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Standardization Activities in IEEE 802.16 Related to IMT-Advanced and Next Generation Wireless Systems

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Outline

- IEEE 802.16 Working Group
- IEEE Project 802.16m
- IEEE 802.16 IMT-Advanced Proposal
- IEEE 802.16 Future Plans

IEEE 802.16 Working Group

IEEE 802.16 Working Group

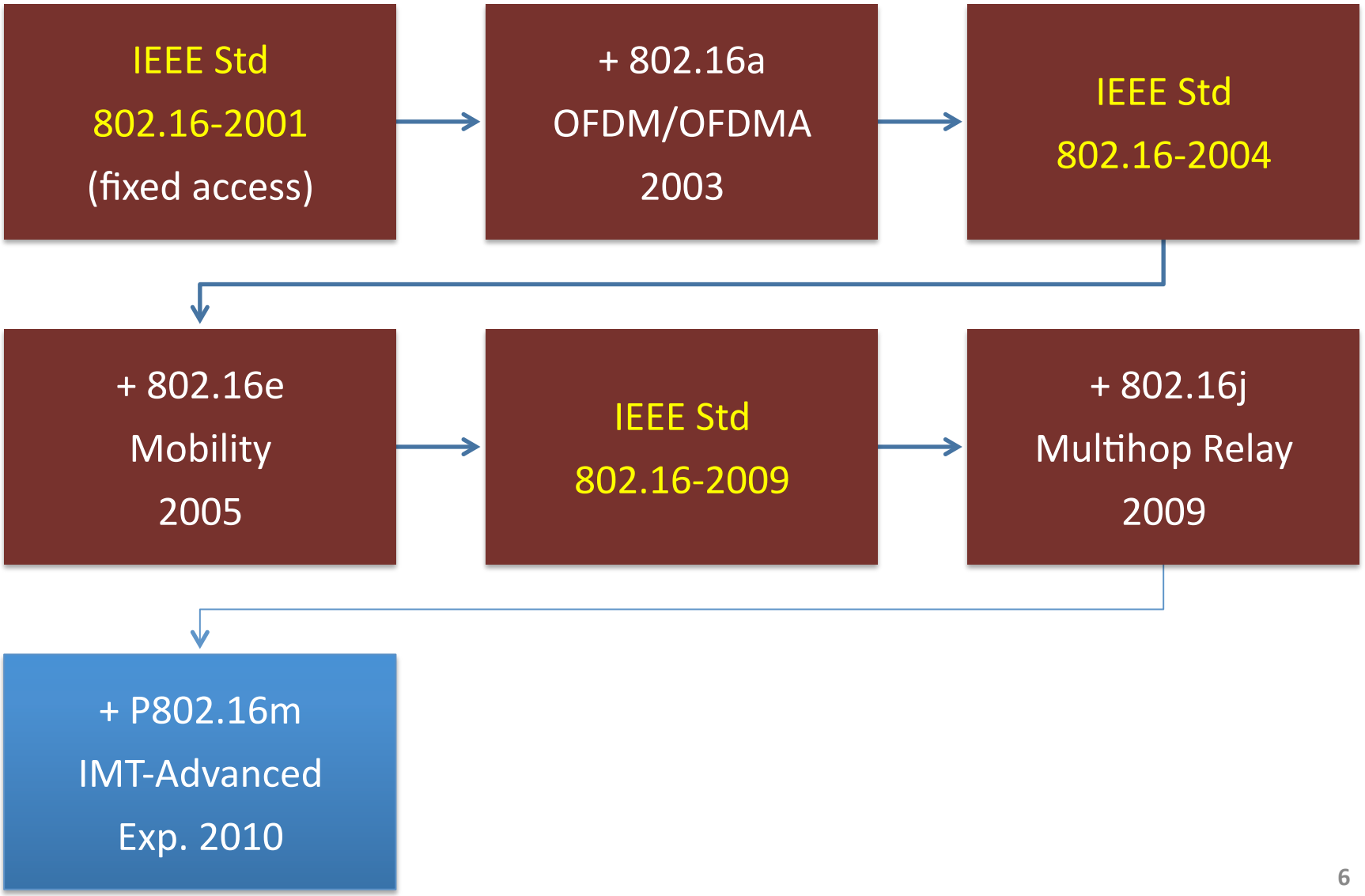
- Initiated in 1998
- Formalized in 1999 (over 10 years old)
- Holds at least six sessions a year
  - Session duration: Four days
- Open process
  - Anyone can participate
- Members are people
  - Membership earned by participation
  - Currently: 378 Members, from around the world

IEEE 802.16 Session Attendance
(excluding IEEE 802 Plenary)

#31	May	2004	China	228
#33	Sep	2004	Korea	287
#35	Jan	2005	China	313
#37	May	2005	Italy	218
#39	Sep	2005	Taiwan	225
#41	Jan	2006	India	111
#43	May	2006	Israel	122
#45	Sep	2006	Canada	191
#47	Jan	2007	UK	274

#49	May	2007	USA	307
#51	Sep	2007	Spain	288
#53	Jan	2008	Finland	303
#55	May	2008	China	402
#57	Sep	2008	Japan	415
#59	Jan	2009	USA	310
#61	May	2009	Egypt	210
#63	Sep	2009	Korea	257
#65	Jan	2010	USA	216

IEEE 802.16: Key Evolution Steps



IEEE Project 802.16m

IEEE Project 802.16m

- Amendment project, initiated 2006
- "Advanced Air Interface"
  - Amend IEEE 802.16 WirelessMAN-OFDMA specification to provide an advanced air interface
  - Meet the cellular layer requirements of IMT-Advanced next generation mobile networks
  - Support for legacy WirelessMAN-OFDMA equipment (i.e., backward compatibility)
  - Provide performance improvements to support future advanced services and applications

IEEE 802.16m Key Features

- New Subframe-based Frame Structure
- New Subchannelization Schemes and More Efficient Pilot Structures
- New and Improved Control Channel Structures
- Extended and Improved MIMO Modes
- Increased VoIP Capacity
- Multi-Hop Relay
- Femto BS
- Self-organization
- Multi-carrier Operation
- Interference Mitigation
- Multi-BS MIMO
- Improved Intra-RAT and Inter-RAT Handover
- Multi-Radio Coexistence
- Location Based Services
- Enhanced Multicast and Broadcast Service

802.16m System Requirements

Requirements	IMT-Advanced	802.16m
Peak spectral efficiency (b/s/Hz/sector)	DL: 15 (4x4) UL: 6.75 (2x4)	DL: 8.0/15.0 (2x2/4x4) UL: 2.8/6.75 (1x2/2x4)
Cell spectral efficiency (b/s/Hz/sector)	DL (4x2) = 2.2 UL (2x4) = 1.4 (Base coverage urban)	DL (2x2) = 2.6 UL (1x2) = 1.3 (Mixed Mobility)
Cell edge user spectral efficiency (b/s/Hz)	DL (4x2) = 0.06 UL (2x4) = 0.03 (Base coverage urban)	DL (2x2) = 0.09 UL (1x2) = 0.05 (Mixed Mobility)
Latency	C-plane: 100 ms (idle to active) U-plane: 10 ms	C-plane: 100 ms (idle to active) U-plane: 10 ms
Mobility b/s/Hz at km/h	0.55 at 120 km/h 0.25 at 350 km/h	Optimal performance up to 10 km/h “Graceful degradation” up to 120 km/h “Connectivity” up to 350 km/h Up to 500 km/h depending on operating frequency
Handover interruption time (ms)	Intra frequency: 27.5 Inter frequency: 40 (in a band) 60 (between bands)	Intra frequency: 27.5 Inter frequency: 40 (in a band) 60 (between bands)
VoIP capacity (Active users/sector/MHz)	40 (4x2 and 2x4) (Base coverage urban)	60 (DL 2x2 and UL 1x2)

802.16m System Requirements

Requirements	IMT-Advanced	802.16m
Antenna Configuration	Not specified	DL: 2x2 (baseline), 2x4, 4x2, 4x4, 8x8 UL: 1x2 (baseline), 1x4, 2x4, 4x4
Cell Range and Coverage	Not specified	Up to 100 km with optimal performance up to 5 km
Multicast and Broadcast Service (MBS)	Not specified	4 bit/s/Hz for ISD 0.5 km and 2 bit/s/Hz for ISD 1.5 km
MBS channel reselection interruption time	Not specified	1.0 s (intra-frequency) 1.5 s (inter-frequency)
Location based services (LBS)	Not specified	Location determination latency < 30 s MS-based position determination accuracy < 50 m Network-based position determination accuracy < 100 m
Operating bandwidth	Up to 40 MHz (with aggregation)	5 to 20 MHz (up to 100 MHz through band aggregation)
Duplex scheme	Not specified	TDD, FDD (support for H-FDD terminals)
Operating frequencies	IMT bands	Bands below 6 GHz including IMT

IEEE 802.16m Documents

Background documents prior to development of 802.16m draft standard:

- Evaluation Methodology Document (EMD)
  - Defines link-level and system-level simulation models and associated parameters for evaluation and comparison of technologies for IEEE 802.16m
- System Requirements Document (SRD)
  - Stage 1
  - Includes advanced features beyond IMT-Advanced requirements
- System Description Document (SDD)
  - Stage 2
  - System level description of IEEE 802.16m
  - IEEE 802.16m standard is being developed in accordance with SDD
  - Shall be maintained and may evolve

IEEE 802.16m Draft Standard:

- Began Working Group Letter Ballot in July 2009
- Current version: D5
- Expected completion in 12/2010

Development of IEEE 802.16 IMT-Advanced Proposal

- Solicited input material towards development of candidate RIT:
  - Call for comments and contributions over the past year
  - Correspondence Group activities between IEEE 802.16 sessions
  - Liaison activities with external organizations (e.g. WiMAX Forum, ARIB, TTA, and ITU-R WP 5D)

- Contributions received containing calibration/simulation results as well as texts for description templates and other elements of the submission from authors affiliated with:
  - Alcatel Shanghai Bell, Clearwire, ETRI, Fujitsu, Hitachi, Intel, ITRI, KDDI, LG Electronics, MediaTek, Mitsubishi Electric, Motorola, NEC, Samsung Electronics, Toshiba, UQ Communications, WiMAX Forum, and others.

International support for IEEE 802.16 IMT-Advanced Proposal

- Cooperating with national standards bodies
- Japan's Contribution 5D/466 (June 2009) notified ITU-R of its IMT-Advanced preparations
  - "Japan basically endorses the works of 3GPP and IEEE 802.16 relating to the submission of proposals for candidate radio interface technologies..."
- Korea's TTA organized the "Joint ARIB, IEEE and TTA leadership meeting for IMT-Advanced" in Jeju, Korea, 30 Aug 2009
- Relevant contributions to WP 5D Meeting #6; e.g.:
  - 5D/544 (Japan): *Proposal for candidate radio interface technologies for IMT-Advanced based on IEEE 802.16*
  - 5D/560 (TTA): *Submission of a candidate IMT-Advanced RIT based on IEEE 802.16*

IEEE 802.16 IMT-Advanced Proposal

IMT-Advanced Requirements

- IEEE has proposed a single RIT (inclusive of TDD and FDD) to meet or exceed all IMT-Advanced requirements in all test environments

Test Environment / Deployment Scenario	Proposal Meets IMT-Advanced Requirements
Indoor Hotspot (InH)	✓
Urban Microcell (UMi)	✓
Urban Macrocell (UMa)	✓
Rural Macrocell (RMa)	✓

Performance: Cell Spectral Efficiency

DL cell spectral efficiency in bit/s/Hz/cell for TDD

	InH	UMi	UMa	RMa
Cell spectral efficiency	6.93	3.22	2.41	3.23
ITU-R requirement	3.0	2.6	2.2	1.1

DL cell spectral efficiency in bit/s/Hz/cell for FDD

	InH	UMi	UMa	RMa
Cell spectral efficiency	6.87	3.27	2.41	3.15
ITU-R requirement	3.0	2.6	2.2	1.1

UL cell spectral efficiency in bit/s/Hz/cell for TDD

	InH	UMi	UMa	RMa
Cell spectral efficiency	5.99	2.58	2.57	2.66
ITU-R requirement	2.25	1.8	1.4	0.7

UL cell spectral efficiency in bit/s/Hz/cell for FDD

	InH	UMi	UMa	RMa
Cell spectral efficiency	6.23	2.72	2.69	2.77
ITU-R requirement	2.25	1.8	1.4	0.7

Performance: VoIP Capacity

VoIP capacity (users/sector/MHz) for TDD

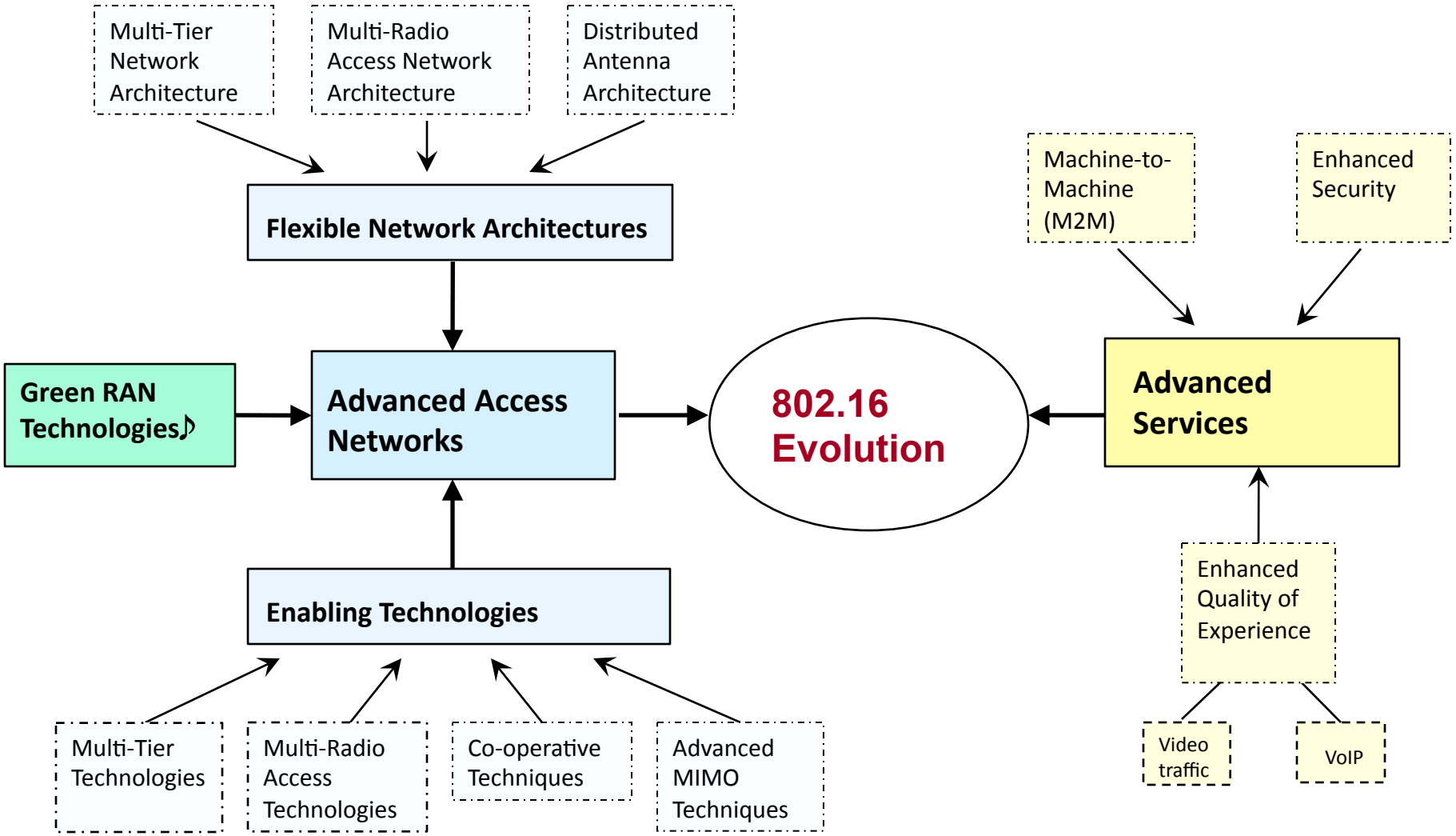
	DL	UL	Minimum {DL, UL}	ITU-R required
InH	140	165	140	50
UMi	82	104	82	40
UMa	74	95	74	40
RMa	89	103	89	30

VoIP capacity (users/sector/MHz) for FDD

	DL	UL	Minimum {DL, UL}	ITU-R required
InH	139	166	139	50
UMi	77	102	77	40
UMa	72	95	72	40
RMa	90	101	90	30

IEEE 802.16 Future Plans

Future 802.16 – Enabling Technologies



Potential Technologies to Achieve Peak Rate

Metric	Potential Target	Enabling Technologies
Peak Data Rate *(bps)*	• **1 to 5 Gbps** <u>Baseline (16m) – ITU submission</u> • Peak rate ~ 356 Mbps, 4x4 MIMO, 20MHz • Peak rate ~ 712 Mbps, 8x8 MIMO, 20MHz • Carrier Aggregation (100MHz) ~3.6 Gbps	**Higher BW support (40 MHz)** • Peak Rate ~ 16m rate x 2 = 1.4Gbps **Multi-Carrier, licensed & unlicensed** • Peak Rate ~ 1.4 Gbps x 4 carriers • 802.11 radio is used in conjunction with 802.16 **Improve Peak Spectral Efficiency (below)**
Peak Spectral Efficiency *(bps/Hz)*	• **Downlink: 45 bps/Hz** • **Uplink: 22 bps/Hz** [~ 3x IMT-advanced requirements] <u>Baseline (16m) – ITU submission</u> • DL Peak SE ~ 35.6 bps/Hz, 8 streams • UL Peak SE ~ 9.4 bps/Hz, 2 streams	**Higher order MIMO in UL (4 streams)** •UL Peak SE ~ 16m SE x 2 = 18.8 bps/Hz **Higher modulation (up to 256 QAM)** • DL Peak SE ~ 16m SE x (8/6) = 47.5 bps/Hz • UL Peak SE ~ 16m SE x (8/6) x 4 = 25 bps/Hz

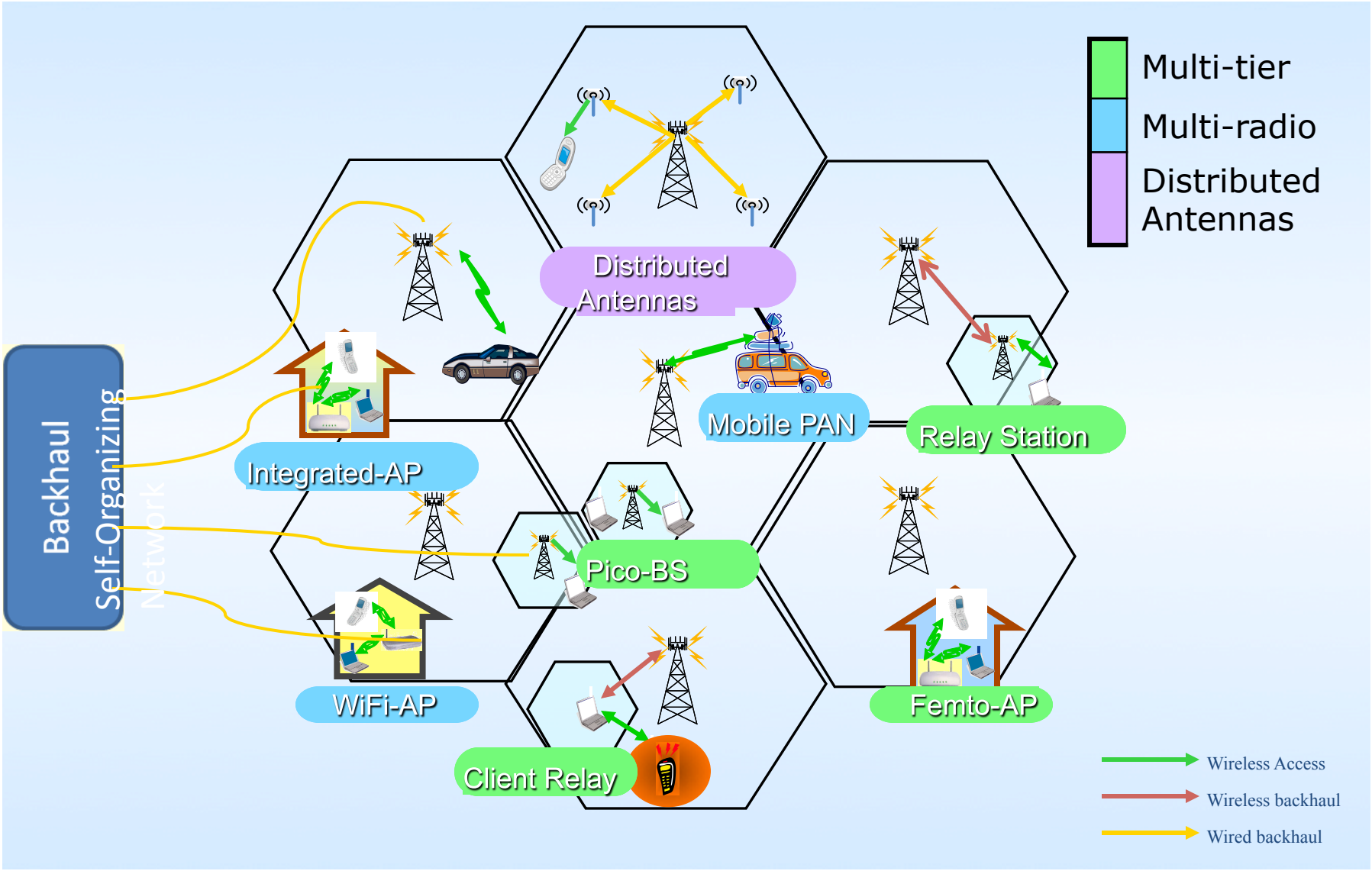
System Metric Targets and Technologies

Metric	Potential Target	Enabling Technologies
Average SE *(bps/Hz/cell)*	• **Downlink > 2x with 4x4 (or 8x4)** • **Uplink > 2x with 4x4 (or 4x8)** <u>Baseline (16m) ~ IMT-adv Requirements</u> • DL Avg SE = 2.2 bps/Hz/sec, 4x2 • UL Avg SE = 1.4 bps/Hz/sec, 2x4 (Urban-coverage scenario)	**Advanced MIMO techniques** Ex. Distributed antennas • DL Avg SE ~ 3x with 4x4
		Multi-tier networks Ex. Same Frequency Femtocell Network • Outdoor Avg SE ~ 1.5x (offload macro)
Cell-edge user SE *(bps/Hz/cell/ user)*	• **Downlink > 2x with 4x4 (or 8x4)** • **Uplink > 2x with 4x4 (or 4x8)** <u>Baseline (16m) ~ IMT-adv Requirements</u> • DL Cell-edge SE = 0.06 bps/Hz/sec, 4x2 • UL Cell-edge SE = 0.03 bps/Hz/sec, 2x4 (Urban-coverage scenario)	**Co-operative Techniques** Ex. Client collaboration • UL Cell-edge SE ~ 1.3 to 2x **Interference Mitigation Techniques**

New Metrics for Advanced Access Networks

Metric	Potential Target	Enabling Technologies
Areal Capacity *(bps/m^2)*	• Areal capacity = Sum throughput delivered by multiple network tiers / Coverage area • Areal capacity should be greater than single tier (macro) capacity	**Multi-radio access Networks**
		Multi-tier Femtocell Networks Ex. Same frequency Macro & Femto overlay • Areal Capacity ~ N_femto_APs x Avg SE x BW
		Multi-tier Relay Networks

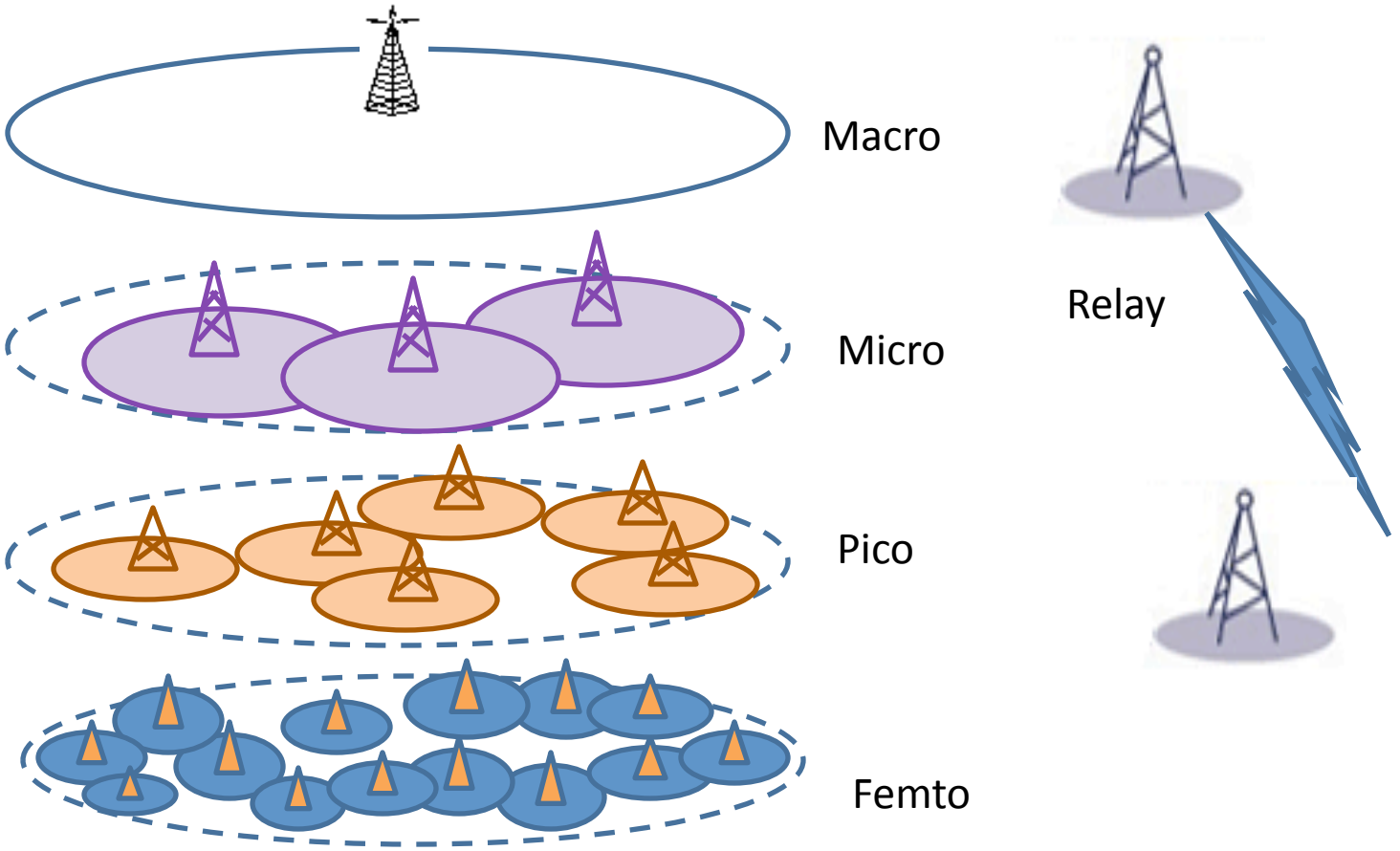
Vision of Advanced Access Network Architecture



Multi-tier Networks

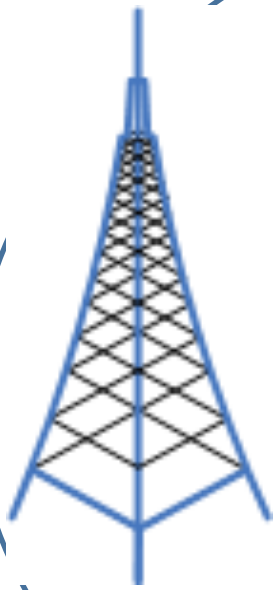
Aggressive Spectrum Utilization

- Overlay multiple tiers of cells, macro/pico/femto, potentially sharing common spectrum

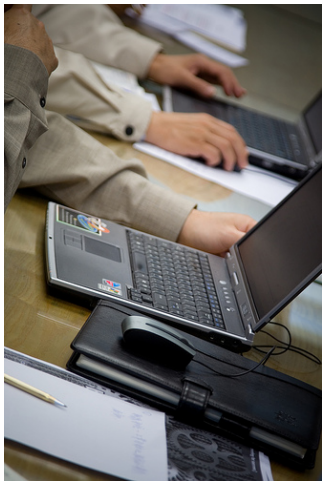


Cooperative Techniques

Most devices have more than one type of connectivity
Most users are nomadic/stationary ♪



Coffee shops



Meetings / Offices

Class rooms

We can leverage this clustering to offer better end-user experience

Advanced Services

- Machine-to-Machine communications
  - Data communication between devices or device and server that may not require human interaction
    - Different business scenarios
    - Potentially very large number of devices
    - Lower cost and energy for M2M devices
    - Coexistence with other RFs in neighboring M2M network
- Enhanced Quality of Experience for voice & video
  - Not straightforward to map today's QoS parameters to user experience
  - Large number of heterogeneous mobile internet devices with various applications requiring a range of quality of experience (QoE) metrics.
    - Example: Smartphone/Netbook supporting apps such as social networking, Skype, browsing, video conferencing, streaming, IPTV
- Enhancements for Security
  - Strong Authentication backed up by Device Integrity

In Summary - Key Technical Features

- Very high Peak throughput in mobile environment (> 1Gbps)
  - Support for bandwidths greater than 20MHz
- Advanced Access Networks
  - New flexible network architectures
  - Low cost deployments
  - Enabling technologies providing
    - Higher Spectral Efficiency (> 2x)
    - High Areal Capacity
    - Improved Energy Efficiency
- Advanced Services
  - Enhancements for video, voice & security
  - Support for new M2M service

Conclusion

- The IEEE 802.16 WirelessMAN standard has been evolving for 10 years to bring the latest technology to the marketplace
- IEEE follows an open, worldwide development process
- IEEE has submitted a complete IMT-Advanced candidate RIT, based on IEEE Project 802.16, including documentation demonstrating that it meets the IMT-Advanced requirements in all four test environments
- IEEE 802.16 WirelessMAN standard is still evolving to enhance performance and network capacity

Resources

- IEEE 802.16 web site
  - http://WirelessMAN.org

- IEEE 802.16 IMT-Advanced web page
  - http://WirelessMAN.org/imt-adv