The IEEE 802.16 WirelessMAN™ Standard

http://WirelessMAN.org

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Relevant Topics from ISART Day 1

- concerns with 3G deployment
- radio in the local loop (>100Mbit/s)
- efficient spectrum use
- new efficient architectures
- space-time coding
- TDD for adaptive antennas
- air interface that plans for smart antennas
- growing use of license-exempt spectrum

IEEE 802

The LAN/MAN Standards Committee

voluntary consensus standards

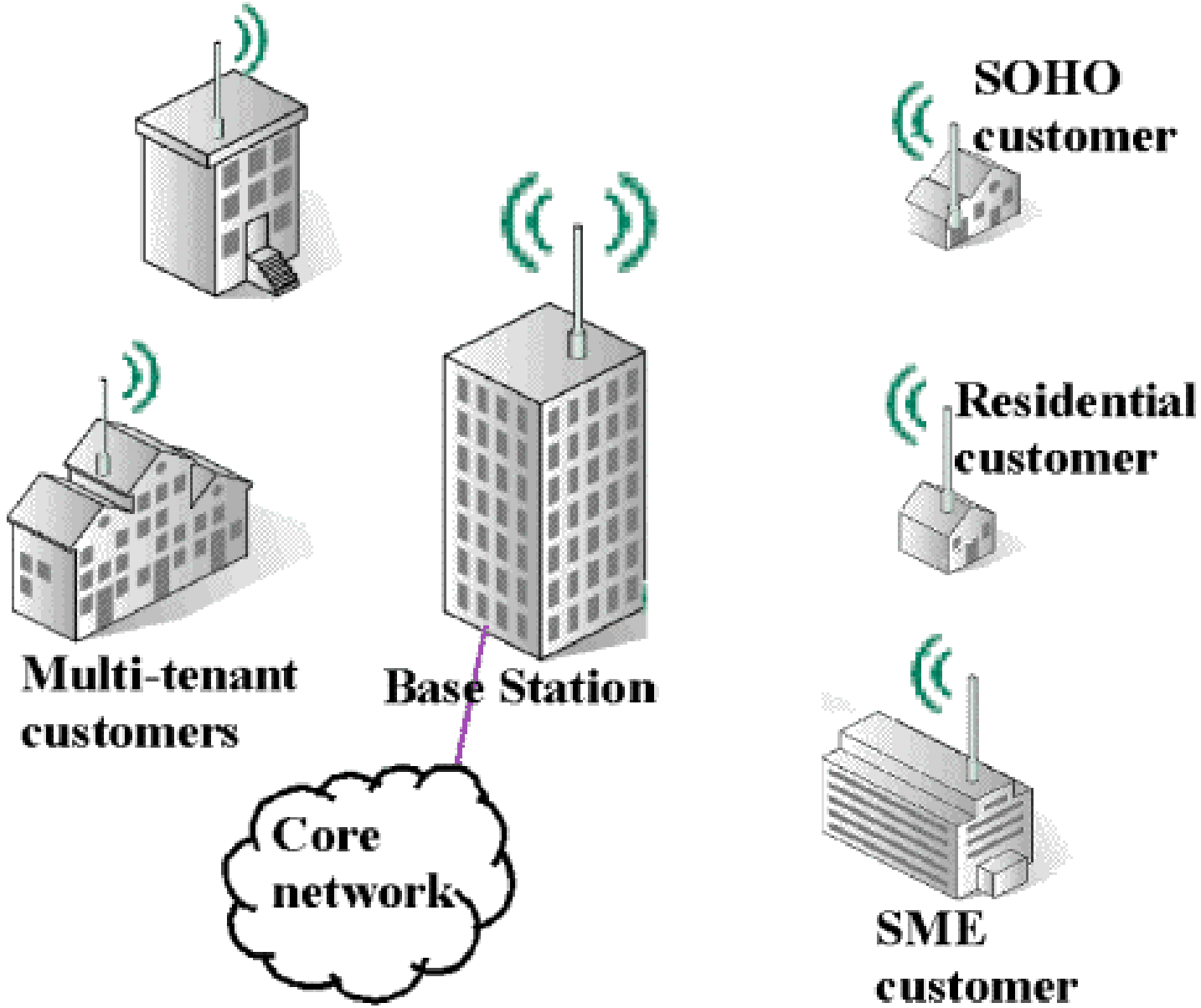
Wired:

- 802.3 (Ethernet)
- 802.17 (Resilient Packet Ring)

Wireless:

- 802.11: Wireless LAN
  - Local Area Networks
- 802.15: Wireless PAN
  - Personal Area Networks {inc. Bluetooth}
- 802.16: WirelessMAN™
  - Metropolitan Area Networks

Fixed Broadband Wireless Access



The News on 802.16

- IEEE 802.16 is delivering what it promised!

- Approval for Publication (6 December 2001)
  - IEEE Standard 802.16: Air Interface for Fixed Broadband Wireless Access Systems (10-66 GHz)
  - Final draft complete and for sale since October 2001
  - Publication coming this month

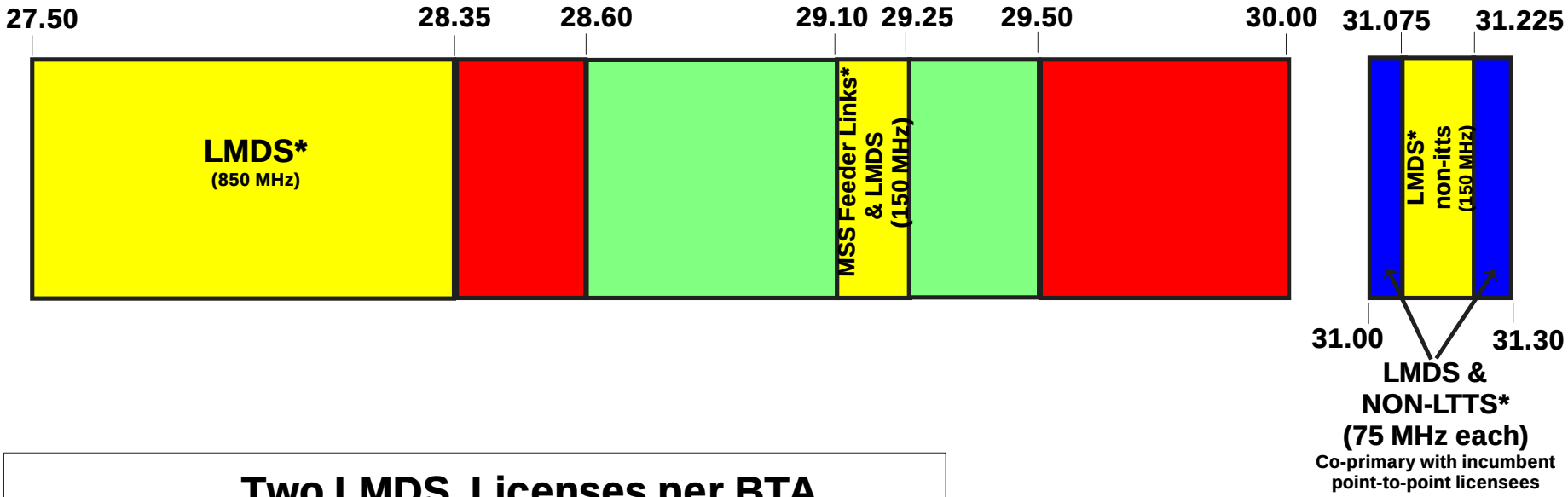
- Publication (10 September 2001)
  - IEEE Standard 802.16.2: Recommended Practice-Coexistence of Fixed Broadband Wireless Access Systems (10-66 GHz)

IEEE 802.16 Project Structure

Air Interface (Standard)	Coexistence (Recommended Practice)
IEEE Standard 802.16 (**ratified**) MAC 10-66 GHz PHY (“LMDS”)	IEEE Standard 802.16.2 (**published**) 10-66 GHz
P802.16a 2-11 GHz PHY (“MMDS” + U-NII) MAC enhancements Completion: August 2002	**P802.16.2a** 2-11 GHz Completion: March 2003

LMDS Band Allocation
(Local Multipoint Distribution Service)

28 & 31 GHz Band Plan



Two LMDS Licenses per BTA

Block A - 1150 MHz:
27,500-28,350 MHz
29,100-29,250 MHz
31,075-31,225 MHz

Block B - 150 MHz:
31,000-31,075 MHz
31,225-31,300 MHz

Legend

"*" - Primary Service
MSS - Mobile Satellite Service
NON-LTTS - Non-Local Television Transmission Service

Source: Federal Communications Commission

Projects in Development

- **Tutorials at 802 meeting next week**
  - **Gigabit radio at upper millimeter waves**
  - **Broadband data for vehicular mobility**

Steady Progress

- Since 1998, we have steadily followed our timetable and carried out our plan.
  - IEEE Standard 802.16 was 8 months behind original project plan (written in January 1999)
    - Not bad. Delayed by adaptation for lower frequencies.
- We have heard many predictions of our failure.
- We have seen many critics come and go.
- Let's review their concerns:

Top Ten Reasons Why IEEE 802.16 Is Doomed to Failure

#10: It's too late to start

- ***Now, in 1998, it's too late to start working on BWA standards; the technology is too mature, and deployments are going ahead.***

- **Deployments did go ahead, but perhaps not as fast as the industry would have liked.**

- **Early technology was proven immature.**

- **The evidence shows that the industry, and the currently risk-averse financial community behind it, both want standards.**

#9: It's too early to start.

- *It's too early to work on BWA standards; the technology is not yet mature or deployed. You will lock in an immature technology.*
- Standards take time. If you can find people to work on them, then it's time to make them.
- IEEE Standard 802.16 was designed by a dedicated team of the world's top engineers.
  - It did not arrive on a platter.
  - It is more sophisticated than the technologies we started with.
  - It is flexible and will allow great vendor differentiation.
  - It will evolve through amendments.
    - Examples: IEEE 802.3 (Ethernet) and 802.11

#8: We can leave this to the Government.

- ***This sounds like a lot of work. We can let the Government handle it.***
- **U.S. Government lacks the resources and lacks the expertise to make your business decisions.**
- **U.S. Government agencies are mandated to follow voluntary consensus standards.**
- **There are a lot of governments. A U.S. Government standard may not be the best basis of a global standard.**
  - **FCC has not encouraged standardization.**
    - **some positive sign recently**
  - **EU regulatory bodies have.**

#7: We can't leave this to the Government!

- ***I hear the Chair works for the U.S. Government. We don't want the Government to set our standards.***
- **Technical decisions are made by the Working Group, not the Chair.**
- **Chair is the only U.S. Government employee.**
- **The U.S. Federal Government is mandated by law to support the development of private-sector standards.**
- **Steady support of the Chair in this position, since 1998, has aided progress.**

#6: ETSI is too far ahead.

- ***ETSI HIPERACCESS has a big head start.***

- **802.16 caught up with and sped by HIPERACCESS long ago.**
- **HIPERACCESS is struggling to create a draft.**
- **Last fall, ETSI HIPERMAN made formal decisions to embrace 802.16 as a baseline.**

- ***However, ETSI is supported by EU and CEPT, in spirit and financially.***

MAC in 802.16 and ETSI

IEEE 802.16

IEEE Standard 802.16
10-66 GHz
approved

802.16a
2-11 GHz
Completion: August 2002

ETSI BRAN

HIPERACCESS
>11 GHz

HIPERMAN
2-11 GHz

#5: Interoperability doesn't matter.

- ***All we need is coexistence standards. Interoperability doesn't matter since the radios don't roam and require only local connectivity.***

- **In 2001, the IEEE 802.16 Working Group completed BOTH a coexistence and an interoperability standard (10-66 GHz).**
- **Roaming aside, interoperability *does* matter.**
- **Standards have proven their merit in other networks with local connectivity (examples: IEEE 802.3 [Ethernet]; cable modems; ADSL).**

#4: It's only a bunch of human beings.

- ***The IEEE process is based on individual, not corporate, members. What difference can a bunch of humans make?***
- **IEEE 802.16 Working Group members are humans acting as professional experts.**
  - **Membership earned by participation only; no "dues".**
- **Of course, people are sponsored by companies and generally act in company interest.**
- **Standards balance the business and technical concerns, but the process strengthens the technical side.**
- **We build teams & rely on human relationships.**

#3: No one will participate.

- ***Companies are too busy making product. They won't participate.***
- 175 Members
- 39 "Potential Members"
- 58 Official Observers
- >700 different individuals have attended a session
- Members and Potential Members from
  - 10 countries
  - >110 companies
- 2.8 Million file downloads in year 2000

Current Participants

CANADA	36
CHINA	2
FINLAND	6
FRANCE	2
GERMANY	1
GREECE	2
ISRAEL	28
ITALY	1
JAPAN	2
KOREA	11
NETHERLANDS	1
SPAIN	1
UK	10
USA	150
TOTAL	**253**

#2: Too many people will participate.

- ***You will attract so many people with different interests that you will never reach consensus.***

- **In IEEE, Consensus is not unanimity.**
  - **75% majority decides**
- **It's possible to make tough decisions.**
  - **10-66 GHz effort began with 35 proposals**
    - **Consolidated into one unified result.**
- **IEEE Ballot process.**
  - **Opens Working Group output to all interested parties.**
  - **"Balanced" voting group.**

#1: My consortium will set the standard.

- ***Formal standards groups are SO Twentieth Century. Only consortia matter these days.***
- **Wireless DSL Consortium closed in favor of backing IEEE 802.16 and WCA**
- **OFDM Forum and TDD Coalition support their positions within IEEE 802.16**
- **BWIF has retracted, particularly after HIPERMAN chose 802.16 instead**
- **Consortia have a place in supporting standards through interoperability testing, etc.**
  - **802.11 has WECA**
  - **802.16 has the WiMAX Forum**

WiMAX Forum

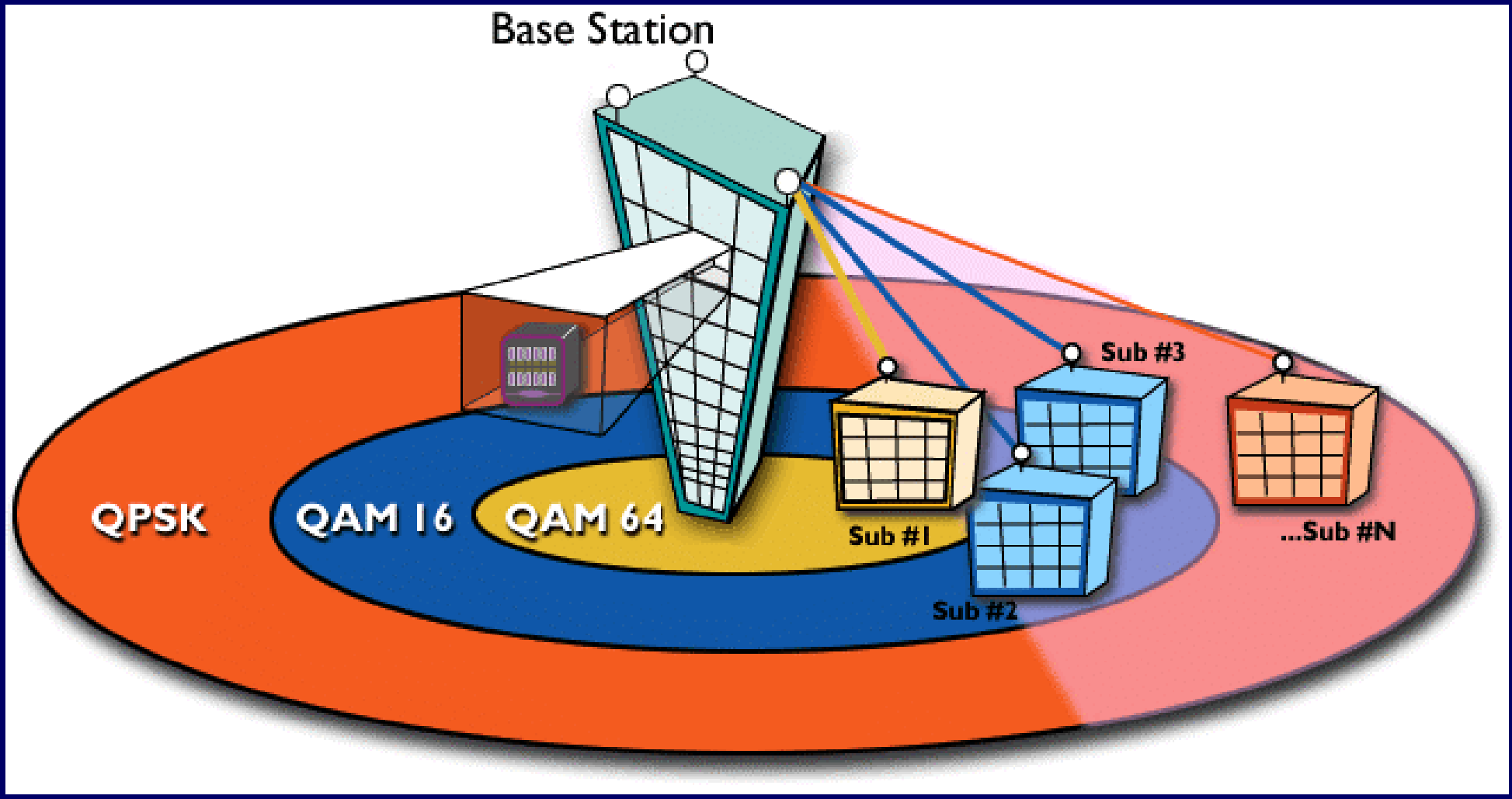
- **WiMAX: Worldwide Interoperability for Microwave Access**

- ***Formed to promote deployment of BWA by using a IEEE 802.16 and certifying interoperability of products and technologies.***

10-66 GHz PHY in IEEE Std 802.16

- Multiple Access: TDM/TDMA
- Burst operation
- Unified treatment of both duplex schemes
  - Time-Division Duplex (TDD)
  - Frequency-Division Duplex (FDD) [burst]
- Spectrally efficient
  - TDD
  - Adaptive Burst Profiles on Uplink and Downlink
    - moduluation (QPSK, 16-QAM, 64-QAM)
    - coding
  - Broadband Channels
    - 20, 25, and 28 MHz

Physical Layer Adaptivity

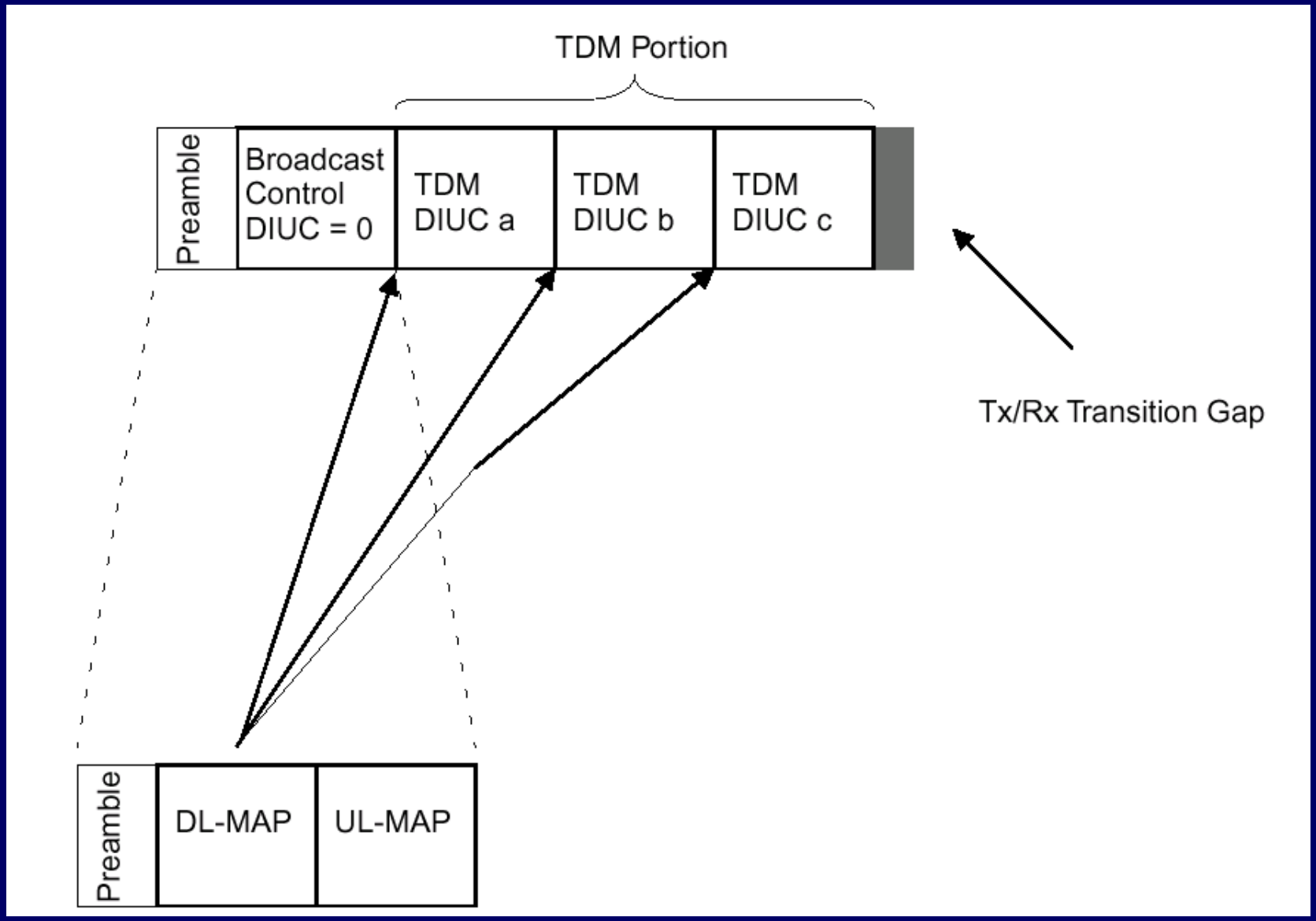


(burst-by-burst adaptivity not shown)

Adaptive Burst Profiles

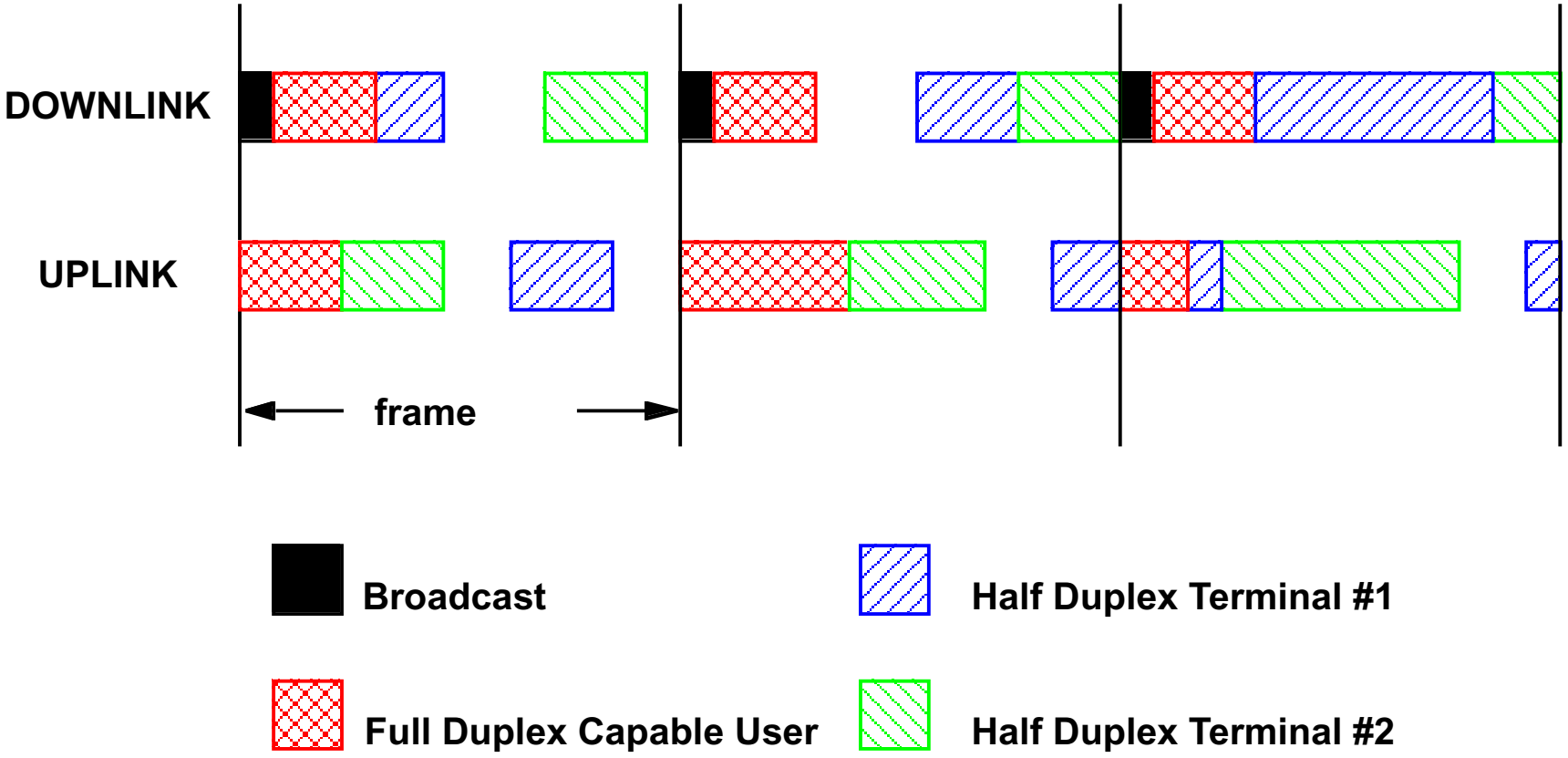
- Burst profile
  - Modulation and FEC
- Dynamically assigned
  - by Base Station
  - according to link conditions
  - burst by burst, per subscriber station
- Trade-off capacity vs. robustness
  - in real time
- Allows vendor to implement innovative schemes to efficiently use the spectrum while remaining interoperable.

TDD Downlink Subframe



DIUC: Downlink Interval Usage Code

FDD Framing



Allows great scheduling flexibility

FEC

- Reed Solomon
  - RS GF(256), t = 0…16
- For robust communications, the RS code is concatenated with a BCC
  - No interleaving, suitable for burst
  - BCC is a rate 2/3 block code based on a tail-bite termination of the $(7,5)_8$ Convolutional Code for every 16 data bits
- Shortening allowed
- Turbo Product Codes (TPC) are optional

Baud Rates & Channel Size (10-66 GHz)

- **Flexible plan - allows equipment manufactures to choose according to spectrum requirements**

Channel Width (MHz)	Symbol Rate (Msym/s)	QPSK Bit Rate (Mbit/s)	16-QAM Bit Rate (Mbit/s)	64-QAM Bit Rate (Mbit/s)
20	**16**	**32**	**64**	**96**
25	**20**	**40**	**80**	**120**
28	**22.4**	**44.8**	**89.6**	**134.4**

802.16 MAC: Overview

- Connection-oriented
- Supports difficult user environments
  - High bandwidth on demand, hundreds of users per channel
  - Continuous and bursty traffic
  - Very efficient use of spectrum
    - Fragmentation, packing, header-suppression, ...
- Protocol-Independent core (ATM, IP, Ethernet, …)
  - ATP-based and Packet-based Convergence layers
- Flexible QoS offerings
  - CBR, rt-VBR, nrt-VBR, BE, with granularity within classes
- Solid privacy and encryption
  - public key encryption for authentication & key exchange
- Many options for vendor innovation and differentiation
  - e.g., scheduling
- Built for support of multiple PHYs

Key Features of emerging 802.16a PHY (2-11 GHz)

- TDD or FDD

- OFDM (256-point FFT)
- OFDMA (2048-point FFT)
- Single-Carrier TDMA
  - with Frequency-Domain Equalization

- Support for Space-Time Coding

Key 802.16a MAC Enhancements

- OFDM/OFDMA Support
- ARQ
- Support for Advanced Antennas
- Mesh Mode
  - Optional topology for Unlicensed Operation
  - Subscriber-to-Subscriber communications

International Impact

"IEEE 802.16a Broadband Wireless Access (BWA) Standard Development and Internet Application": conference sponsored by the government of People's Republic of China 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"

- 240 people (100 from government; 80 from telecom operators)

What's Next

- Complete 2-11 GHz work
- Enhance 10-66 GHz spec
  - Interoperability test protocols
    - Develop and Publish
    - Implement (WiMAX)
- Expand reach under 802.16 MAC
  - Higher millimeter waves, etc.
- Support for mobility
- Aim to be 4G

How to Participate

- Attend meetings
  next one: March 11-15 in St. Louis
- Read reflector
- Read documents
- Submit documents & comments
- Join sponsor ballot pool

Distribution of IEEE 802 Standards

Conclusions

- With its steady progress, IEEE 802.16 is a BWA success story.
- The IEEE 802.16 MAC is a future-looking platform for an array of services.
- The advanced IEEE 802.16 10-66 GHz PHY is coming soon to a chip set near you.
- WiMAX will support compliance tests.
- IEEE 802.16a (2-11 GHz) this summer.

IEEE 802.16 Resources

IEEE 802.16 Working Group on Broadband Wireless Access

info, documents, email lists, etc:

http://WirelessMAN.org