

The IEEE 802.16 WirelessMAN Standard for Broadband Wireless Metropolitan Area Networks

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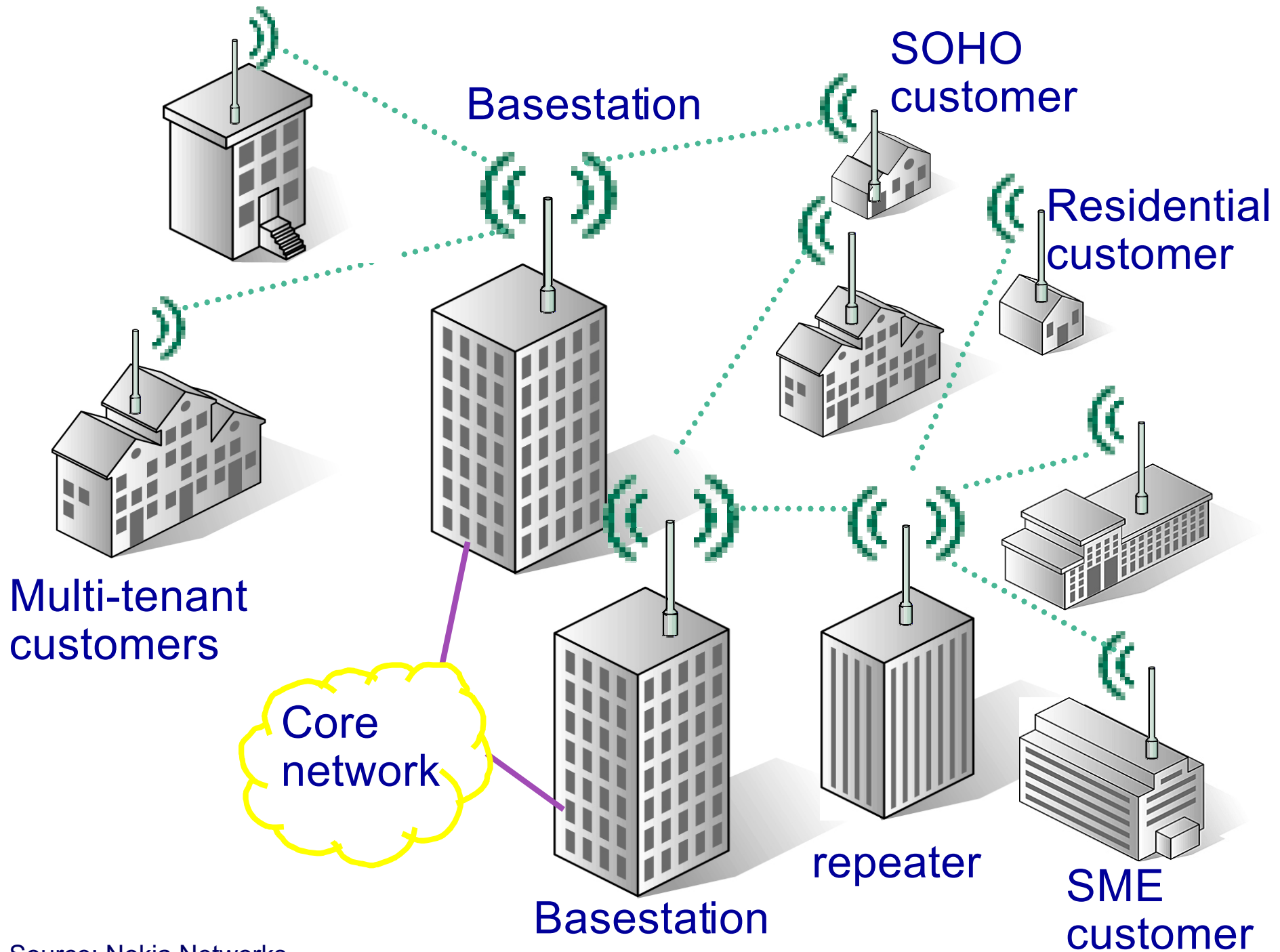
<http://WirelessMAN.org>

Broadband Access to Buildings

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- The “Last Mile”
 - Fast local connection to network
- Business and residential customers demand it
 - Data
 - Voice
 - Video distribution
 - Real-time videoconferencing
 - etc.
- Network operators demand it
- High-capacity cable/fiber to every user is expensive
 - Construction costs do not follow Moore’s Law

WirelessMAN: Wireless Metropolitan Area Network³



Properties of IEEE Standard 802.16

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- Broad bandwidth
 - Up to 134 Mbit/s in 28 MHz channel (in 10-66 GHz air interface)
- Supports multiple services simultaneously with full QoS
 - Efficiently transport IPv4, IPv6, ATM, Ethernet, etc.
- Bandwidth on demand (frame by frame)
- MAC designed for efficient use of spectrum
- Comprehensive, modern, and extensible security
- Supports multiple frequency allocations from 2-66 GHz
 - OFDM and OFDMA for non-line-of-sight applications
- TDD and FDD
- Link adaptation: Adaptive modulation and coding
 - Subscriber by subscriber, burst by burst, uplink and downlink
- Point-to-multipoint topology, with mesh extensions
- Support for adaptive antennas and space-time coding
- Extensions to mobility are coming next.
- Is this 4G?

IEEE 802.16 History

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- Project Development: 1998-1999
- Meet every two months:
 - Session #1: July 1999
 - ...
 - Session #22: Hawaii, Nov 2002
 - Session #23: San Jose, Jan 2003
- Future Sessions
 - Session #24/Mar 2003: Dallas (with 802)
 - Session #25/May 2003: Singapore (with 802.11, etc)
 - Session #26/July 2003: San Francisco (with 802)

IEEE 802.16 Projects: 10-66 GHz ⁶

- Air Interface (MAC and PHY)
 - IEEE Standard 802.16
 - Completed in October 2001
 - Published in April 2002
 - Now free
 - Followup interoperability projects (unusual in 802)
 - 802.16c (Profiles): published in Jan 2003
 - 1802.16.1 (PICS): in ballot; completion expected Mar 2003
 - 1802.16.2: (Test Suite Structure & Purposes)
 - Initiated on 11 Dec; WiMAX submitted proposal in Jan 2003
- Coexistence
 - IEEE Standard 802.16.2 (Recommended Practice)
 - Published in September 2001
 - Now free

IEEE 802.16 Projects: 2-11 GHz

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- Air Interface

- new PHY based on 802.16 MAC

- IEEE Standard 802.16a

- Completed in November 2002

- Approved 29 January 2003

- Followup interoperability projects

- P802.16d: first meeting Jan 2003

- Followup air interface project: *mobility*

- P802.16e: first meeting Jan 2003

- Coexistence

- IEEE Standard 802.16.2a (Recommended Practice)

- In IEEE ballot

- Completion expected in March 2003

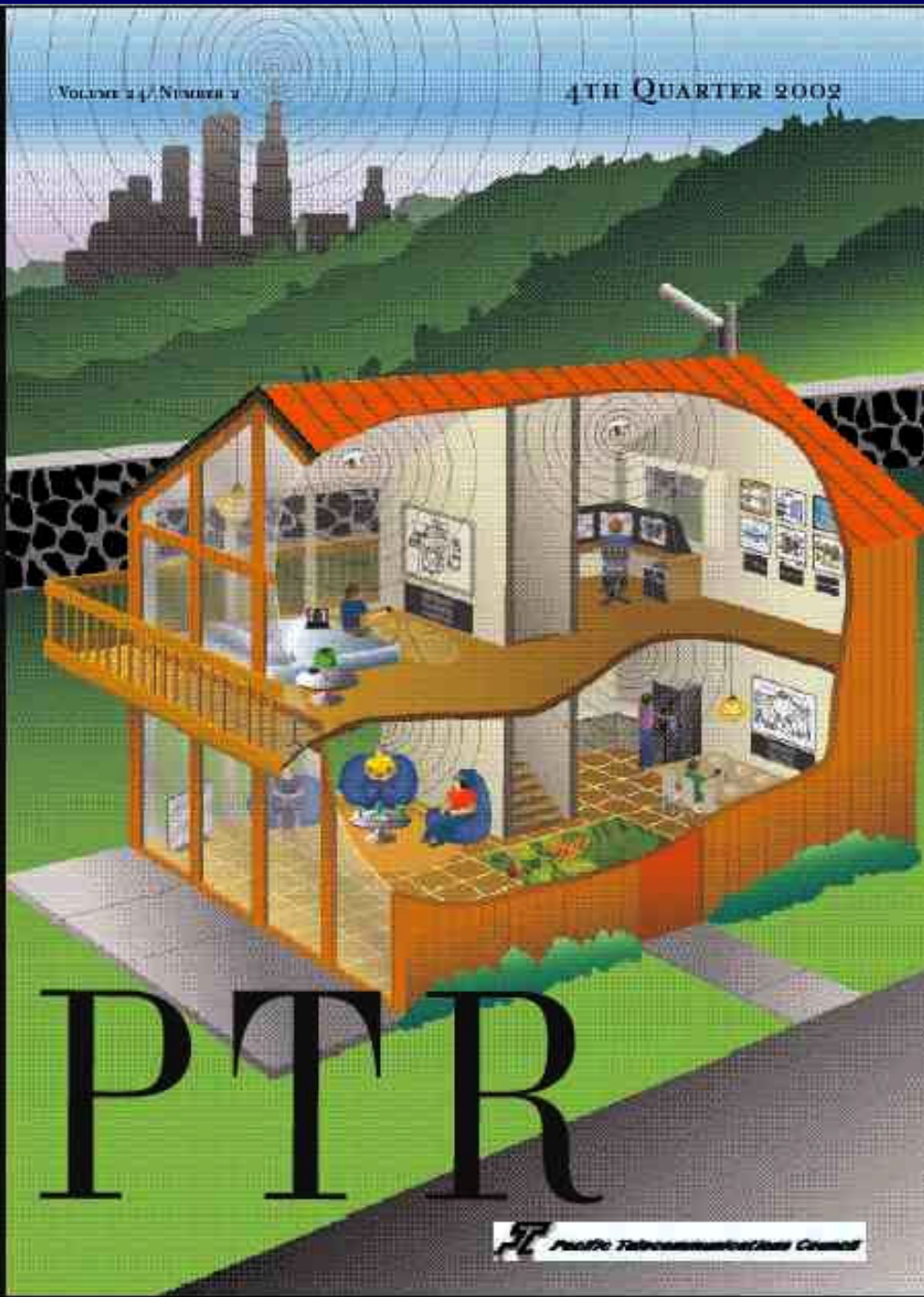
The World Wants Standards

- Standards are at the forefront of world trade
 - World Trade Organization rules accelerating process
 - e.g. Chinese-language MediaView magazine is instituting a monthly column on standards
- In all fields of telecommunications, the world wants standards.
- Broadband Wireless Access is not isolated from this trend.
- Some say that stationary systems don't require standards. But consider:
 - Ethernet
 - DOCSIS

Pacific Telecommunications Council

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PACIFIC TELECOMMUNICATIONS REVIEW



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The World Wants 802.16

WirelessMAN™ Standards

- Have had attendees from 21 countries (Australia, Canada, China, Finland, France, Germany, Greece, Israel, Italy, Japan, Korea, Netherlands, Norway, Pakistan, Russia, Singapore, Spain, Sweden, Taiwan, UK, USA)
- 2002 meetings in:
 - Finland
 - Korea
 - Canada twice (Vancouver and Calgary)
 - U.S. twice (Hawaii and St. Louis)
- Coordinated European efforts in ETSI

802.16 and ETSI

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- Over 50 liaison letters between 802.16 and ETSI
 - (European Telecom Standards Institute)
- ETSI HIPERACCESS
 - Above 11 GHz
 - ETSI began first, but IEEE finished first
 - 802.16 has encouraged harmonization
- ETSI HIPERMAN
 - Below 11 GHz
 - IEEE began first
 - Healthy cooperation
 - Harmonized with 802.16a OFDM

BWA/802.16 Interest within China

“IEEE 802.16a Broadband Wireless Access (BWA) Standard Development and Internet Application”: conference sponsored by BUPT and MII on 24 August 2001 in Beijing “on the specific topic of whether to use 802.16a as the Chinese national standard for fixed broadband wireless access at 3.5 GHz” (Prof. Liu Yuan An, Chair)



WiMAX Forum

- **WiMAX: Worldwide Interoperability for Microwave Access**
- Mission: *To promote deployment of BWA by using a global standard and certifying interoperability of products and technologies.*
- Principles:
 - Support IEEE 802.16
 - 2-66 GHz
 - Propose access profiles for the IEEE 802.16 standard
 - Guarantee known interoperability level
 - Promote IEEE 802.16 standard to achieve global acceptance
 - Open for everyone to participate
- Developing & submitting baseline test specs

IEEE Standard 802.16: The WirelessMAN-SC™ Air Interface

Published: 8 April 2002

IEEE Std 802.16-2001®

IEEE Standard for
Local and metropolitan area networks

Part 16: Air Interface for Fixed Broadband Wireless Access Systems

Sponsor

LAN/MAN Standards Committee
of the
IEEE Computer Society

and the
IEEE Microwave Theory and Techniques Society



Approved 6 December 2001

IEEE-SA Standards Board

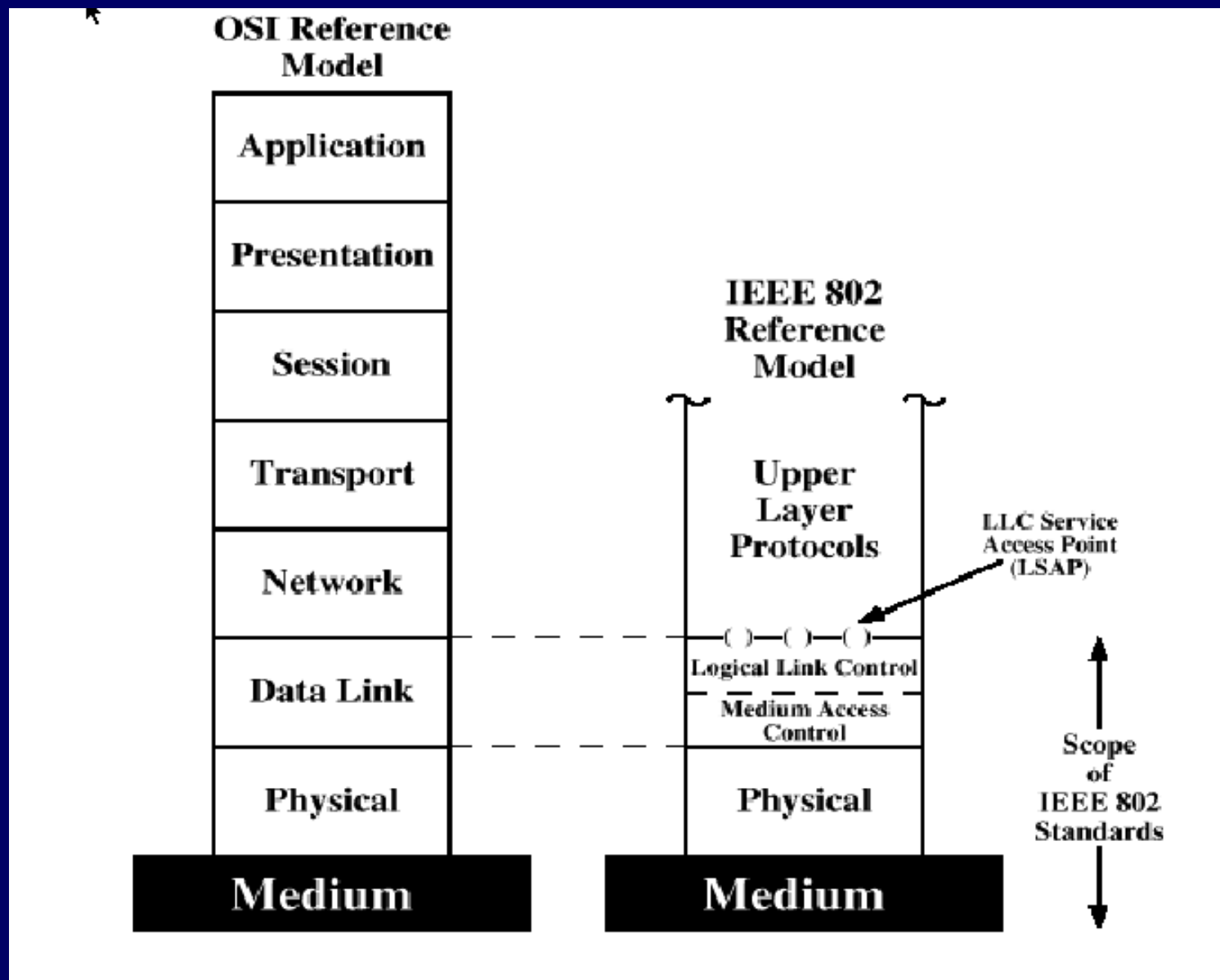
Abstract: This standard specifies the air interface of fixed (stationary) point-to-multipoint broadband wireless access systems providing multiple services. The medium access control layer is capable of supporting multiple physical layer specifications optimized for the frequency bands of application. The standard includes a particular physical layer specification applicable to systems operating between 10 and 66 GHz.

Keywords: fixed broadband wireless access network, metropolitan area network, microwave, millimeter wave, WirelessMAN™ standards

Point-to-Multipoint Wireless MAN: not a LAN

- Base Station (BS) connected to public networks
- BS serves Subscriber Stations (SSs)
 - SS typically serves a building (business or residence)
 - provide SS with first-mile access to public networks
- Compared to a Wireless LAN:
 - Multimedia QoS, not only contention-based
 - Many more users
 - Much higher data rates
 - Much longer distances

Scope of 802 Standards



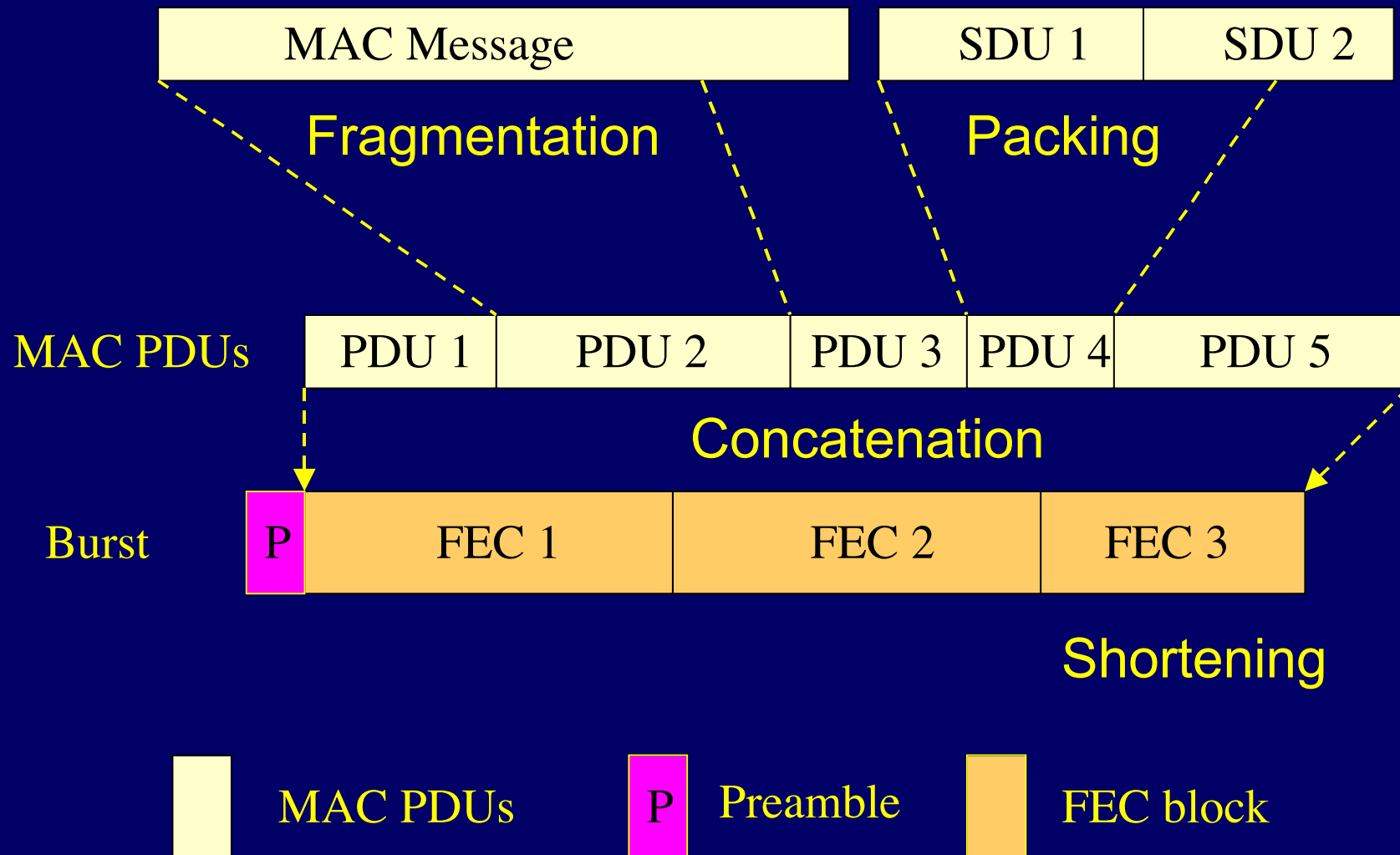
802.16 MAC: Overview

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- Point-to-Multipoint
- Metropolitan Area Network
- Connection-oriented
- Supports difficult user environments
 - High bandwidth, hundreds of users per channel
 - Continuous and burst traffic
 - Very efficient use of spectrum
- Protocol-Independent core (ATM, IP, Ethernet, ...)
- Balances between stability of contentionless and efficiency of contention-based operation
- Flexible QoS offerings
 - CBR, rt-VBR, nrt-VBR, BE, with granularity within classes
- Supports multiple 802.16 PHYs

MAC PDU Transmission

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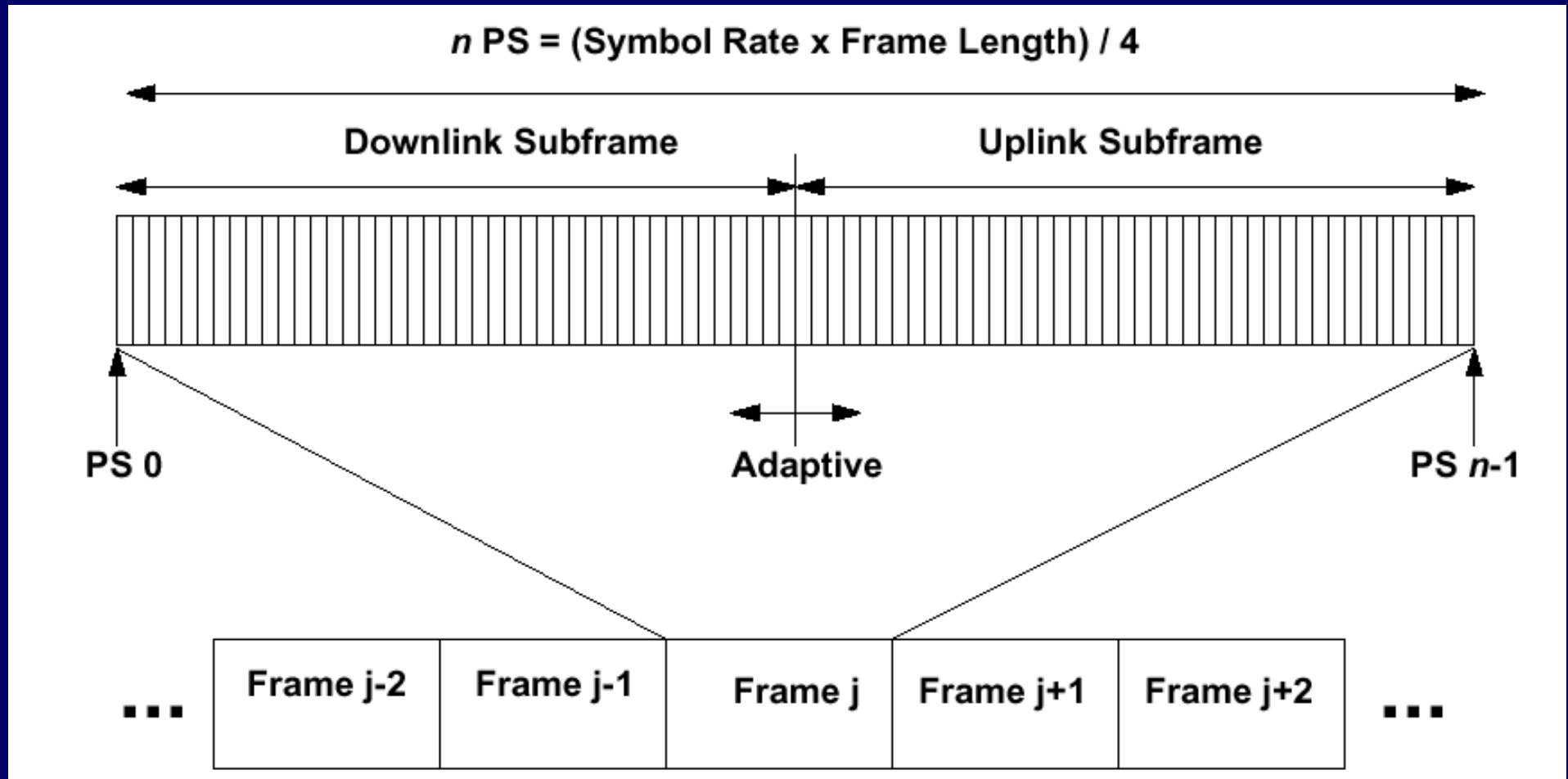
Multiple Access and Duplexing

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- On DL, SS addressed in TDM stream
- On UL, SS is allotted a variable length TDMA slot
- Time-Division Duplex (TDD)
 - DL & UL time-share the same RF channel
 - Dynamic asymmetry
 - SS does not transmit/receive simultaneously (low cost)
- Frequency-Division Duplex (FDD)
 - Downlink & Uplink on separate RF channels
 - Static asymmetry
 - Half-duplex SSs supported
 - SS does not transmit/receive simultaneously (low cost)

TDD Frame (10-66 GHz)

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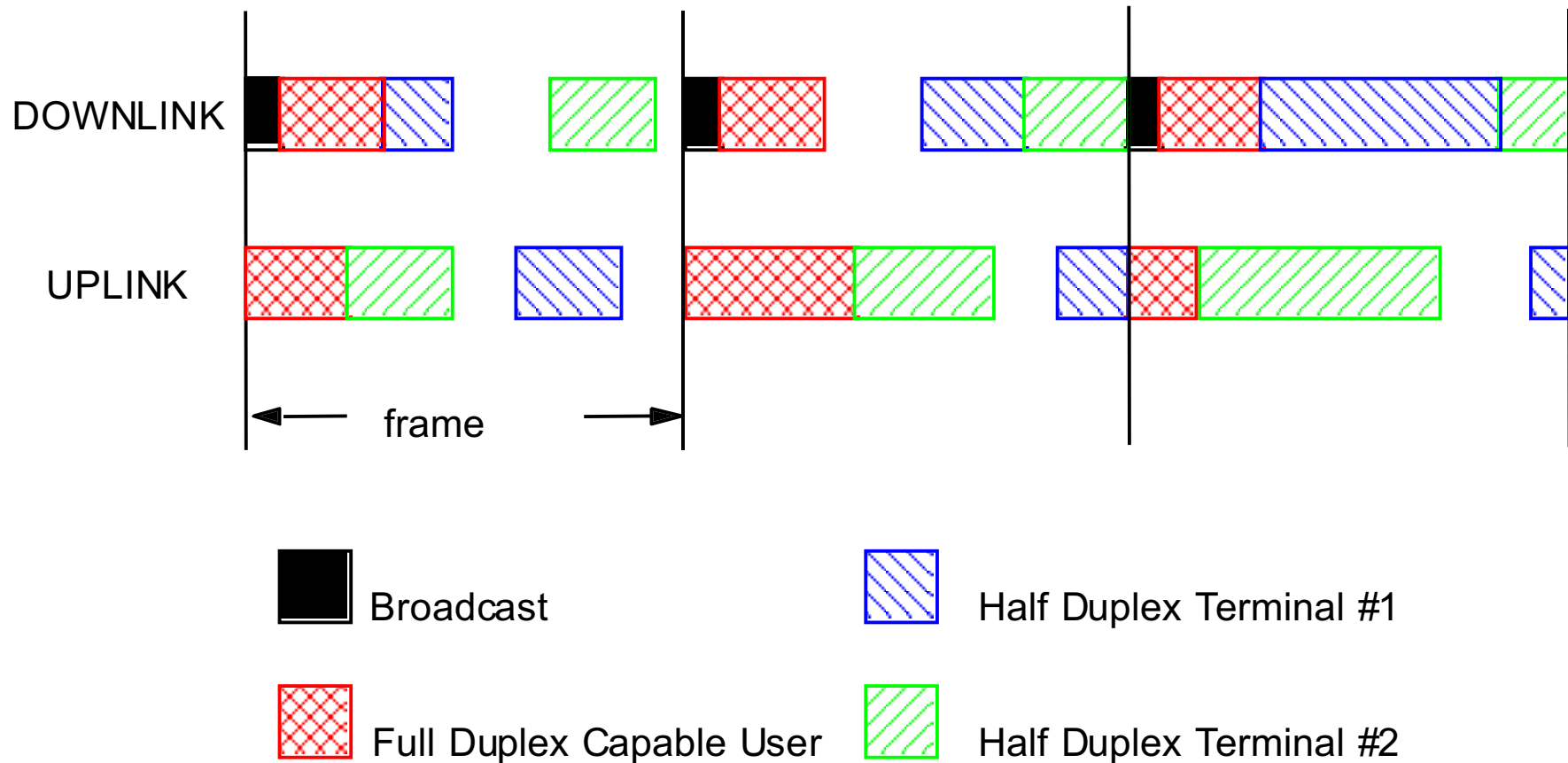


Frame duration: 1 ms

Physical Slot (PS) = 4 symbols

Burst FDD Framing

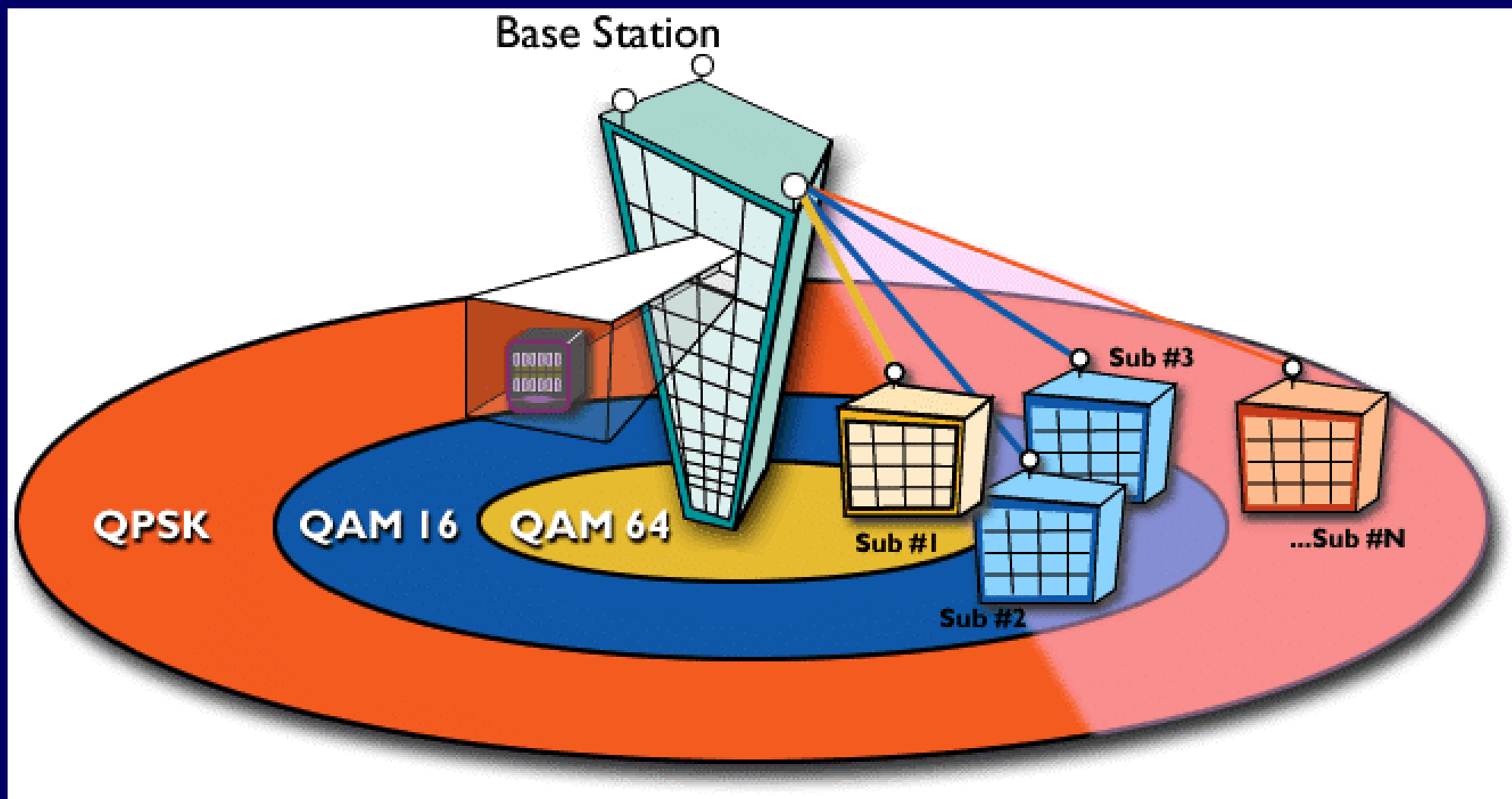
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Allows scheduling flexibility

Adaptive PHY

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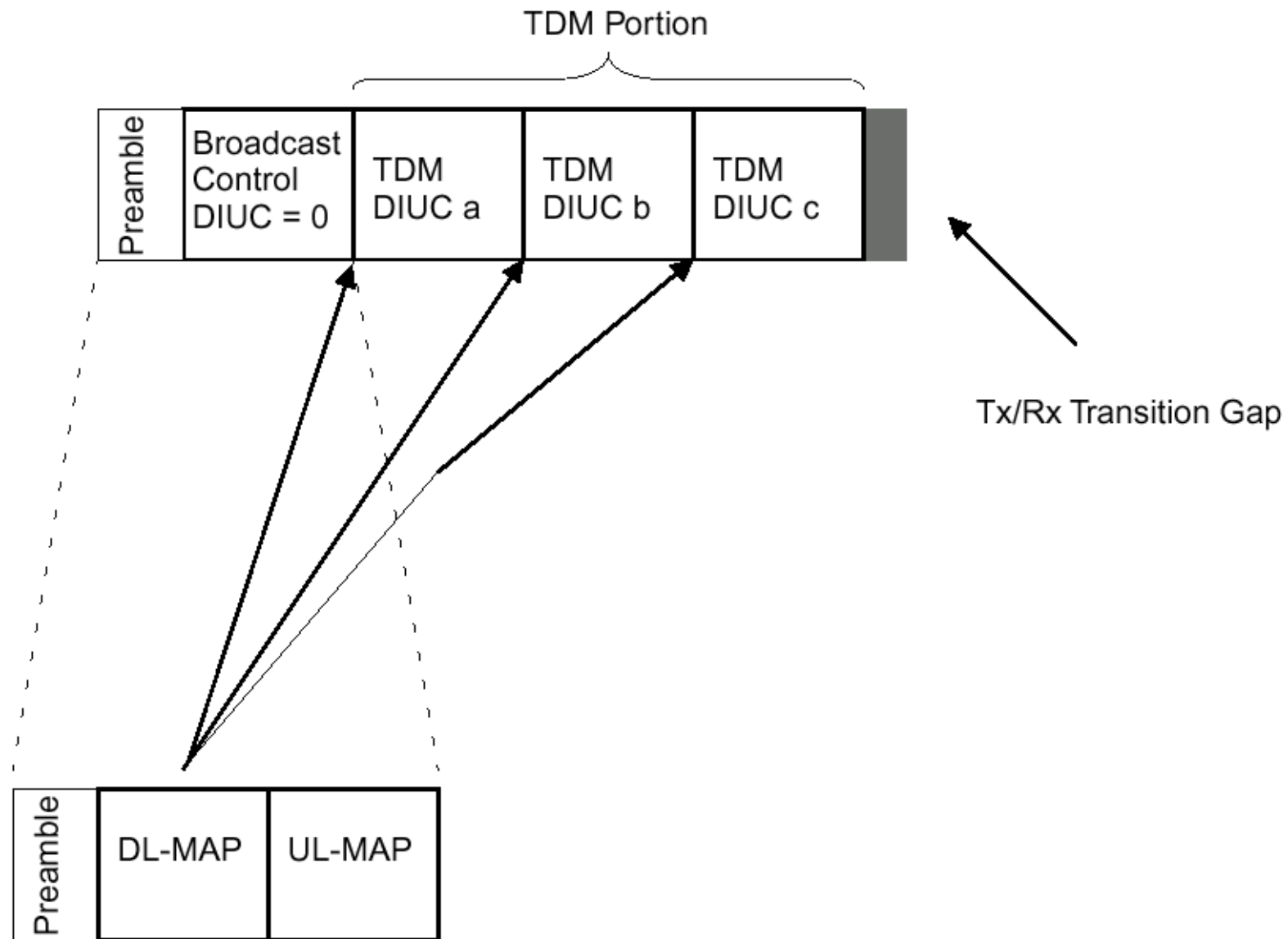


(burst-by-burst adaptivity not shown)

Adaptive Burst Profiles

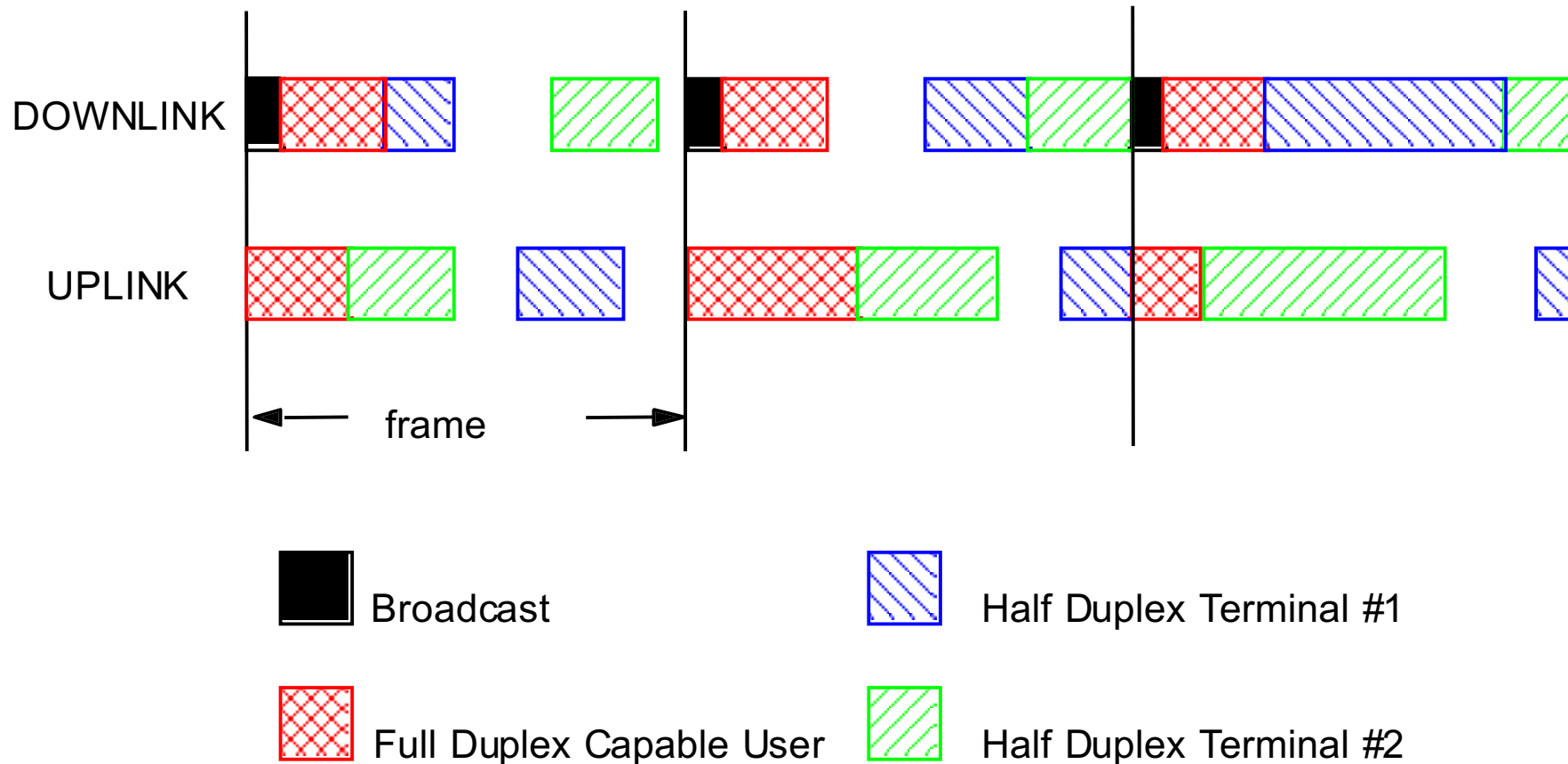
- Burst profile
 - Modulation and FEC
- Dynamically assigned according to link conditions
 - Burst by burst, per subscriber station
 - Trade-off capacity vs. robustness in *real time*
- Roughly doubled capacity for the same cell area
- Burst profile for downlink broadcast channel is well-known and robust
 - Other burst profiles can be configured “on the fly”
 - SS capabilities recognized at registration

TDD Downlink Subframe



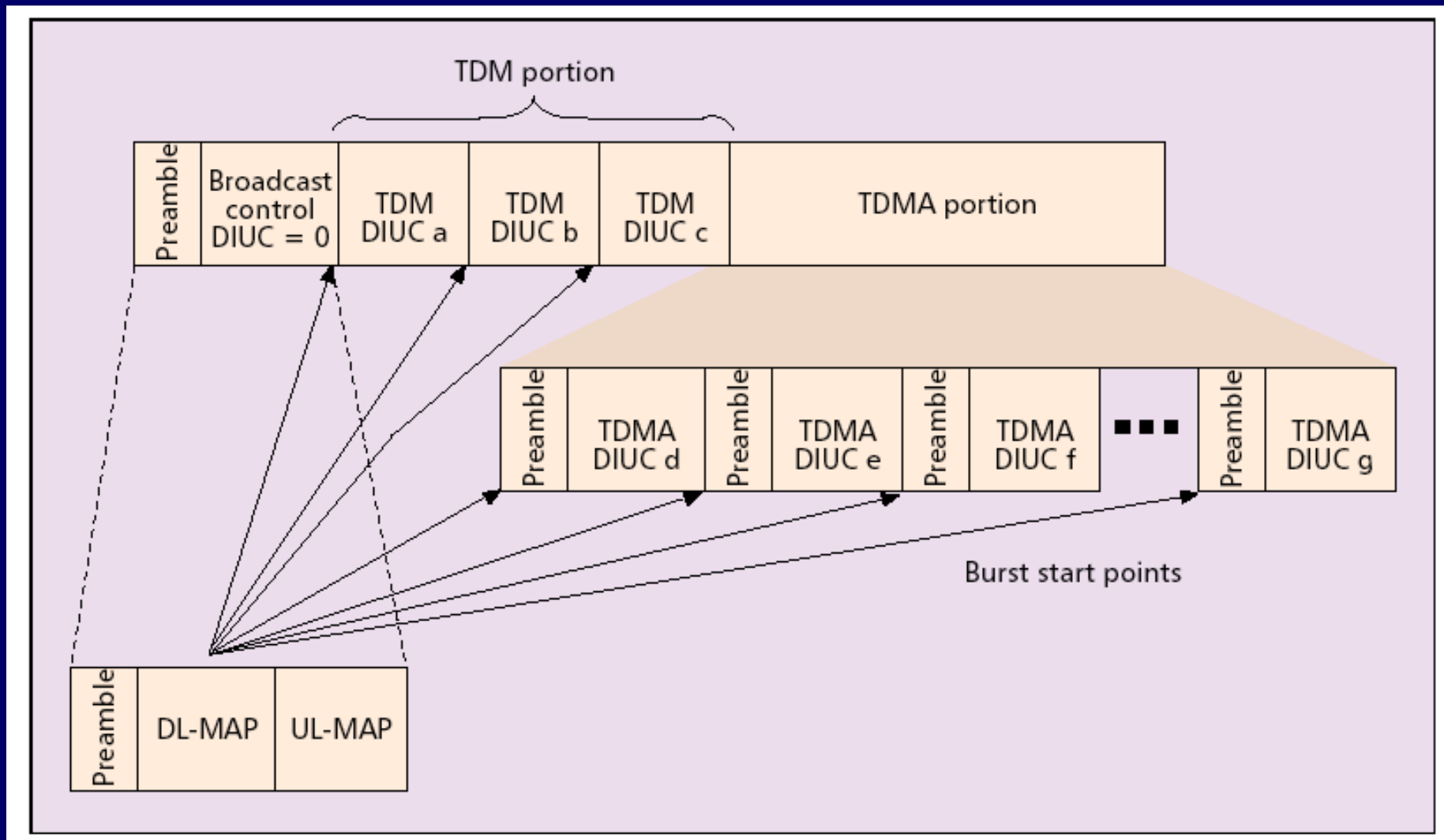
DIUC: Downlink Interval Usage Code

Burst FDD Framing



Allows scheduling flexibility

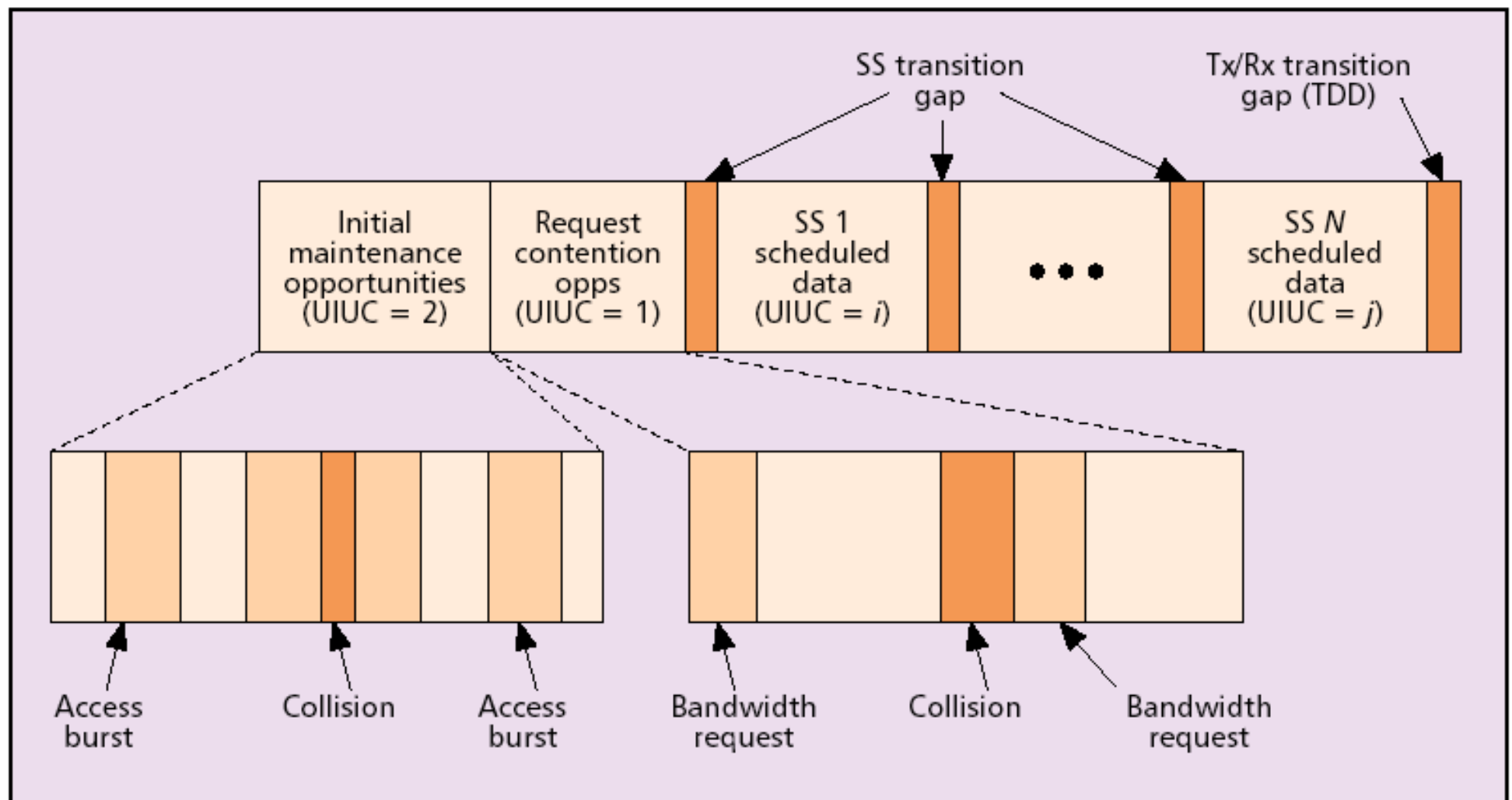
FDD Downlink Subframe



TDMA portion: transmits data to some half-duplex SSs (the ones scheduled to transmit earlier in the frame than they receive)

- Need preamble to re-sync (carrier phase)

Typical Uplink Subframe (TDD or FDD) ²⁷



Interoperability Testing for WirelessMAN-SC™ (10-66 GHz)

- IEEE P802.16c (Detailed System Profiles)
 - Published 15 January 2003
 - specifies particular combinations of options
 - used as basis of compliance and interoperability testing
 - MAC Profiles: ATM and Packet
 - PHY Profiles: 25 & 28 MHz; TDD & FDD
- Test Protocols
 - PICS (P1802.16.1 in ballot)
 - Test Suite Structure & Test Purposes (started)

Amendment Project

IEEE P802.16a

*Medium Access Control
Modifications and Additional
Physical Layer Specifications for
2-11 GHz*

802.16a PHY Alternatives: Different Applications, Bandplans, and Regulatory Environments

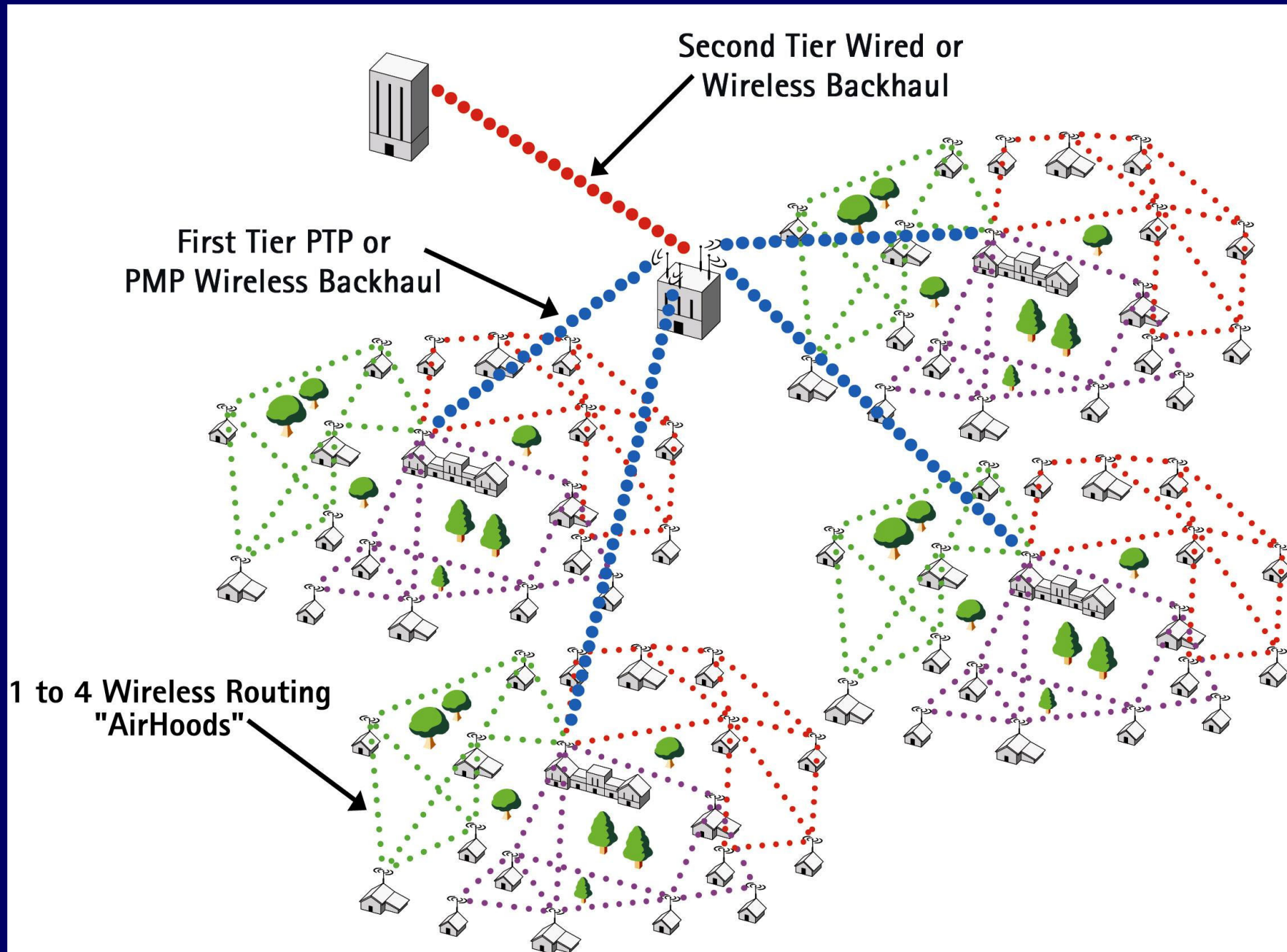
- OFDM (WirelessMAN-OFDM Air Interface)
 - 256-point FFT with TDMA (TDD/FDD)
- OFDMA (WirelessMAN-OFDMA Air Interface)
 - 2048-point FFT with OFDMA (TDD/FDD)
- Single-Carrier (WirelessMAN-SCa Air Interface)
 - TDMA (TDD/FDD)
 - BPSK, QPSK, 4-QAM, 16-QAM, 64-QAM, 256-QAM
 - Most vendors will use Frequency-Domain Equalization

Key 802.16a MAC Features

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- OFDM/OFDMA Support
- ARQ
- Dynamic Frequency Selection (DFS)
 - license-exempt
- Adaptive Antenna System (AAS) support
- Mesh Mode
 - Optional topology for license-exempt operation only (TDD only)
 - Subscriber-to-Subscriber communications
 - Complex topology and messaging, but:
 - addresses license-exempt interference
 - scales well
 - alternative approach to non-line-of-sight

Mesh-based WirelessMAN



What's Next ?

- Compliance documentation
- Mobility
- Potential new 802 project on common 802 handoff framework

802.16 Summary

- The IEEE 802.16 WirelessMAN Air Interface, addresses worldwide needs
- The 802.16 Air Interface provides great opportunities for vendor differentiation, at both the base station and subscriber station, without compromising interoperability.
- Interoperability tests are coming.
- Mobility is the next major enhancement.

Free IEEE 802 Standards

- Since May 2001, IEEE 802 standards have been available for free download.
- See:

<http://WirelessMAN.org>

beginning six months after publication

- IEEE Std 802.16.2 is now free
- IEEE Std 802.16 is now free

IEEE Standard 802.16: Tutorial

IEEE Communications Magazine, June 2002
(available on 802.16 web site)

TOPICS IN BROADBAND ACCESS

IEEE Standard 802.16: A Technical Overview of the WirelessMAN™ Air Interface for Broadband Wireless Access

Carl Eklund, Nokia Research Center

Roger B. Marks, National Institute of Standards and Technology

Kenneth L. Stanwood and Stanley Wang, Ensemble Communications Inc.

Conclusion

IEEE 802.16 WirelessMAN standards are:

- open in development and application
- addressed at worldwide markets
- engineered as optimized technical solutions
- significantly complete
 - With test spec documents in development
- being enhanced for expanded opportunities

IEEE 802.16 Resources

IEEE 802.16 Working Group on Broadband Wireless
Access

info, documents, tutorials, email lists, etc:

<http://WirelessMAN.org>

