

# Standards Breakthroughs to Lower BWA Costs and Spread Risk: The IEEE 802.16 WirelessMAN™ Standard

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To inform the Working Group concerning an address on IEEE 802.16 given by the Working Group Chair at the 2002 Technical Symposium of the Wireless Communications Association (15 January 2002).

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# **Standards Breakthroughs to Lower BWA Costs and Spread Risk: The IEEE 802.16 WirelessMAN™ Standard**



<http://WirelessMAN.org>

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Chair, IEEE 802.16 Working Group

# Have you heard the news?

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

# **IEEE 802.16 is still in business!**

- Two follow-on projects, each an amendment to the base standard:
- **IEEE Project P802.16a** (amends 802.16)
  - Standard Air Interface
  - Enhancement to include 2-11 GHz (licensed or not)
  - Based on the MAC in IEEE Standard 802.16
  - Completion planned for August 2002
- **IEEE Project P802.16.2a** (amends 802.16.2)
  - Recommended Practice on Coexistence
  - Enhancement to include 2-11 GHz
  - New recommendation regarding point-to-point
  - Completion planned for March 2003

# IEEE 802.16 Project Structure

## Air Interface (Standard)

IEEE Standard 802.16  
(ratified)  
MAC  
10-66 GHz PHY

**P802.16a**  
2-11 GHz PHY  
MAC enhancements

in ballot  
Completion: August 2002

## Coexistence (Recommended Practice)

IEEE Standard 802.16.2  
(published)  
10-66 GHz

**P802.16.2a**  
2-11 GHz

in development  
Completion: March 2003

# 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.*

### **REALITY:**

- Deployments did go ahead, but perhaps not as fast as the industry would have liked.
- Early technology was proven immature.
- The evidence shows that industry, and the currently risk-averse financial community behind it, wants 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.*

### **REALITY:**

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 starting technologies.
  - It is flexible and will allow **great vendor differentiation.**
  - It will evolve through amendments.
    - Examples: IEEE 802.3 (Ethernet ) and 802.11

## **#8: The Government will handle it.**

- ***This sounds like a lot of work. We can let the Government handle it.***

### ***REALITY:***

- **U.S. Government hasn't cared what technology you use (Homeland Security may change this).**
- **U.S. Government lacks the resources and lacks the expertise to make your business decisions.**
- **U.S. Government is mandated by law to follow private-sector standards.**
- **There are a lot of governments. A U.S. Government standard may not be the best basis of a global standard.**

## **#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.*

### **REALITY:**

- Technical decisions are made by the Working Group, not the Chair.
- Of 178 Members of IEEE 802.16, the 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: 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.*

### **REALITY:**

- 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).

## **#5: ETSI is too far ahead.**

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

### ***REALITY:***

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

## **#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?*

### **REALITY:**

- 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.

# People and Relationships Matter



**Congratulations to  
Phil and Rebecca on  
their engagement!**

## **#3: No one will participate.**

- ***Companies are too busy making product. They won't participate.***

### ***REALITY:***

- **178 Members**
- **34 “Potential Members”**
- **52 Official Observers**
- **>700 different individuals have attended a session**
- **Members and Potential Members from**
  - **10 countries**
  - **>110 companies**



## **#2: Too many people will participate.**

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

### **REALITY:**

- **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.***

## ***REALITY:***

- **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**

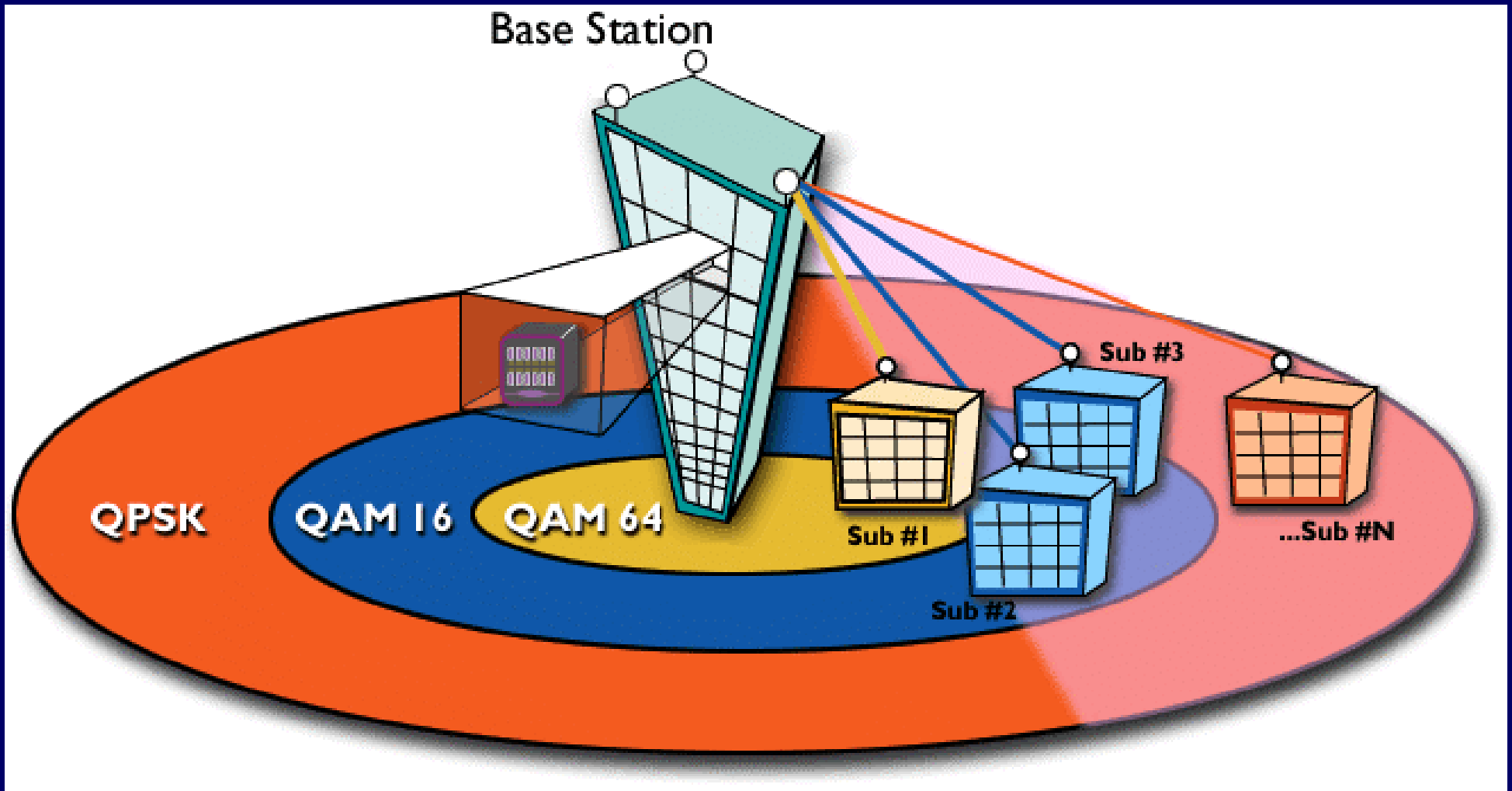
# WiMAX Forum

- **WiMAX: Worldwide Interoperability for Microwave Access**
- **Mission:** *To promote deployment of BWA above 11 GHz by using a global standard and certifying interoperability of products and technologies.*
- **Principles:**
  - Support IEEE 802.16 above 11 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
- **Info: WiMAX President, Mika Skarp (Nokia)**

# 10-66 GHz PHY in IEEE Std 802.16

- **Burst operation**
  - earlier continuous mode option was deleted
- **Duplex schemes**
  - Time-Division Duplex (TDD)
  - Frequency-Division Duplex (FDD)
- **Adaptive Burst Profiles on Uplink and Downlink**
- **Broadband Channels**
- **Multiple Access**
  - TDM/TDMA

# Physical Layer Adaptivity

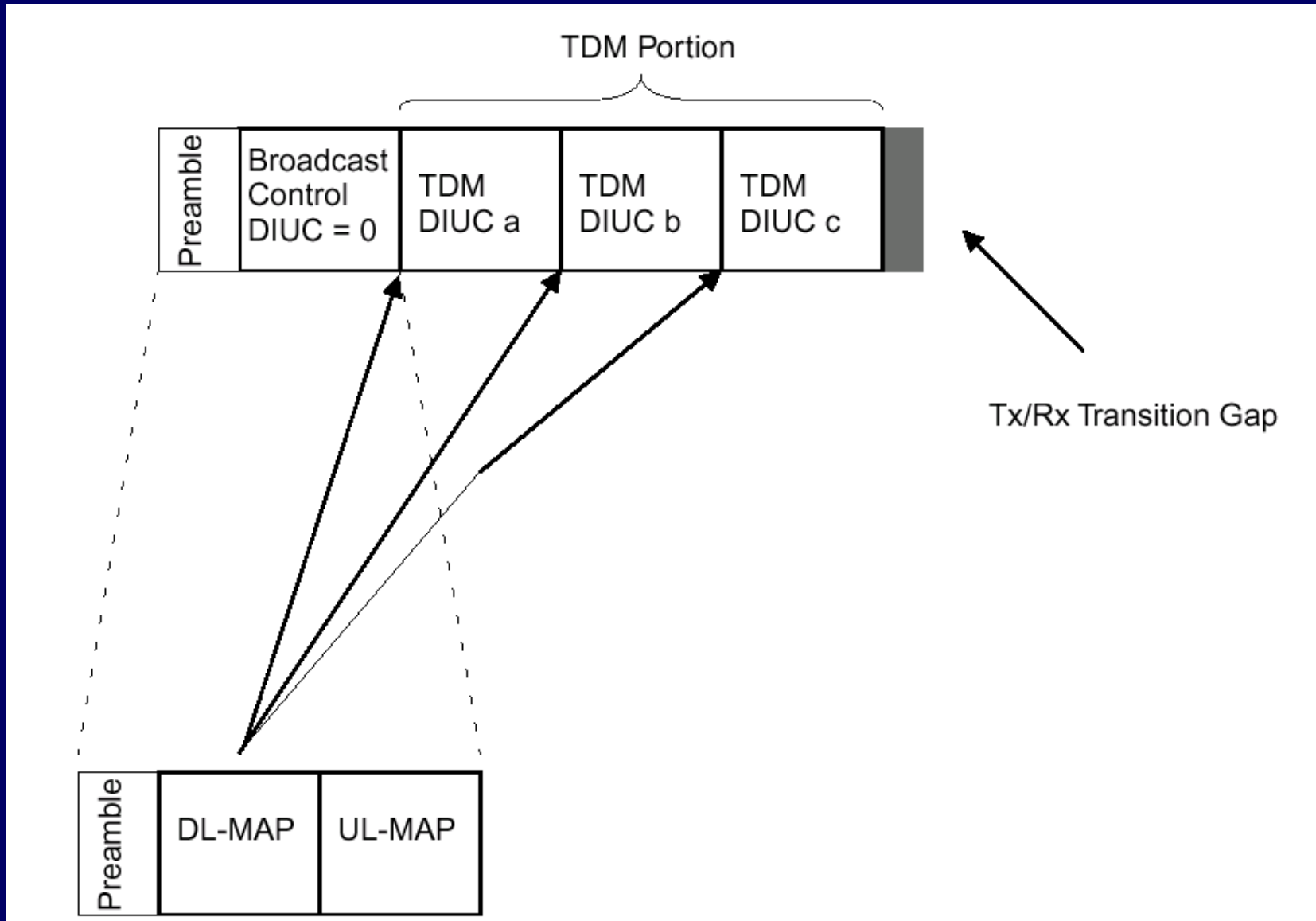


(burst-by-burst adaptivity not shown)

# Adaptive Burst Profiles

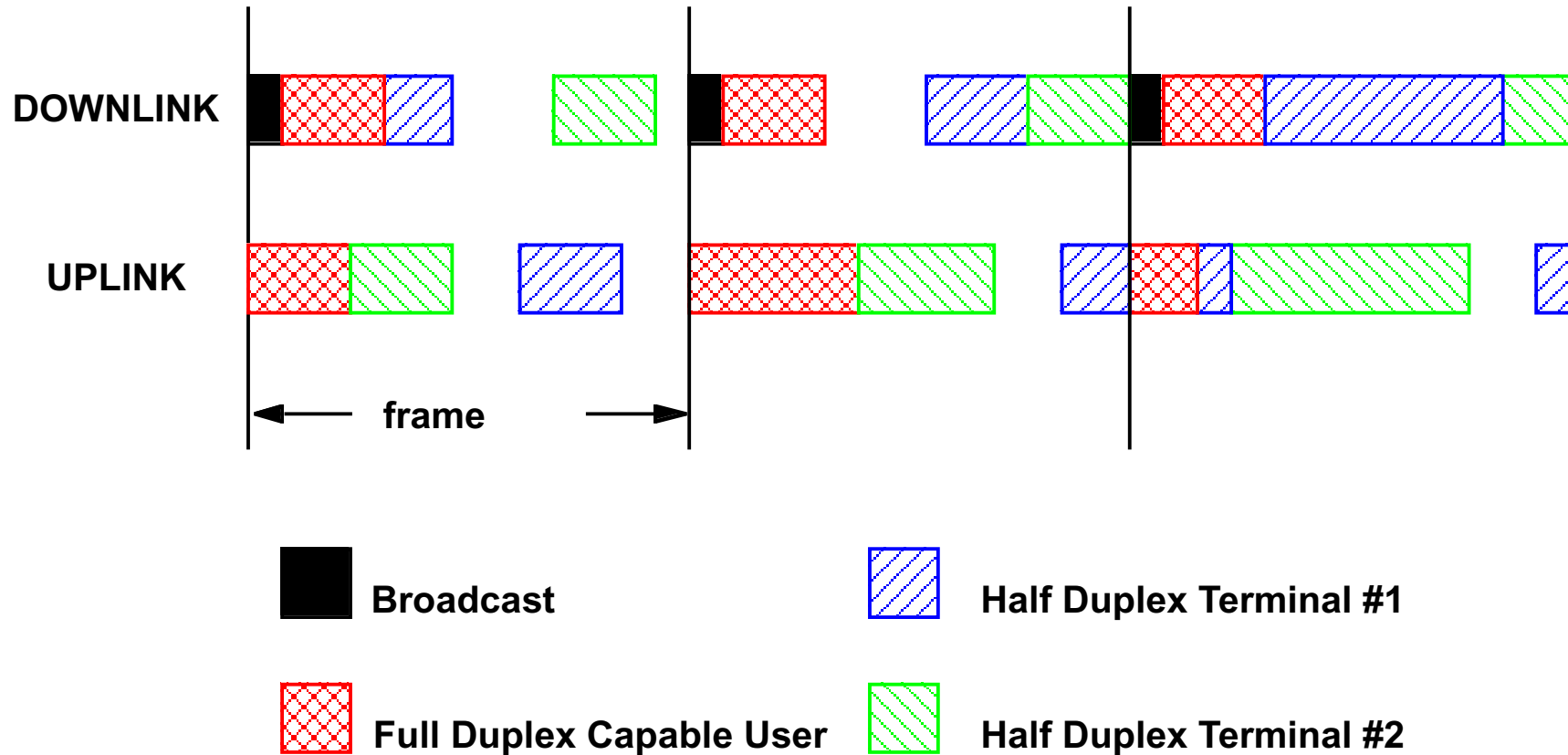
- **Burst profile**
  - Modulation and FEC
- **Dynamically assigned**
  - by Base Station
  - according to link conditions
  - burst by burst, per subscriber station
- **Trade-off capacity vs. robustness**
  - in real time
- **Allows vendor to implement innovative schemes to efficiently use the spectrum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

# TDD Downlink Subframe



**DIUC: Downlink Interval Usage Code**

# FDD Framing



Allows great scheduling flexibility



# Modulation (10-66 GHz)

- **Single Carrier QAM, Gray coded**
  - **QPSK**
  - **16QAM**
    - **Mandatory for Downlink, Optional for Uplink**
  - **64QAM**
    - **Optional for both Downlink & Uplink**

# FEC

- **Reed Solomon**
  - RS GF(256),  $t = 0 \dots 16$
- **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)
<b>20</b>	<b>16</b>	<b>32</b>	<b>64</b>	<b>96</b>
<b>25</b>	<b>20</b>	<b>40</b>	<b>80</b>	<b>120</b>
<b>28</b>	<b>22.4</b>	<b>44.8</b>	<b>89.6</b>	<b>134.4</b>

# 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
- **Protocol-Independent core (ATM, IP, Ethernet, ...)**
  - ATP-based and Packet-based Convergence layers
- **Balances between stability of contentionless and efficiency of contention-based operation**
- **Flexible QoS offerings**
  - CBR, rt-VBR, nrt-VBR, BE, with granularity within classes
- **Solid privacy and encryption**
- **Many options for vendor innovation and differentiation**
  - e.g., scheduling
- **Built for support of multiple PHYs**

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

- **TDD or FDD**
  - **OFDM/OFDMA**
  - **Single-Carrier TDMA**
    - **with Frequency-Domain Equalization**

# Key 802.16a MAC Enhancements

- **OFDM/OFDMA Support**
- **ARQ**
- **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

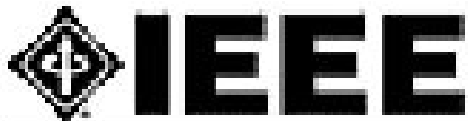
- **Complete 2-11 GHz work**
- **Enhance 10-66 GHz spec**
  - **Interoperability test protocols**
    - **Develop and Publish**
    - **Implement (WiMAX)**
- **Expand reach under 802.16 MAC**
  - **Higher millimeter waves, FSO, etc.**
- **Consider support for mobility**
- **Aim to be 4G**



# How to Participate

- Attend meetings
  - Join us next week in Levi, Finland
    - 100 miles North of Arctic Circle
  - or March in St. Louis
- Read reflector
- Read documents
- Submit documents & comments
- Join sponsor ballot pool

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# 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>

