2011 Taipei WiMAX Summit

IEEE 802.16m

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Presentation Outline

1. 16m - Status and Schedule
2. Advances compared to 16e
3. Migration to 16m
4. Concluding Remarks

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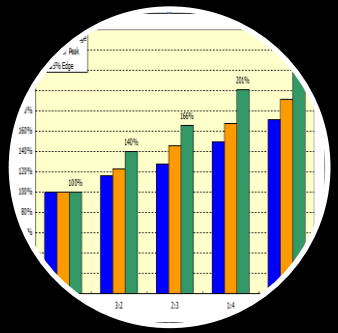
16m : Status and Schedule

IEEE 802.16m Key Achievements



IMT-Adv Requirements met

Successful Technology Demonstration

UQ's CEATEC demo

Technical Specification
(Feature Complete)

UQ's WiMAX 2 Demonstration

【CEATEC JAPAN 2010】UQコミュニケーションズがWiMAX2による330Mbps高速データ通信のデモ

文◎鹿井宏治(IT通信ジャーナリスト) 2010.10.06

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幕張メッセで2010年10月9日まで開かれているCEATEC JAPAN 2010で、UQコミュニケーションズが世界初となる次世代WiMAX、IEEE802.16m(WiMAX2)の伝送デモを公開している。

WiMAX2は、現行WiMAXの10MHzの搬送波幅を20MHz幅まで拡大、8×8MIMOの実装した場合、下り最大300Mbpsクラスのデータ通信を実現できる規格である。今回のデモでは、この20MHz幅の搬送波を2波束ねることで計40MHz幅の帯域で運用、これに4×4MIMOを実装して下り330Mbpsのデータ通信を実現している。

実際のデモはラック上に構築した試作端末と基地局装置との間を有線で結んで行われ、実測で下り最大310Mbpsの通信が可能であることが示された。また、会場には5台のハイビジョンテレビが設置され、この回線を使って3D映像やマルチ映像がスムーズに送れることをアピールした。

UQコムは、現行帯域に隣接する2.6GHz帯の旧モバイル放送帯域を取得してWiMAX2を実用化することを検討しており、「商用端末が供給される2012年のサービス開始を目指している」という。このほかブースでは、米国で使われているWiMAX対応タブレット端末や、展開中のWiMAXを活用した自動販売機の運用デモなどが展示されている。

実測で310Mbps超のデータ通信速度を記録


デモでは計5台のハイビジョンテレビに3D映像やマルチ画面がスムーズに送れることがアピールされた

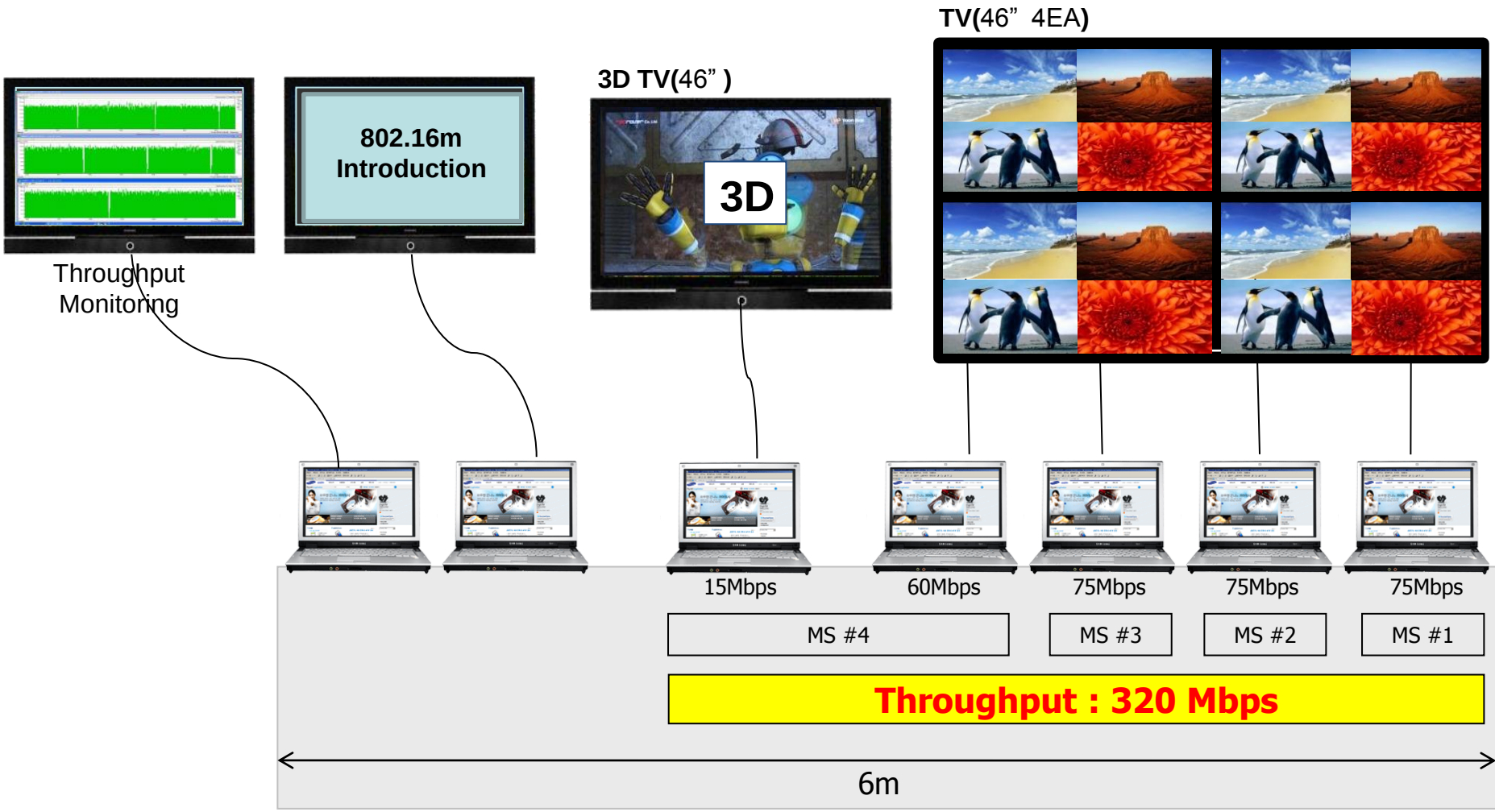

デモに使われている試作WiMAX端末と基地局装置


海外で使われているWiMAX端末。タブレットタイプも提供されている

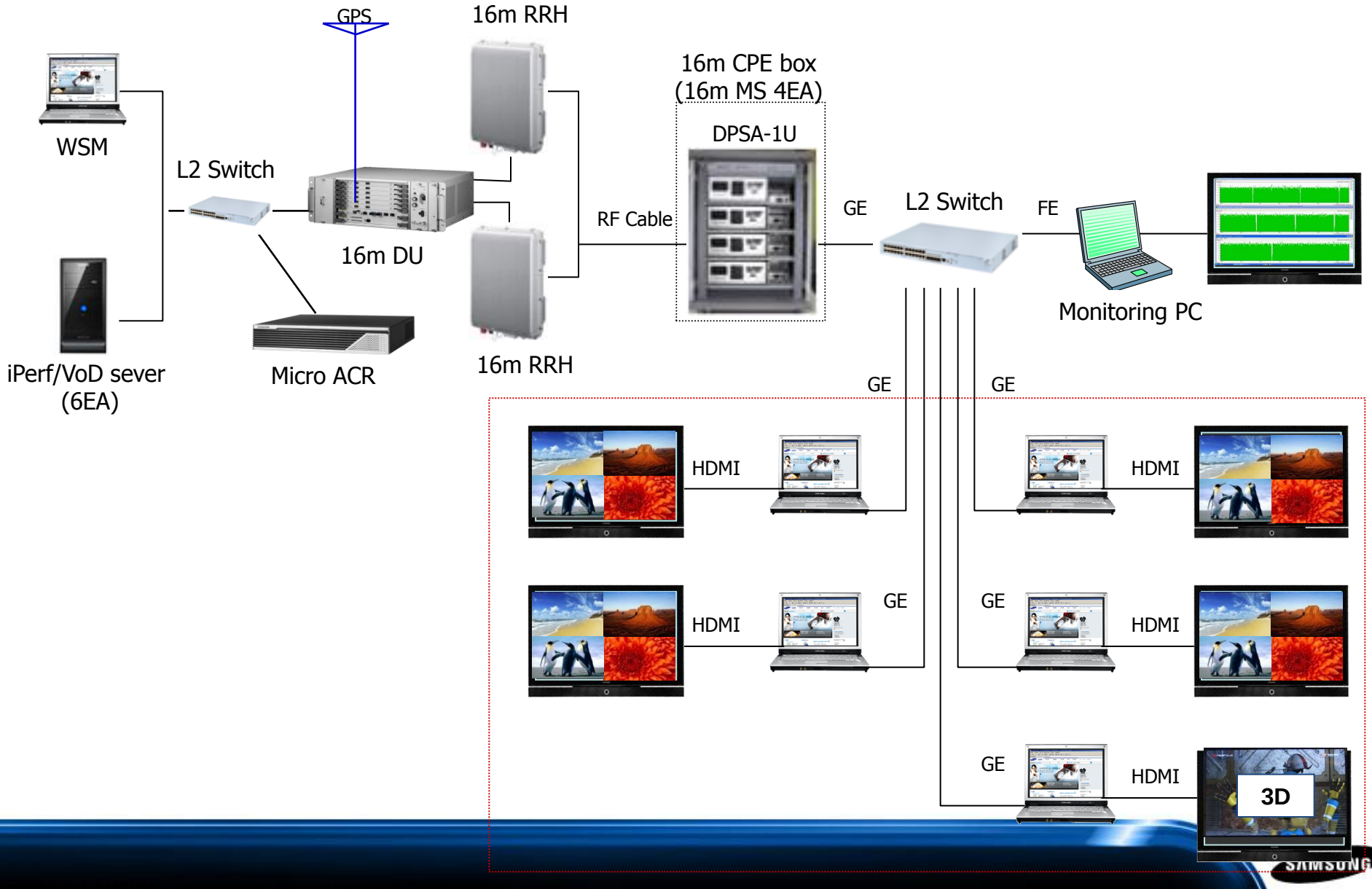
http://www.svp.jp/hosting/uq/02/

UQ's Demo Configuration

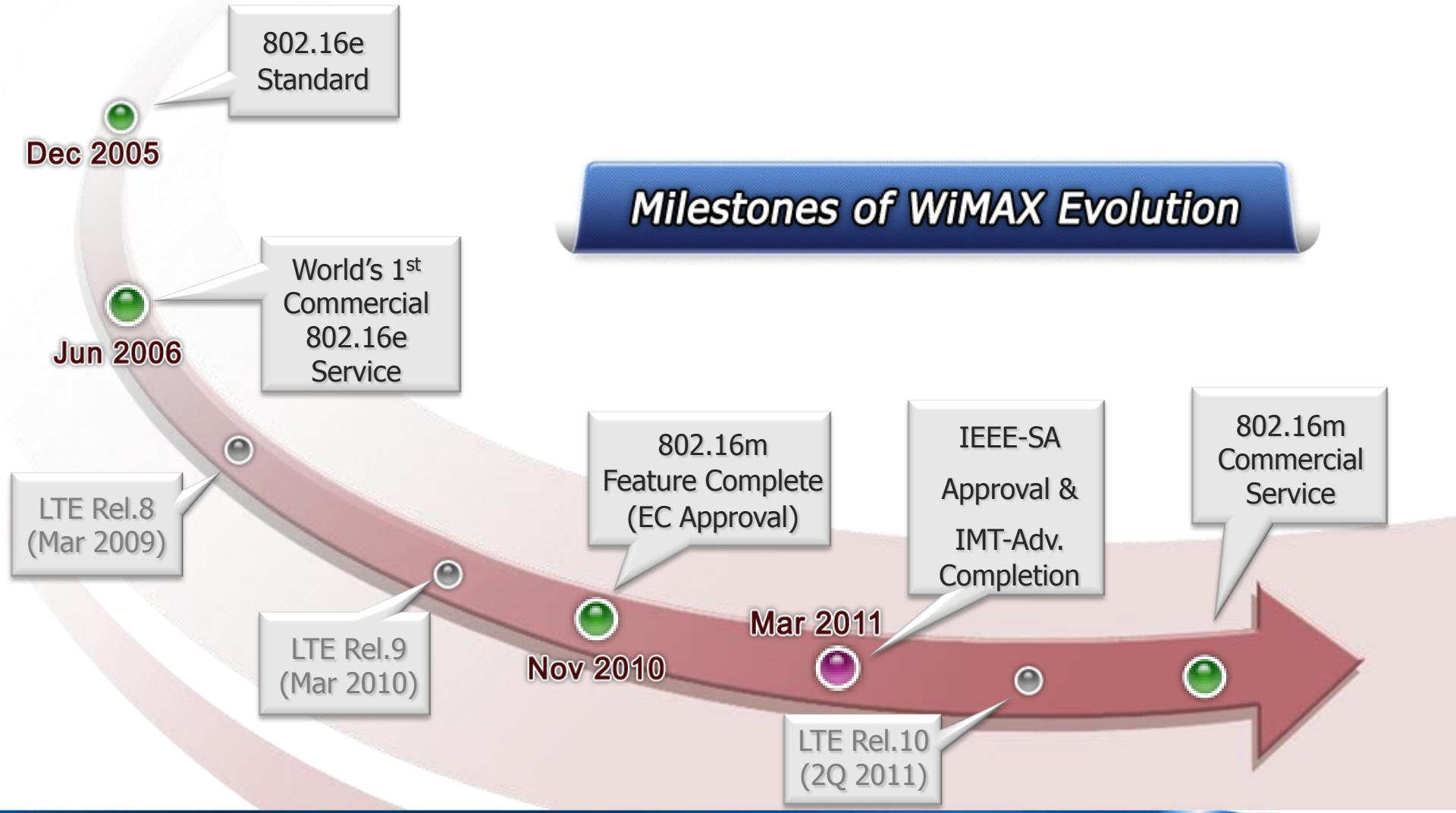
IEEE 802.16m Demonstration



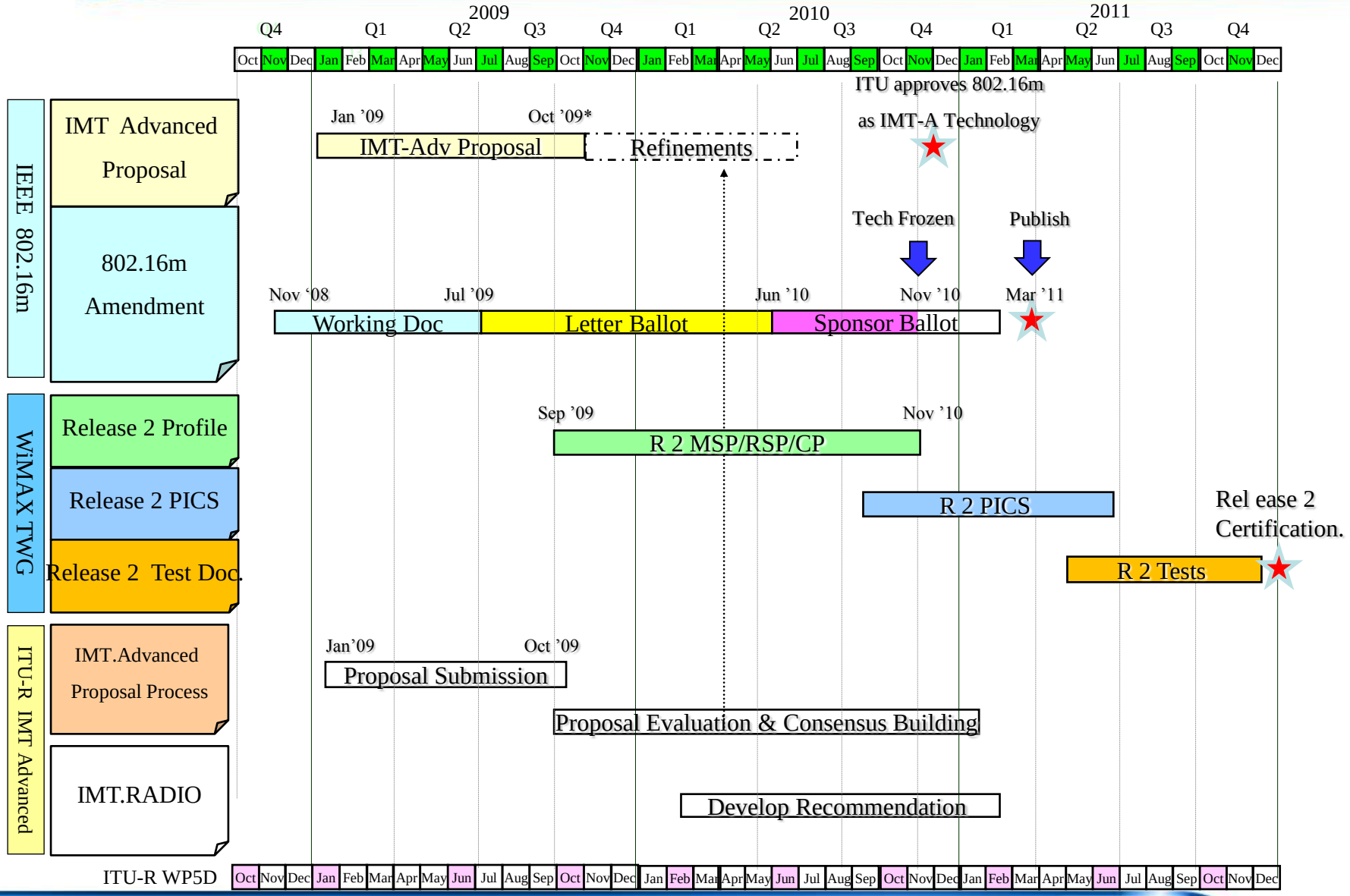
Network Configuration of UQ's Demo



The Journey from 802.16e to 802.16m



Schedule for 16m, TWG and ITU-R



Advances compared to 16e

A Significantly Enhanced 802.16 Core

- New frame structure (sub-frame-based)
- Efficient sub-channelization and DL/UL pilot structures
- Extended and improved DL/UL MIMO modes
- Improved Handover schemes with shorter interruption times
- Enhanced Sleep and Idle mode operations, and the new DCR mode
- Improved data plane operation with simplified header and ARQ
- Improved QoS support and bandwidth request procedure
- Support for faster Network Entry with simplified capability negotiation
- Enhanced Security including new features providing MSID and location privacy

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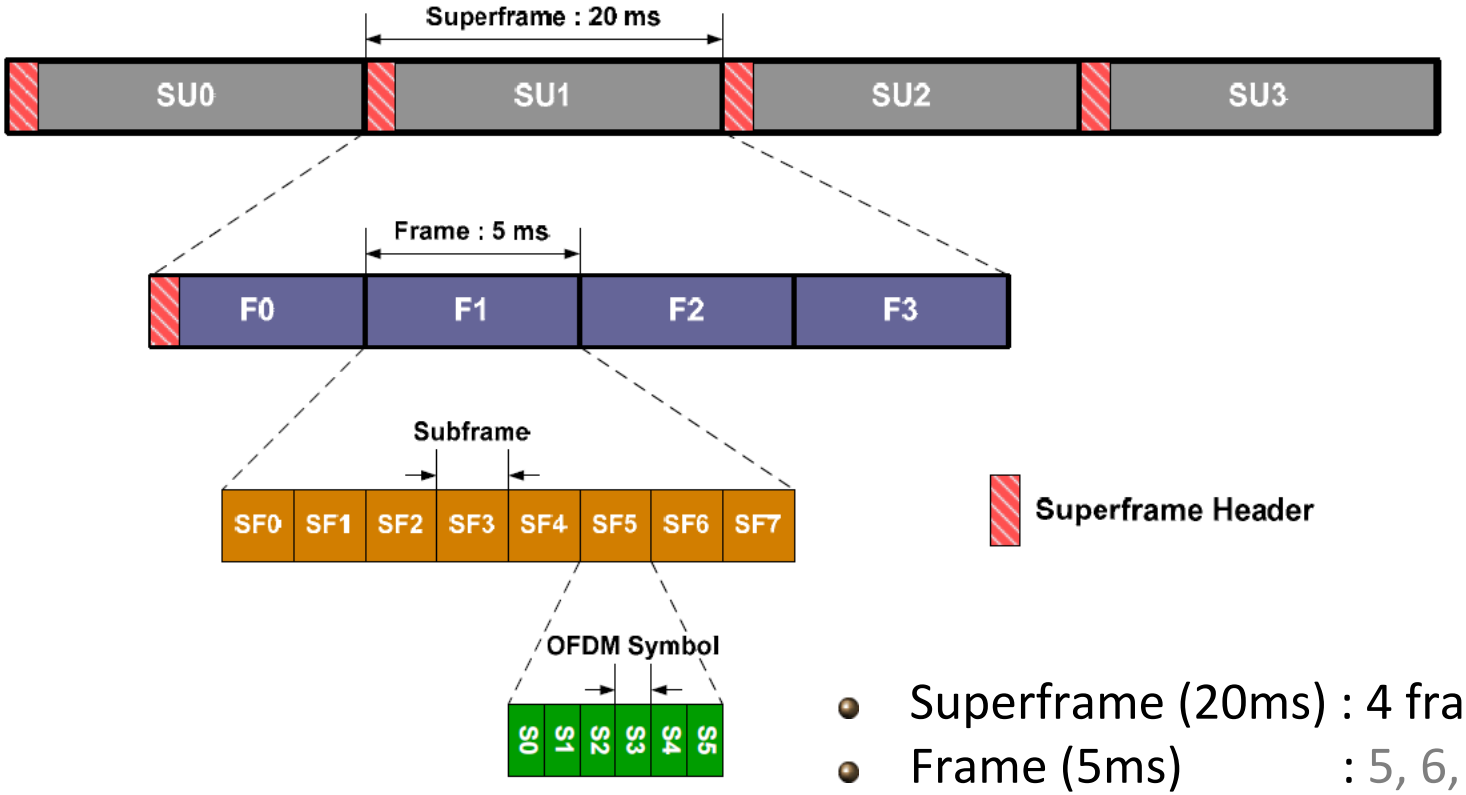
Enhanced Core Supplemented with …

- Multi-carrier operation using a single MAC instantiation
- Support for Femto Cells and Self-Organization
- Support for GPS and Non-GPS based location services
- Enhanced MBS using new CCHs and sub-channelization
- Simplified Relay support
- Support for Multi-BS MIMO

The New Frame Structure



- Superframe (20ms) : 4 frames
- Frame (5ms) : 5, 6, 7, 8 sub-frames
- Subframe : 6, 7, 5 symbols

- Sub-frame for Lower latency
- Super-frame for overhead reduction
- Backward compatibility without legacy performance degradation

Key Factors Influencing Performance

	WiMAX 1 (Rel. 1.0)	WiMAX (Rel. 2.0)
MAP	TDM, Joint coding	FDM, Separate coding
HARQ latency	15ms	5ms
Max. DL Tx Ant.	2	4
Max. UL Tx Ant.	1	4
DL/UL Band AMC	No	Yes
DL/UL CL – MIMO (codebook base)	No	Yes
DL MU – MIMO	No	Yes
UL MU – MIMO	Yes (Max 2)	Yes (Max 4)
Max. BW	10	20
Multi-carrier	No	Yes

Significant Improvement in Peak Rates

	WiMAX 1 (Rel. 1.0) (From [1])	WiMAX (Rel. 2.0) (From [2])
Bandwidth, CP	10MHz, 1/8	20MHz, 1/16
Streams	DL:2, UL:2	DL:4, UL:2
Overhead	3 symbols + pilot	1 symbol + pilot
TDD DL : UL	2 : 1	2 : 1
DL MCS	64QAM, 5/6	64QAM, 1
UL MCS	16QAM, 3/4	64QAM, 1
DL Peak [Mbps]	40.32	**226.1**
UL Peak [Mbps]	10.08	**61.5**

[1] “Mobile WiMAX – Part I: A Technical Overview and Performance Evaluation”, June, 2006, WiMAX Forum

[2] “Submission of a Candidate IMT-Advanced RIT based on IEEE 802.16 “, ITU-R IMT-ADV/4

Significantly Improved System Performance

WiMAX Release 1 @ 10 MHz (From [1])

- Evaluation configurations : Appendix A
- DL O/H : 7 symbols (preamble + MAP)
- UL O/H : 3 symbols

Link	DL : UL = 29 : 18	
	Sector [Mbps]	S.E [bps/Hz]
DL	10.63	1.73
UL	3.05	0.79

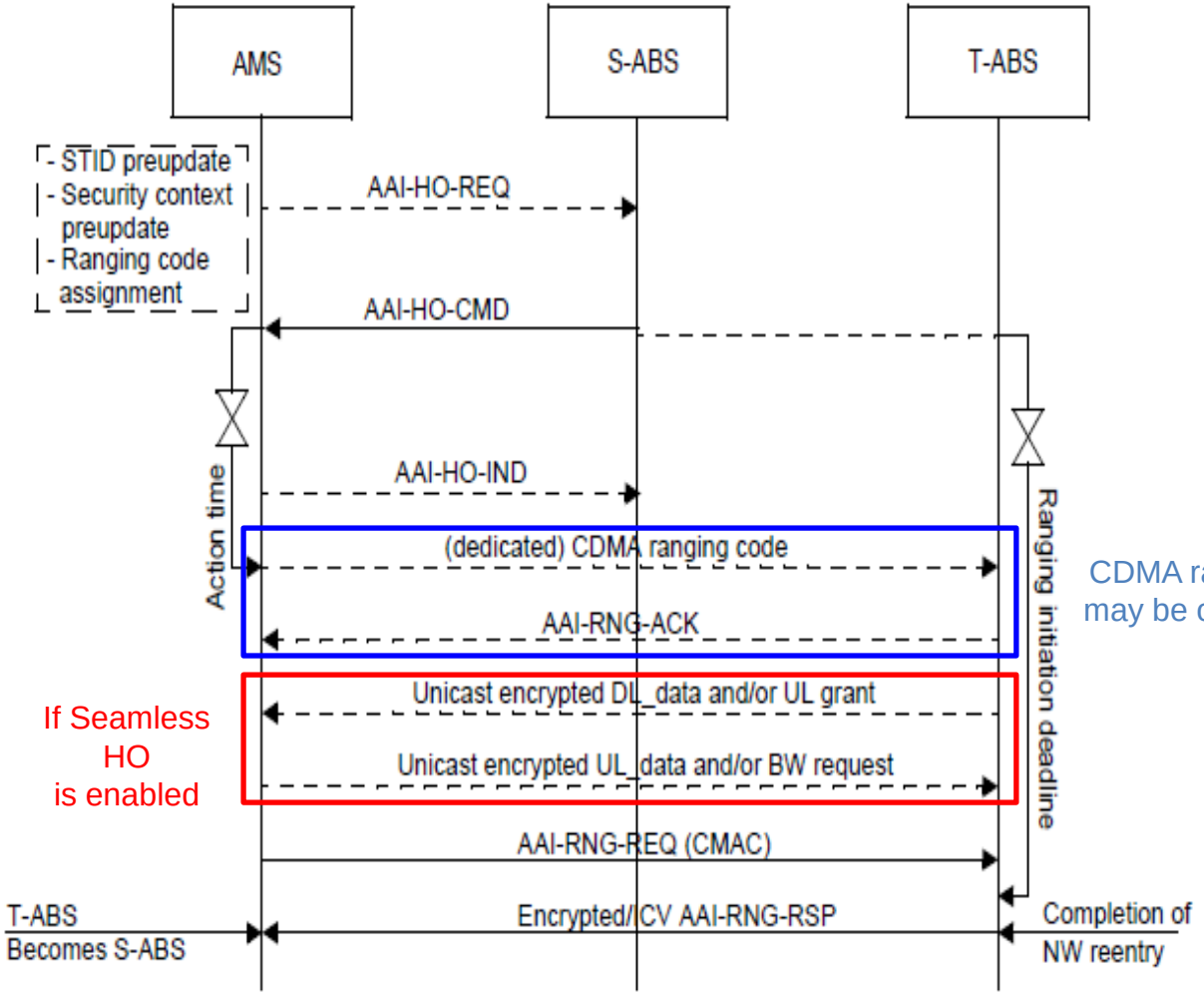
WiMAX Release 2 @ 20 MHz (From [2])

- Evaluation configurations : Appendix B
- Overhead: Appendix C

MIMO		Umi (DL:UL = 5:3)		Uma (DL:UL = 5:3)	
		Rate [Mbps]	S.E [bps/Hz]	Rate [Mbps]	S.E [bps/Hz]
DL 4x2	Sector	40.25	3.22	30.12	2.41
	Edge	1.15	0.092	0.86	0.069
UL 2x4	Sector	19.35	2.58	19.28	2.57
	Edge	0.83	0.111	0.82	0.109

Enhanced Handover Support

- Reduced HO interruption time
  - BBE: Omission of CDMA ranging, Seamless HO
  - EBB: single-carrier/multi-carrier
- Support for handover to/from legacy BS (R1 BS)
- Support for inter-RAT HO



Simplified, Efficient and Flexible Sleep Mode

Facilitating more and frequent sleep opportunities

- Subframe-level Sleep Mode operation
- Traffic Location Indicator Bitmap for Efficient Sleep
- Sleep during control transaction

Traffic-driven Listening Window

- Extendable Listening Window based on traffic characteristics
-

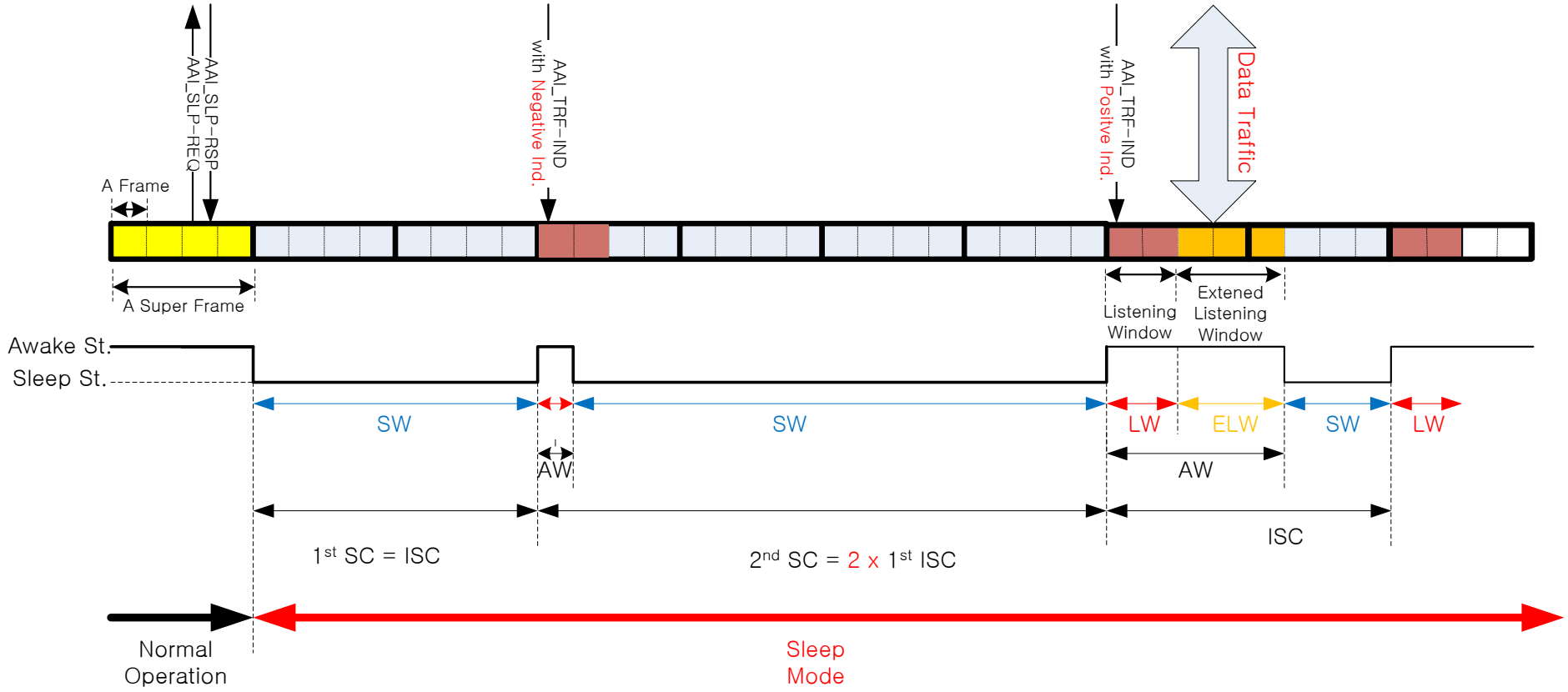
Efficient State Transition

- Transition between Sleep and Active Mode using control signaling

Simplified Sleep Mode operation:

- Single Power Saving Class
- Instant Sleep Cycle setting switching based on control signaling

Basic Sleep Operation Illustrated



More Power Conserving Idle Mode

PGID split from Paging Message

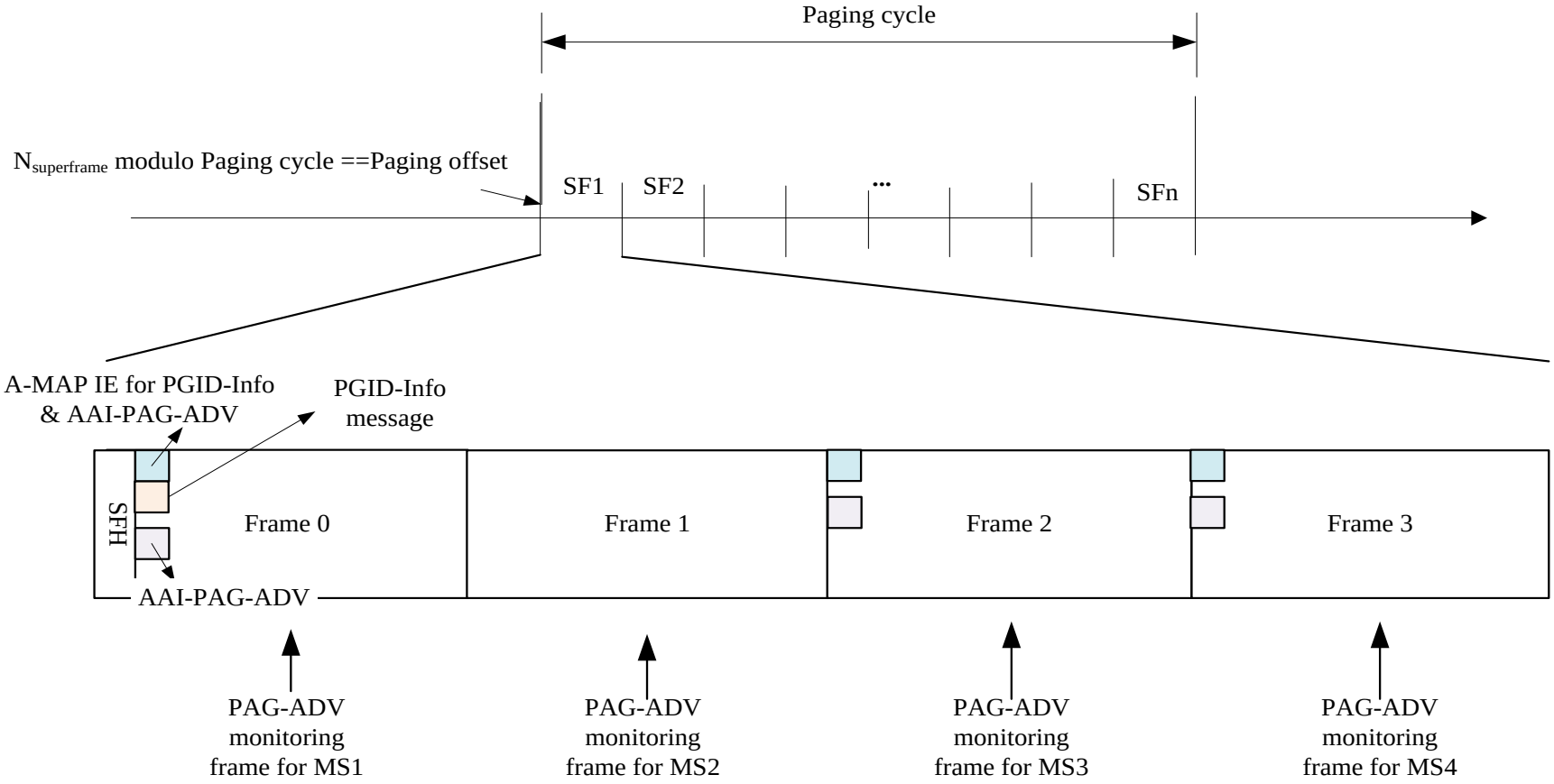
- PGID carried in PGID-Info message
- PGID-Info transmitted at pre-determined location of paging listening interval (right after SFH and A-MAP)
- Early detection of PG change without decoding paging message.

Fixed Location for Paging Message

- For each MS, a frame to monitor AAI-PAG-ADV is pre-determined using DID modulo m (m=1..4)
- Prevents the MS from decoding entire paging listening interval

Operation during Paging Listening Interval

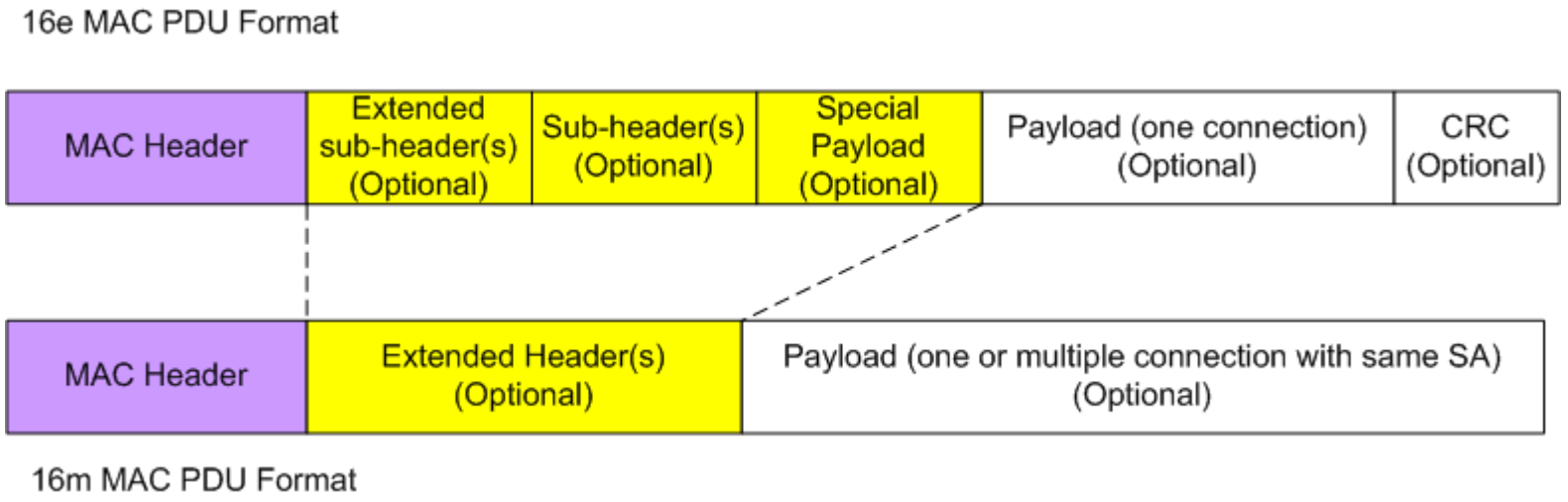
- Example: MS3's DID is 22 and m is 4
  - The paging frame for MS3 is frame index 2 .
  - MS3 monitors PGID-Info in frame index 0 and AAI-PAG-ADV in frame index 2.



Faster Network Entry and Enhanced Security

Support for Faster Network Entry	• Default service flow is established without DSA (3-way handshake). • Fast IP address allocation during registration procedure. • TEK transactions can be omitted thanks to local derivation.
Enhanced Security	• MS identity and location privacy is provided. • Confidentiality and Integrity protection for MAC control messages.
Lighter Encryption Overhead	• Encryption overhead down to 7 bytes from 12 bytes per MAC PDU

Efficient and Simpler MAC PDU Format



- Overhead reduction
  - 6 B GMH to a 2 B AGMH(2byte), and 1 B SPMH
  - MAC CRC removed (PHY CRC only)
- Simplified Header structure
  - Additional headers are merged into a Single extended header
  - MAC PDU payload from Multiple connections with same SA multiplexed into a single MAC PDU

ARQ for High-Speed data Plane Operation

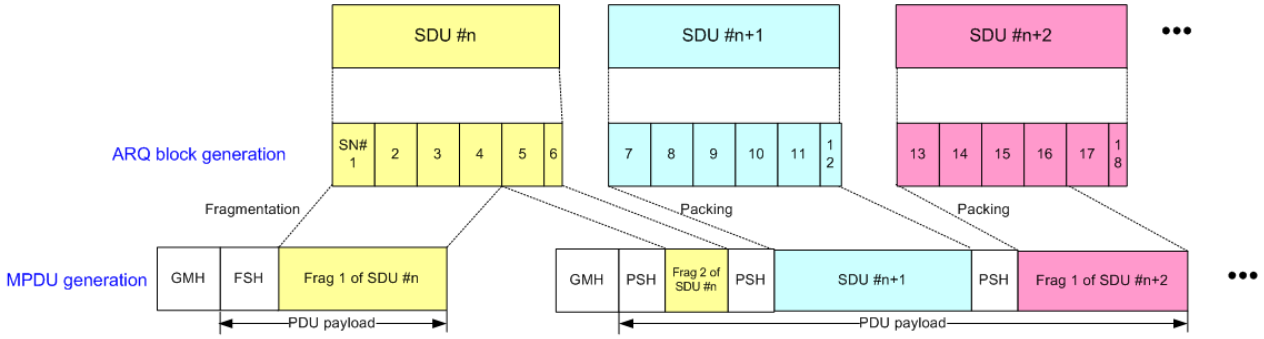


Figure 1. 16e ARQ block and MPDU generation for Initial transmission

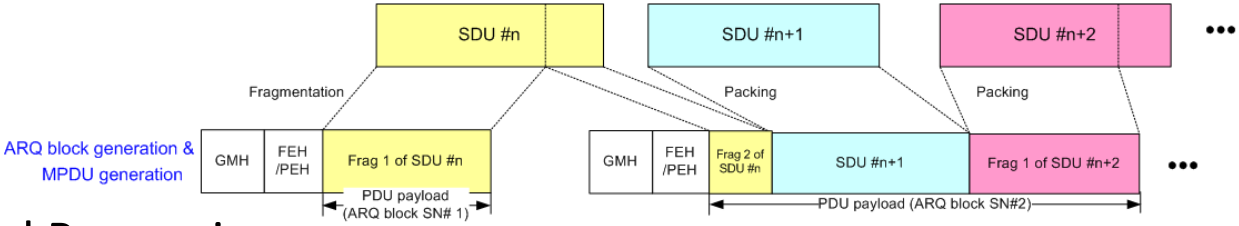


Figure.2. 16m ARQ block and MPDU generation for Initial transmission

- Simplified Processing
  - 3 step processing → 2 step processing
  - MAC PDU payload itself is ARQ block
- Throughput bottlenecks removed
  - MAC throughput made proportional to ARQ block size
  - Fixed ARQ block (16e) → Variable ARQ block (16m)

Migration to 16m

Backward Compatibility with 16e

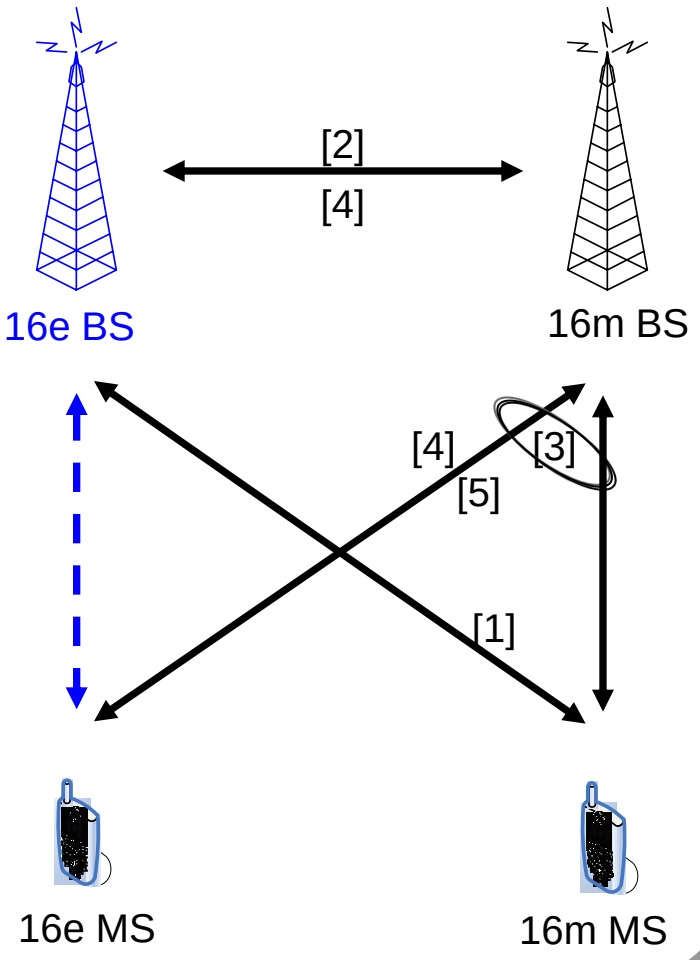
[1] 16m MS to operate with 16e BS

[2] 16m BS and 16e BS on the same carrier

[3] 16m BS to support both 16e & 16m MS

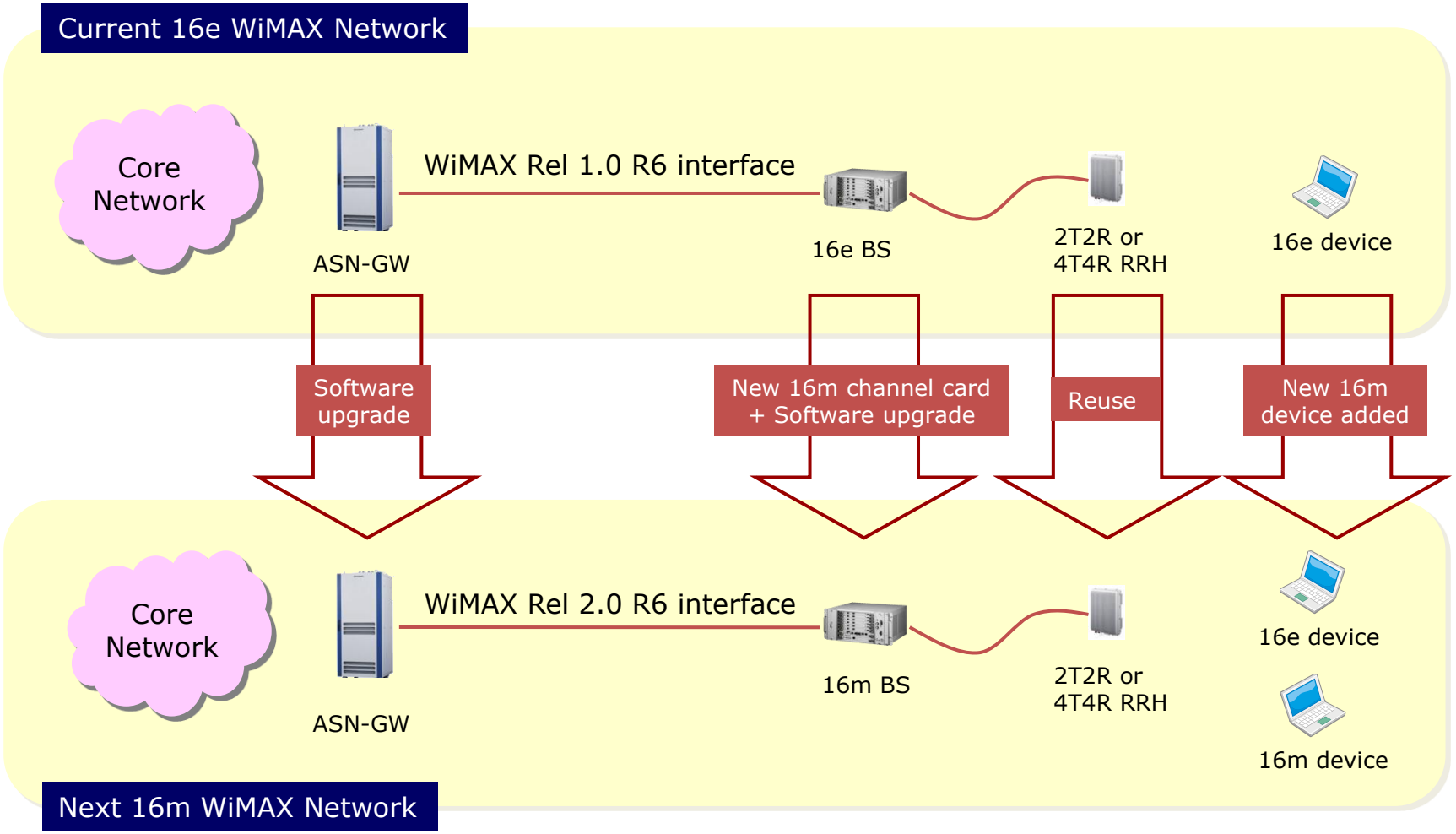
[4] 16m BS to support 16e MS HO to and from 16e BS or 16m BS

[5] 16m BS to efficiently support 16e MS



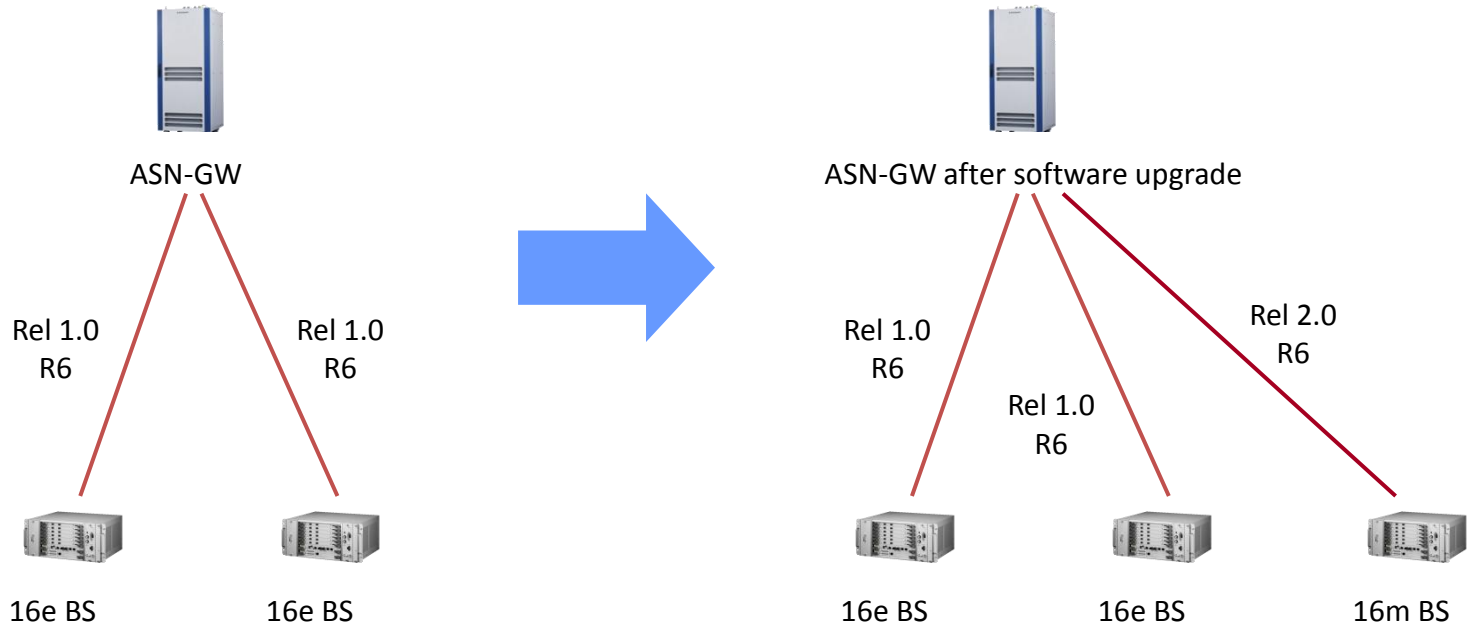
Migrating to 16m-based WiMAX Network

- Smooth migration from 16e to 16m based network was a key requirement



Software Upgradable ASN-GW

- By software upgrade, ASN-GW will be ready to support both 16e BS and 16m BS
  - Reuse of existing infrastructure is very important for protecting previous investment



- WiMAX Forum's NWG is working on Release 2.0 core specifications
- 16m BS will support Release 2.0 R6 interface as well

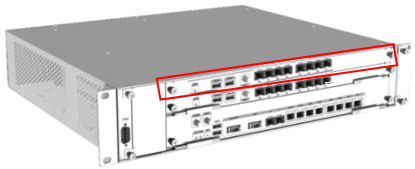
Modular Upgrade for DU

- SU-MIMO
- 10MHz CH BW

Digital Unit (16e)

- MU-MIMO/Beamforming
- 20MHz Channel BW (10+10M or 20M)

Digital Unit (16m)



Add 16m MODEM card

802.16e 802.16m

Soft migration with software upgrade and digital HW addition

- 16m Modem boards can be added.
- RF Units can be reused
  - 2T2R
  - 4T4R
- Main board, fan, power module, etc. can be reused

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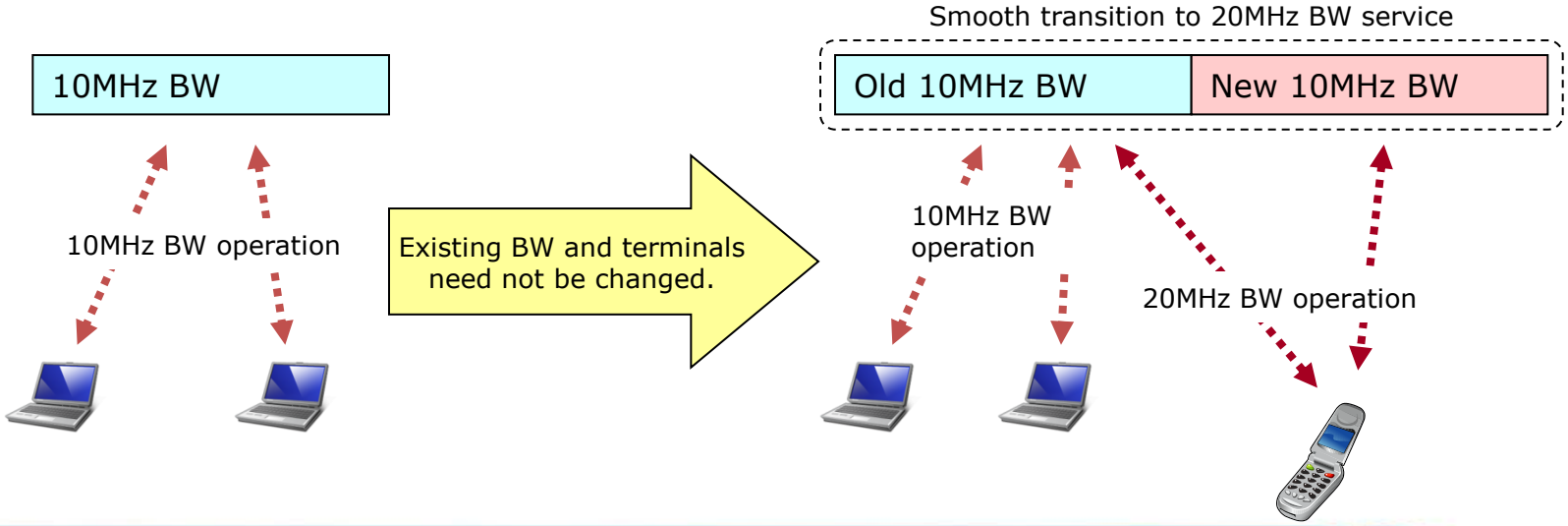
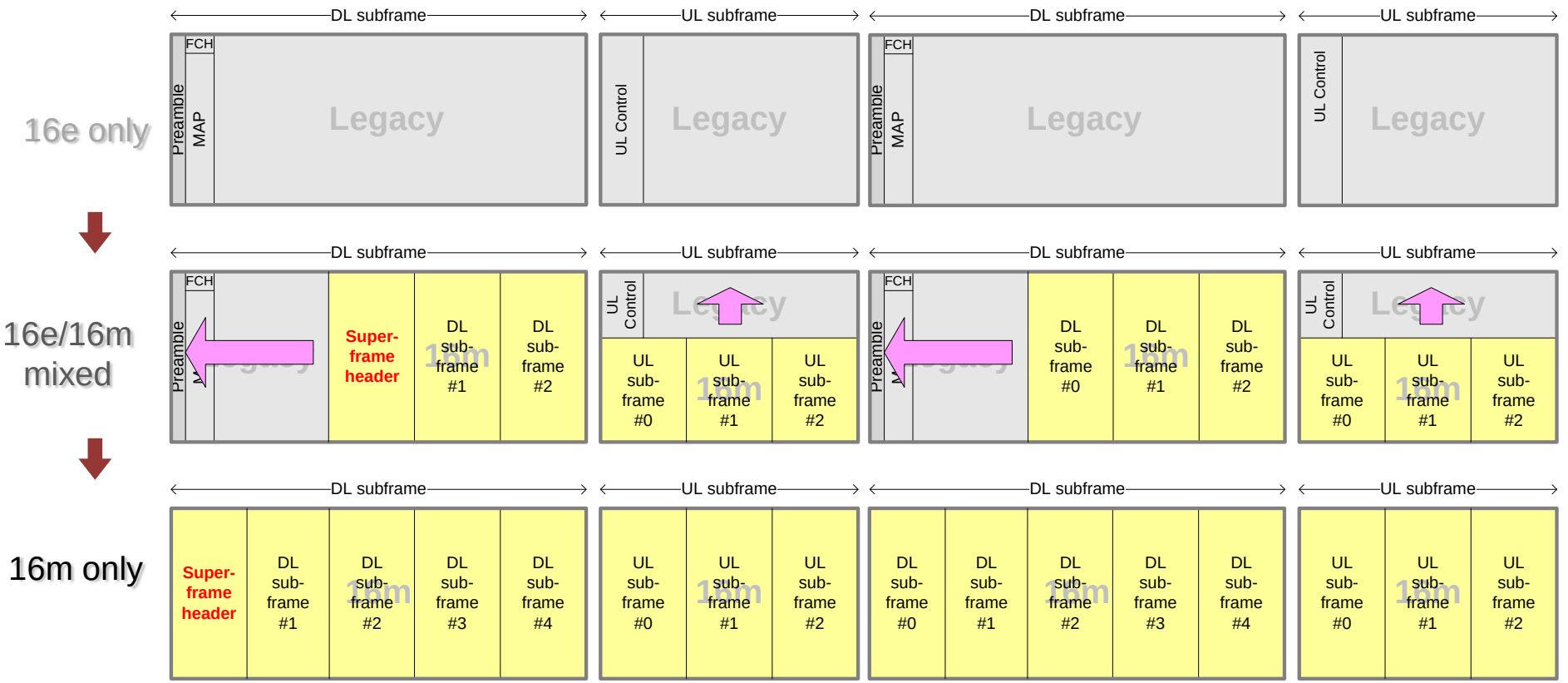
Migration to 16m : Spectrum Perspective

- Same Carrier Migration
  - ✓ 16m and 16e devices on the same RF carrier without performance degradation to 16e.
  - ✓ Flexible resource allocation for 16e and 16m devices.
- Co-existence on different carriers
  - ✓ Same OFDMA numerology and fully aligned DL/UL division
  - ✓ Larger BW support using the newly standardized multi-carrier operation
  - ✓ No impact on synchronization and interference



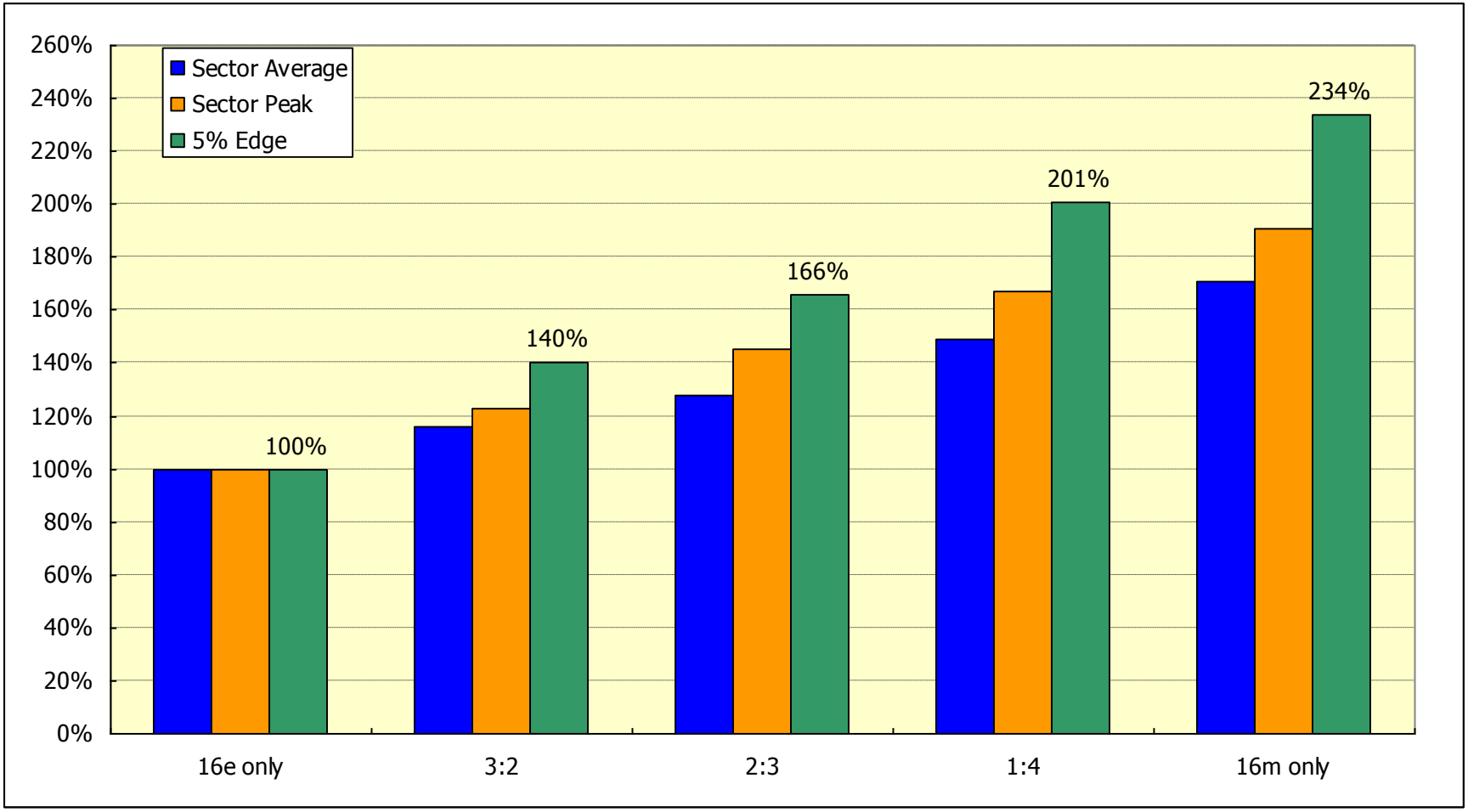
Same Carrier Migration : Mixed Mode



- Last step to 16m -only operation mode
  - Turn off transmission of 16e preamble, FCH, and MAP
  - Move the superframe header and DL subframes to the first frame
  - Extend 16m UL subframes on subchannel domain

Performance in Mixed Mode

- DL sector throughput comparison per 16e:16m ratio
  - DL:UL=5:3, 10MHz channel bandwidth, 4 x 2 MIMO



Concluding Remarks

Looking Further

New Avenues

Not just higher throughput

- Increased Reliability
- Mass device communication
- Dealing with multi-tier and multi-radio systems

iPhone Effect

Dealing with explosive data growth

- Higher cell densities
- Higher bandwidths and frequencies

Join the 802.16 Project Planning Committee and share your thoughts

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Acknowledgments

- Jeongho Park
- Yeongmoon Son
- Hyunjeong Kang
- Youngbin Chang
- Jaeweon Cho
- Jack Jang
- Sassan Ahmadi
- Jiyun Seol
- Wonil Roh

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IEEE-SA Standards Board Operation Manual (subclause 5.9.3)

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Backup

Pilot Overhead Comparison (Rel.1 vs. Rel. 2)

Stream	Downlink		Uplink		
	Rel1(PUSC)	Rel2	Rel1(PUSC)	Rel2(DLRU)	Rel2(CLRU)
1	14.3%	5.6%	33.3%	11.1%	5.6%
2	14.3%	11.1%	33.3%	22.2%	11.1%
3	N/A	11.1%	N/A	N/A	11.1%
4	N/A	14.8%	N/A	N/A	14.8%

Appendix A (1/3): System Parameters

Parameters	Value
Number of 3-Sector Cells	19
Operating Frequency	2500 MHz
Duplex	TDD
Channel Bandwidth	10 MHz
BS-to-BS Distance	2.8 kilometers
Minimum Mobile-to-BS Distance	36 meters
Antenna Pattern	70° (-3 dB) with 20 dB front-to-back ratio
BS Height	32 meters
Mobile Terminal Height	1.5 meters
BS Antenna Gain	15 dBi
MS Antenna Gain	-1 dBi
BS Maximum Power Amplifier Power	43 dBm
Mobile Terminal Maximum PA Power	23 dBm
# of BS Tx/Rx Antenna	Tx: 2 or 4; Rx: 2 or 4
# of MS Tx/Rx Antenna	Tx: 1; Rx: 2
BS Noise Figure	4 dB
MS Noise Figure	7 dB

Appendix A (2/3): OFDM parameters

Parameters		Values
UL PUSC	Null Sub-carriers	184
	Pilot Sub-carriers	280
	Data Sub-carriers	560
	Sub-channels	35

Table 8: OFDMA Parameters

Parameters		Values
System Channel Bandwidth (MHz)		10
Sampling Frequency (F_p in MHz)		11.2
FFT Size (N_{FFT})		1024
Sub-Carrier Frequency Spacing		10.94 kHz
Useful Symbol Time ($T_b = 1/f$)		91.4 microseconds
Guard Time ($T_g = T_b/8$)		11.4 microseconds
OFDMA Symbol Duration ($T_s = T_b + T_g$)		102.9 microseconds
Frame duration		5 milliseconds
Number of OFDMA Symbols		48
DL PUSC	Null Sub-carriers	184
	Pilot Sub-carriers	120
	Data Sub-carriers	720
	Sub-channels	30

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Appendix A (3/3): SLS configurations

Parameters		Value
Cell Configuration		3 Sectors/Cell
Frequency Reuse		1, 1, 3
Users/Sector		10
Traffic Type		Full Buffer
Channel Estimation		Ideal
PHY Abstraction		EESM [21]
Scheduler		Proprietary Proportional Fair
Link Adaptation		Realistic with delay feedback
Antenna Configuration		1x2, 2x2
MIMO Support	DL	Alamouti STC, VSM
	UL	Collaborative SM
MIMO Switch		Adaptive STC/VSM switch
HARQ		CC, 3 Retransmissions
Coding		CTC
Frame Overhead		11 OFDM Symbols (7 DL, 3 UL, 1 TTG)
Data Symbols per Frame		37
DL/UL Partition	A	28:9
	B	22:15

Table 14: Mobile WiMAX Configuration Assumptions

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Appendix B: configurations

Description	***IEEE 802.16m Parameters for Indoor Environment***		***IEEE 802.16m Parameters for Urban Micro-cellular, Urban Macro-cellular, High Speed Environments***	
	TDD	***FDD***	***TDD***	***FDD***
Carrier frequency	*3.4 GHz*		*Urban Micro-cellular: 2.5 GHz* *Urban Macro-cellular: 2.0 GHz* *High Speed: 0.8 GHz*	
Total bandwidth	*40 MHz for data-only (2x20 MHz)*	*2x20 MHz for data-only*	*20 MHz for data-only*	*2x10 MHz for data-only*
	10 MHz for VoIP	*5 + 5 MHz for VoIP*	*10 MHz for VoIP*	*5 + 5 MHz for VoIP*
Number of points in full FFT	*2x2048 for data-only*	*2048 for data-only*	*2048 for data-only*	*1024 for data-only*
	1024 for VoIP	*512 for VoIP*	*1024 for VoIP*	*512 for VoIP*
Sampling frequency	*44.8 MHz for data-only*	*22.4 MHz for data-only*	*22.4 MHz for data-only*	*11.2 MHz for data-only*
	11.2 MHz for VoIP	*5.6 MHz for VoIP*	*11.2 MHz for VoIP*	*5.6 MHz for VoIP*
Subcarrier spacing	*10.9375 kHz*			
OFDMA symbol duration w/o cyclic prefix	*91.43 us*			
Cyclic prefix length (fraction of OFDM symbol w/o CP)	*1/16*			
OFDMA symbol duration with cyclic prefix	*97.143 us*			
Frame length	*5 ms*			
Number of OFDMA symbols in frame (excluding switching gaps)	*50*	*51*	*50*	*51*
Ratio of DL to UL (TDD mode)	*5 DL subframes, 3 UL subframes for data-only*	*8 DL subframes for DL and UL*	*5 DL subframes, 3 UL subframes for data-only*	*8 DL subframes for DL and UL*
	4 DL subframes, 4 UL subframes for VoIP	*8 DL subframes for DL and UL*	*4 DL subframes, 4 UL subframes for VoIP*	*8 DL subframes for DL and UL*
Duplex time	*TTG+RTG = 142.85 us*	*N/A*	*TTG+RTG = 142.85 us*	*N/A*

Appendix C (1/3): DL Control Channel Overhead

- A-A-MAP : dynamically calculated based on scheduler, average Dl/UL A-A-MAP is accounted for accordingly
- HF A-MAP : dynamically calculated with truncated set of sizes
- A-Preamble : fixed portion of 1 OFDMA symbol
- A-Midamble : fixed portion of 1 OFDMA symbol
- SFH : fixed portion of 20 LRUs per superframe

Appendix C (2/3): UL Control Channel Overhead

- FBCH : 5ms report period in UMa and RMa for 10 users/sector
- S-FBCH : feedback of CQI/PMI, 5ms report period
- UL MAC management message : feedback of CQI/PMI, 5ms report period
- H-FBCH : dynamically calculated with truncated set of sizes
- LT-CM : 20ms report period in UMa and RMa
- Sounding : fixed portion of 1 symbol per TTI (2 symbols for FDD, 1 symbol for TDD)
- Initial Ranging : fixed portion of 4 LRUs per superframe
- BW-REQ : fixed portion of 4 LRUs per superframe

Appendix C(3/3): Total Control Channel Overhead

- Per Test Environment : InH, UMi, UMa, RMa

	InH	UMi	UMa	RMa
DL	9.19%	12.33%	11.17%	11.15%
UL	7.85%	12.60%	9.23%	8.34%

- Results include Ctrl CH OH Portion