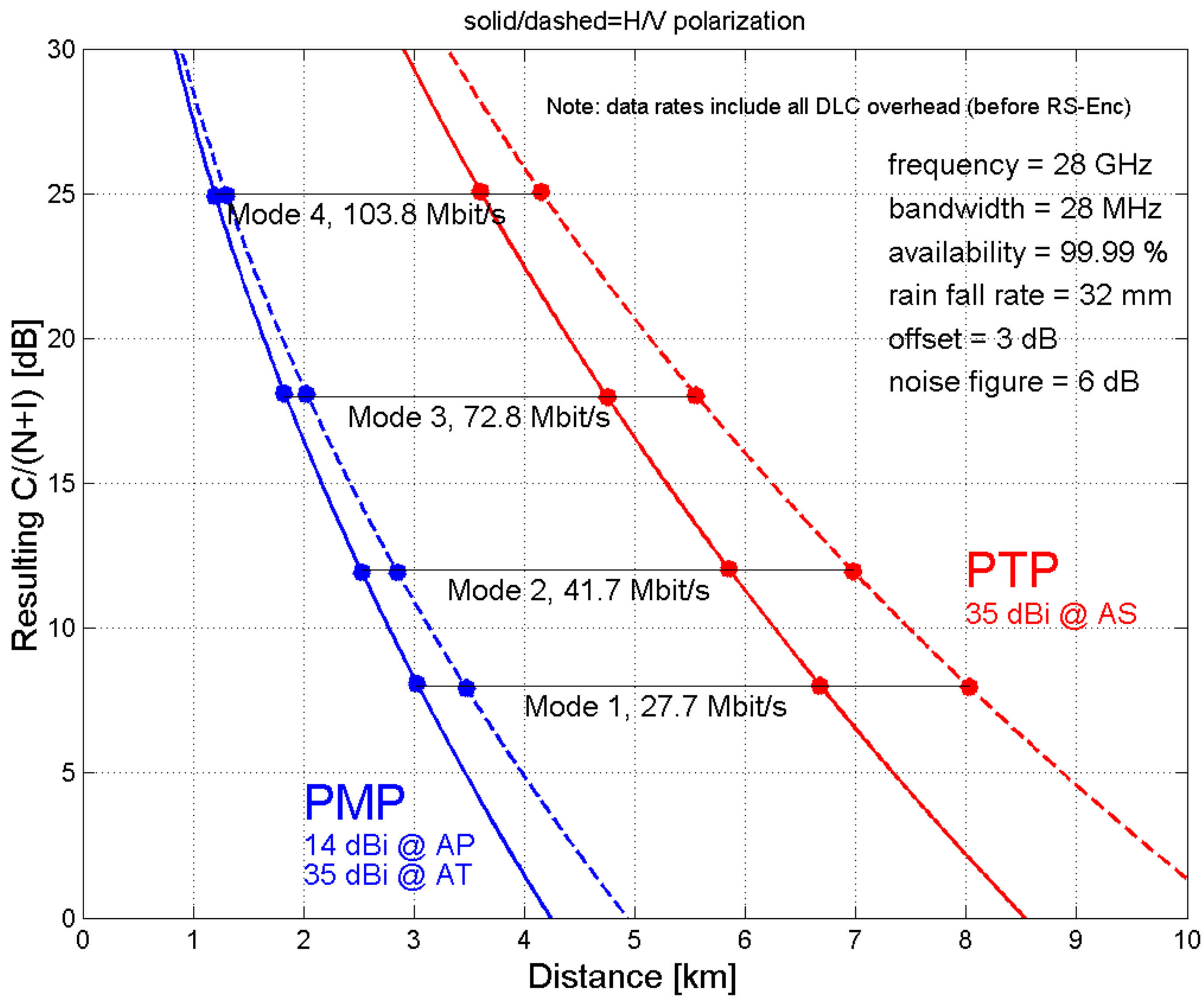
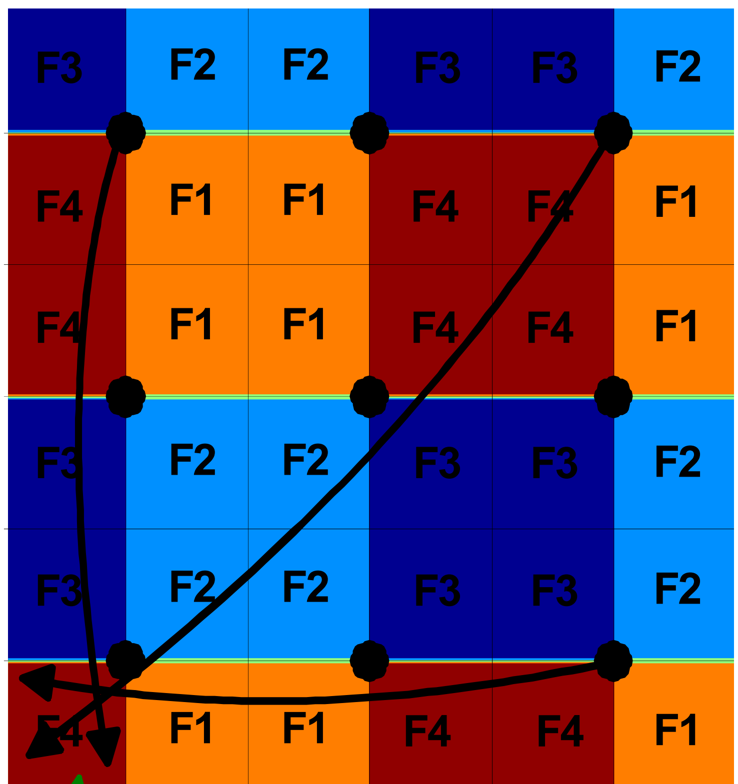
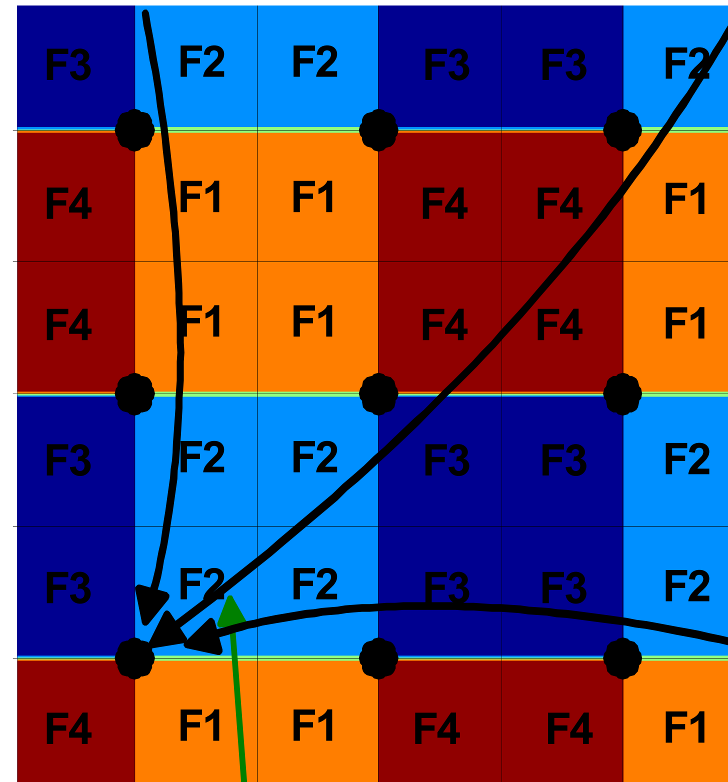
Range and Throughput: PMP versus PTP
@ 28 GHz, 15 dBm, 99.99%, rain zone H



Interference in Downlink and Uplink





DL worst sector

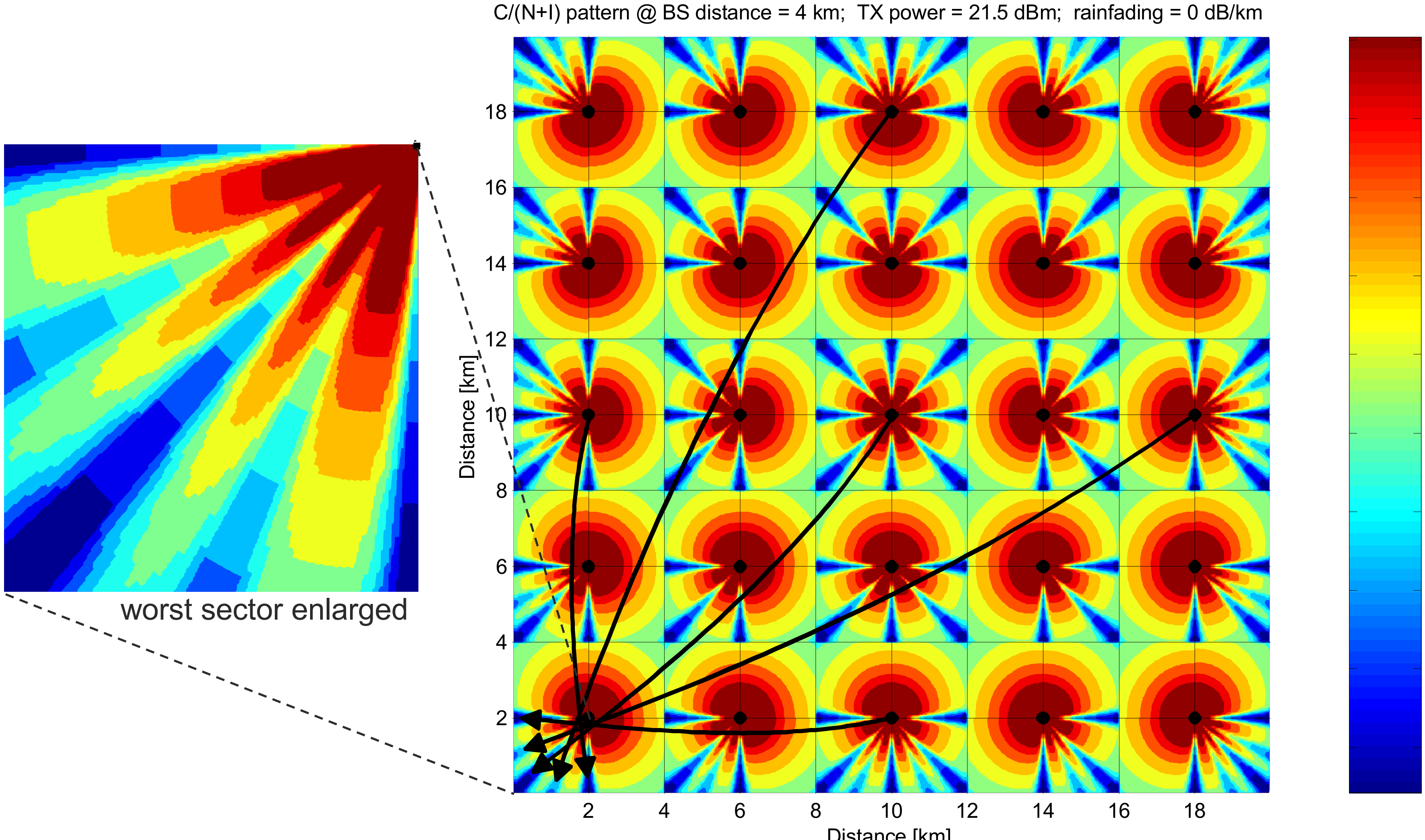
$(C/I)_{min}$ = 20*log(5) = 14.0 dB

UL worst sector

Interference degradation typically depends on direction

- a sector may have poor properties for DL but good properties for UL
- interference is time-invariant for DL and time-variant for UL

C/(N+I) Pattern for 5x5 Rectangular Constellation (Downlink, ClearSky, ReUseFactor =4)



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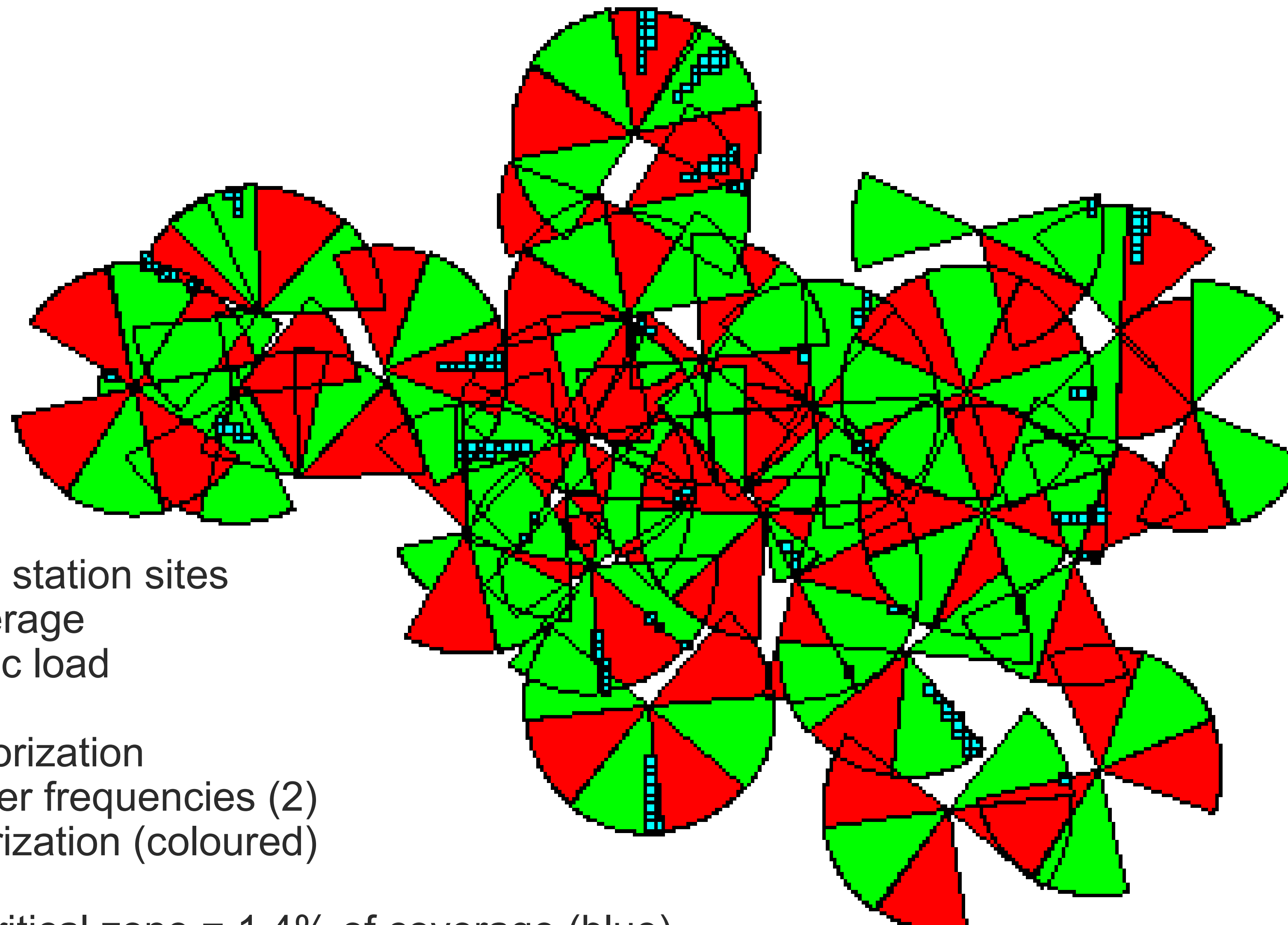
Marconi's Radio Network Planning Tool (Realistic Constellation with 142 Sectors)



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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HiperAccess: 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

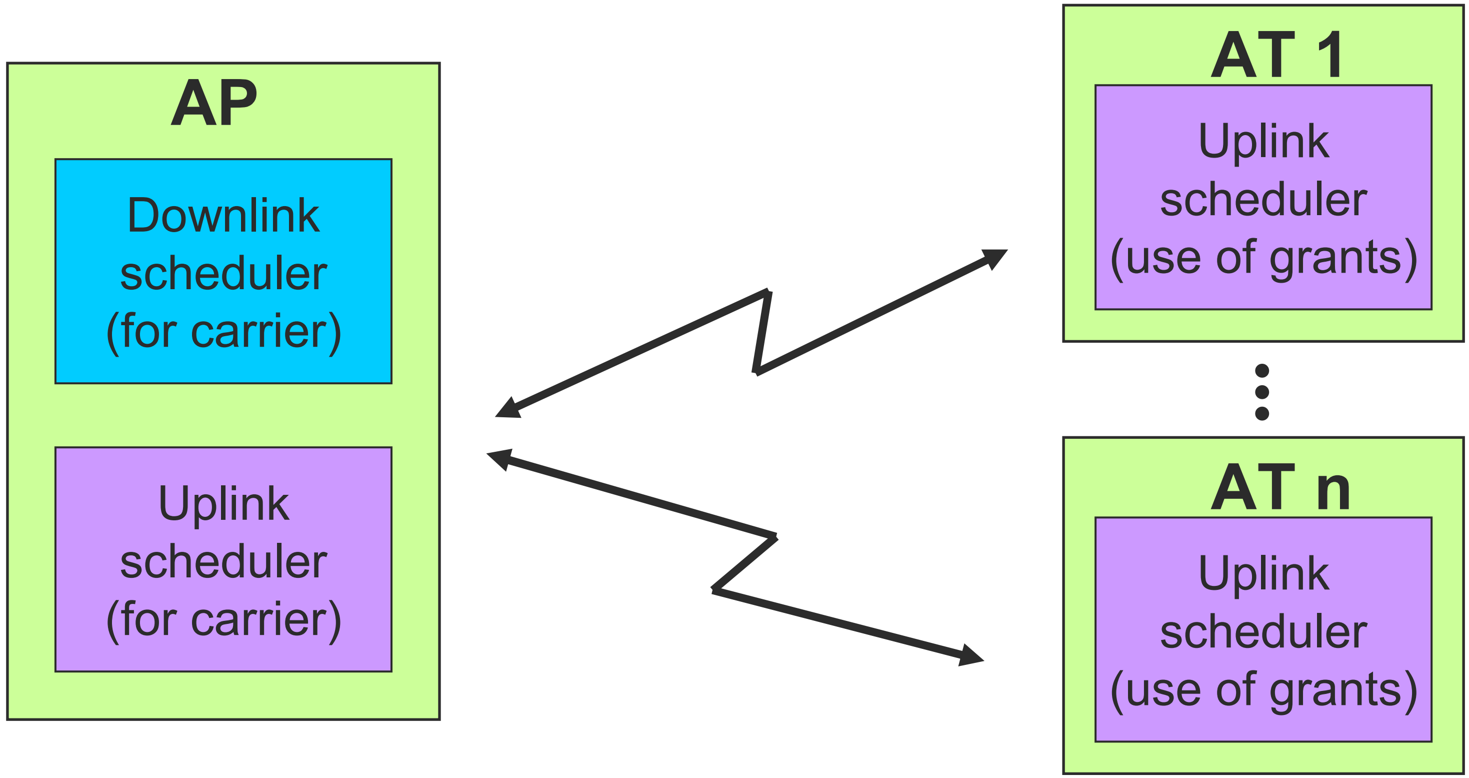
QoS Classes

- 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

HiperAccess: Bandwidth Allocation



Downlink allocation

via DL map
(no action from AT)

Uplink allocation

Requests per connection aggregate (various mechanisms)

Grants per terminal via UL map

HiperAccess: 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)

Statistical Multiplex Gain (1 of 2)

A PMP system performs like a virtual multiplexer:

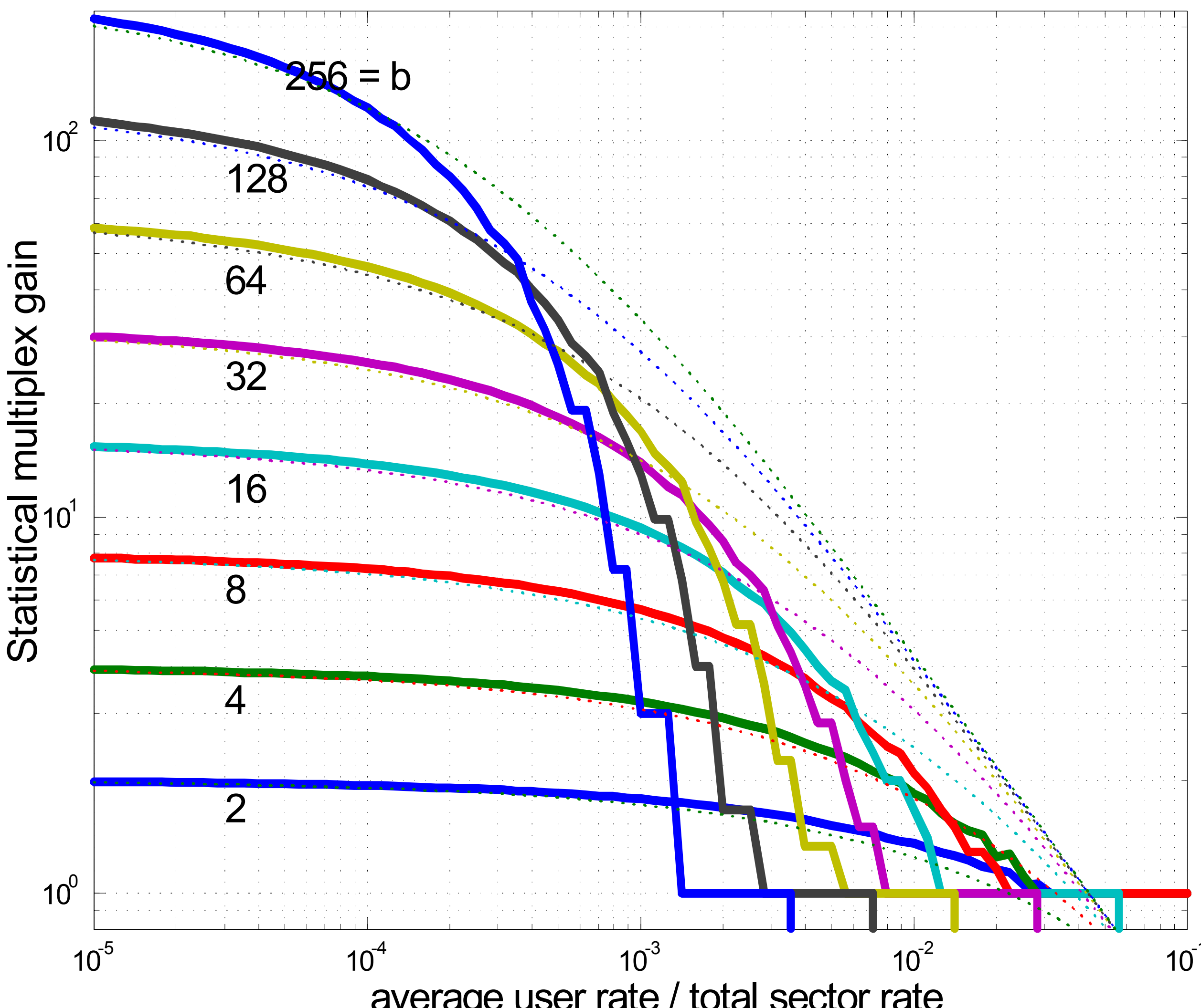
Statistical multiplexing with a small CLR (cell loss rate) allows higher total data rates than fixed allocation guaranteeing peak data rates. Formally,

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

The multiplex gain of a PMP system increases with

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

Statistical Multiplex Gain (2 of 2)



Conditions:

CellLossRate = 10^{-6}
DelayTolerance = 0

Legend:
b = burstiness

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ETSI Approach for Normative Testing
➔ Interoperable Standard

Basic protocol standard development

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

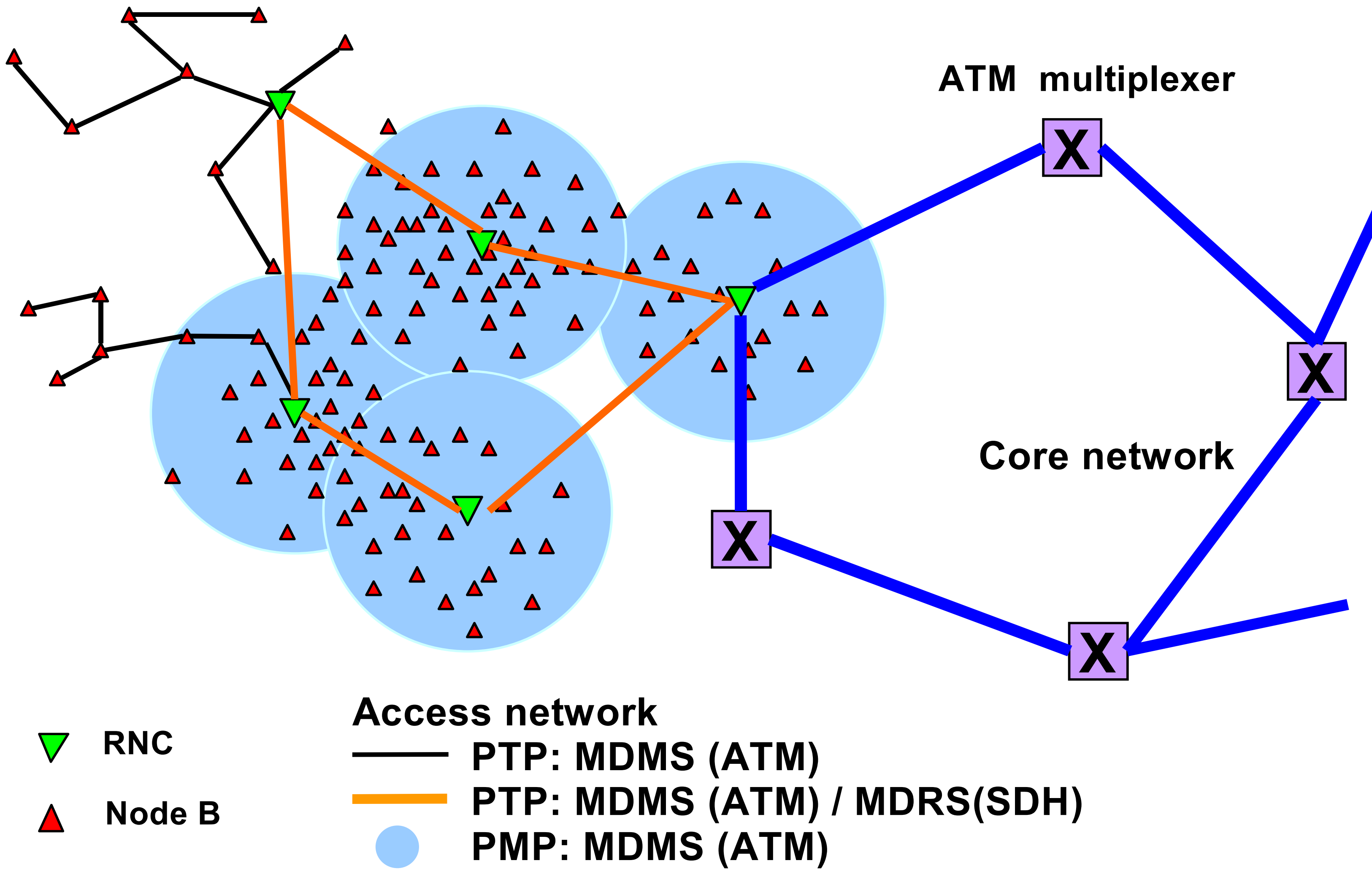
- **PICS** Protocol Implementation Conformance Statement
- **TSS & TP** Test Suite Structure and Test Purposes
- **ATS** Abstract Test Suite (TTCN)

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

Radio test specifications

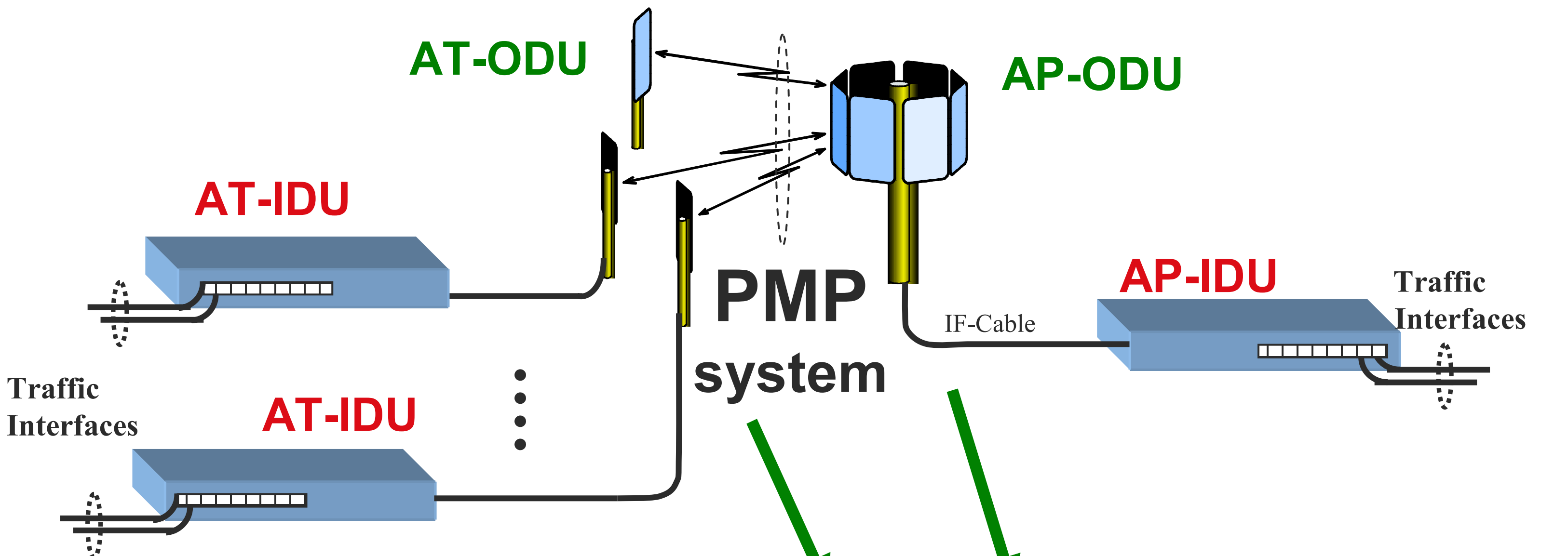
- **RCT** Radio Conformance Test
- **EN** **Harmonized Standard (European Norm)**, covering the essential requirements of article 3.2 of the EC R&TTE Directives

Marconi's PMP / PTP Network Solution for UMTS Backhauling



Future access network IP-based

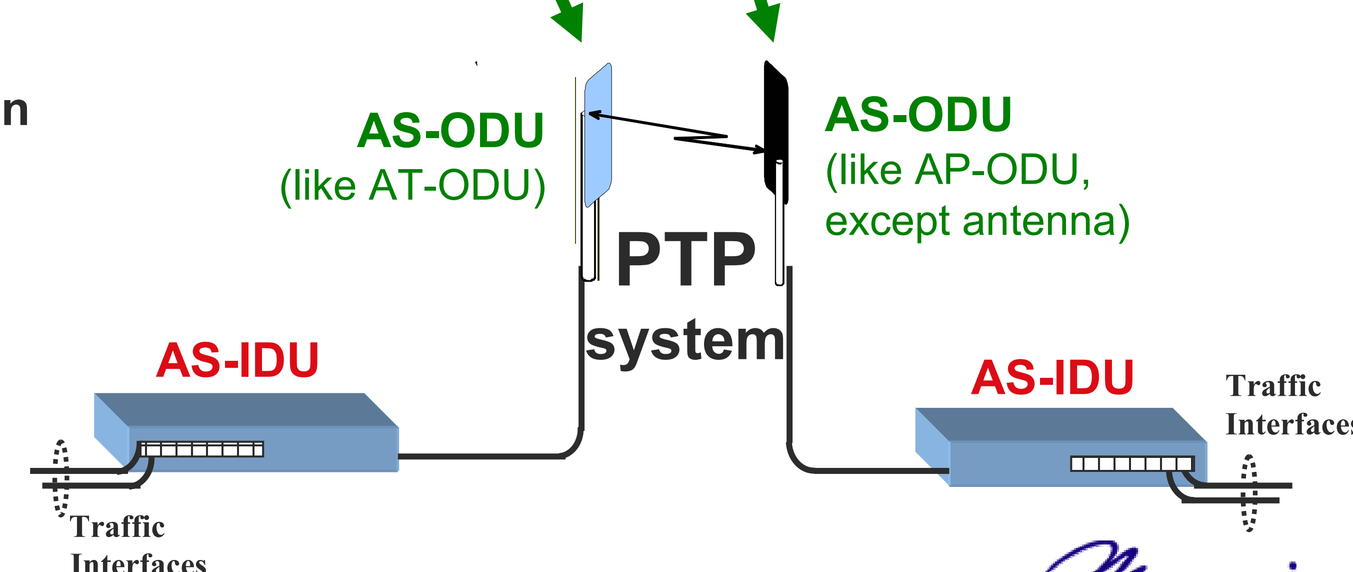
Marconi's Components for PMP and PTP



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)

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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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