Legacy Support: A Key Design Constraint for 802.16m Frame Structure

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Venue:

IEEE 802.16m-07/047, “Call for Contributions on Project 802.16m System Description Document (SDD)”.
Target topic: “Proposed 802.16m Frame Structure with special attention to legacy support”.

Base Contribution:

None

Purpose:

To be discussed and adopted by TGm for the 802.16m SDD

Notice:

Release:

Patent Policy:

Legacy Support: A Key Design Constraint for 802.16m Frame Structure

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January, 2008

Outline

- Background – Legacy Support in SRD
- Scope and Goals of this Contribution
- Issue: Multiplexing 16m and Legacy Bursts (FDM vs. TDM)
- Recommendation on the Multiplexing
- Rationale for the Recommendation
- Text Proposal for Inclusion in SDD

Background

What does the SRD say about Legacy Support?

Legacy Support According to SRD

① 16m/legacy system shall/should be able to operate on the same RF carrier with same/different BW **(a)**

② 16m BS shall support a mix of legacy and 16m MS's on the same RF carrier **(c & e)**

③ 16m BS shall support legacy MS with the same performance as legacy BS **(b = c)**

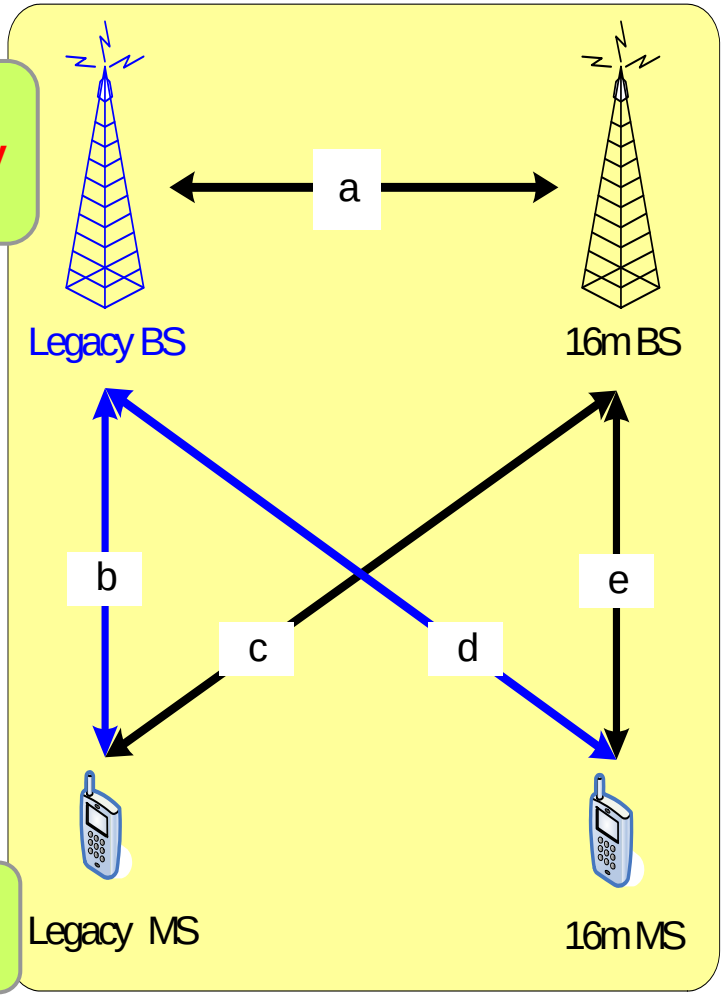
④ 16m BS shall support handover of legacy MS to/from legacy BS **(b ⇔ c)**

⑤ 16m MS shall be able to operate with legacy BS with the same performance as legacy MS **(b = d)**

16m/ Legacy Mixed

⑥ 16m shall provide the ability to disable legacy support **(e only)**

16m only



The SRD Legacy Support Clause and Its Implications

- Excerpt form the 802.16m SRD:

  "An IEEE 802.16m BS shall be able to support a legacy MS while also supporting IEEE 802.16m MSs on the same RF carrier, at a level of performance equivalent to that a legacy BS provides to a legacy MS"

➢ This means ….

  - Sacrificing performance of a legacy MS is NOT an option

- In particular…

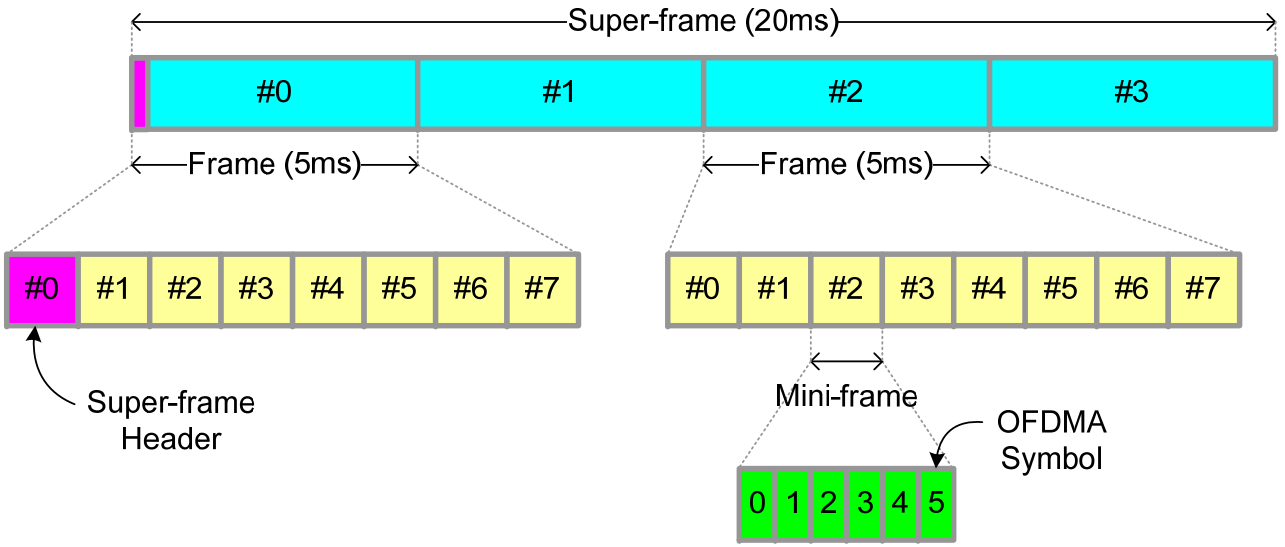
  - *Reduced cell coverage for legacy MS* due to operation of new 16m MS should be avoided to meet the SRD requirements.

About This Document

Scope and Goals

Scope

- A Generic, high level frame structure has been proposed for 802.16m (*See input contribution IEEE C802.16m-08/062*).
- The generic frame structure can be abstracted as illustrated below:



- Legacy support issues, in this document, are discussed within the bounds of the aforementioned frame structure.

Goals

- To illustrate how
  - Multiplexing 16m and legacy bursts with the same frame can be accomplished using the generic frame structure, and
  - We can achieve transparency in 16m BS/MS operation regardless of the presence of legacy MS using the generic frame structure,

  without violating the SRD.
- Provide text for inclusion in SDD

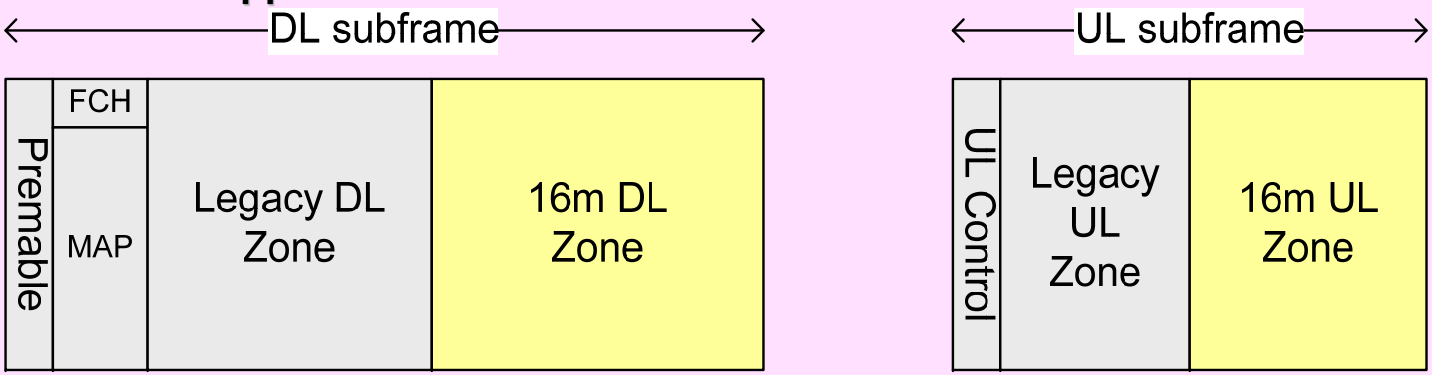
Multiplexing 16m and Legacy Bursts in the Same Frame

The Multiplexing Issue

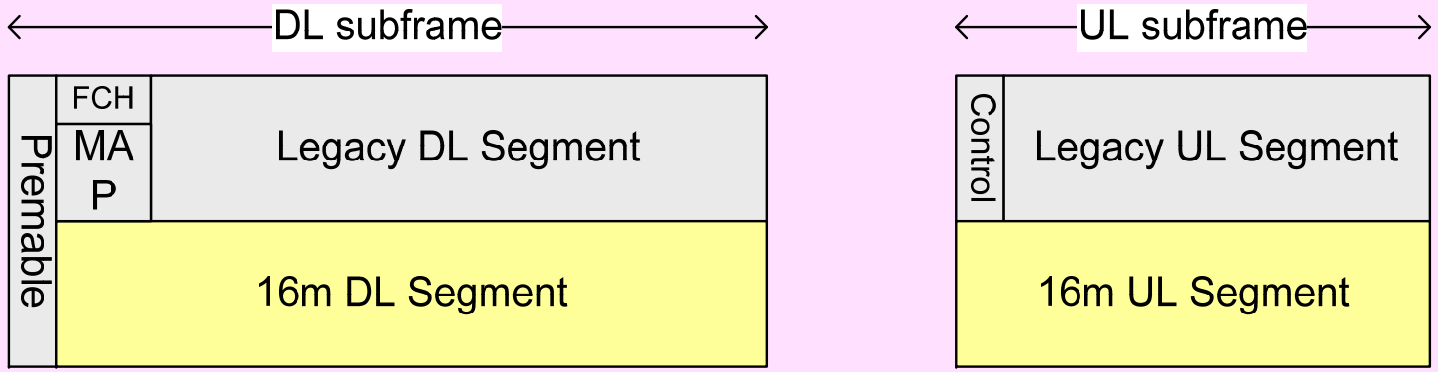
- How to split PHY resources between legacy and 16m MS's?

Multiplexing Approaches

Time Division Approach

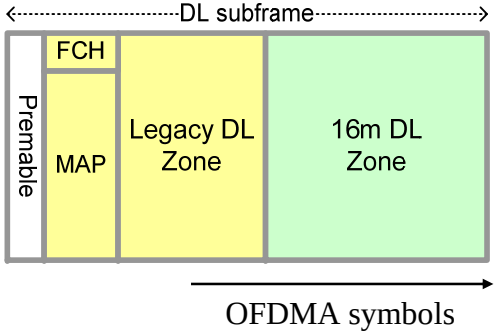


Frequency Division Approach

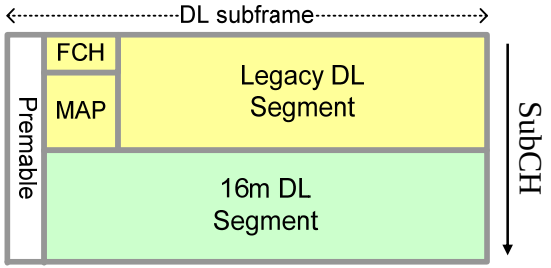


DL Multiplexing Approaches

- Approach 1: Time Division
  - Divide DL subframe by Time Zone



- Approach 2: Frequency Division
  - Divide DL subframe by 16e PUSC SubCH group (i.e. *'used subchannel bitmap' in FCH*)

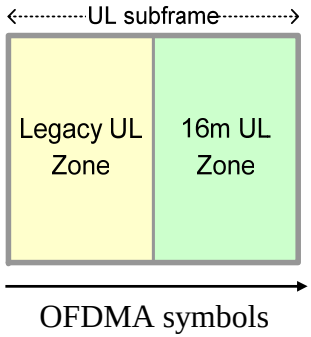


- Recommendation: Use Time Division in the downlink
  - Provides more degrees of freedom in developing 16m specific techniques

UL Multiplexing Approaches

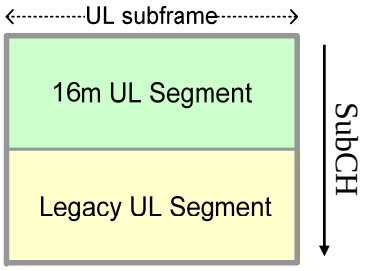
- Approach 1: Time Division
  - Divide UL subframe by Time Zone
  - More degrees of freedom in 16m design
  - Issue: Impacts 16e performance!
    - The shorter UL Tx period, The lower Tx power density
      → Decrease 16e cell coverage and system capacity

      (See analysis results in the following slides)



- Approach 2: Frequency Division
  - Divide UL subframe by 16e PUSC SubCH group (e.g. *'UL allocated subchannels bitmap' in UCD*)
  - 16e performance remains unaltered.

    (See analysis results in the following slides)

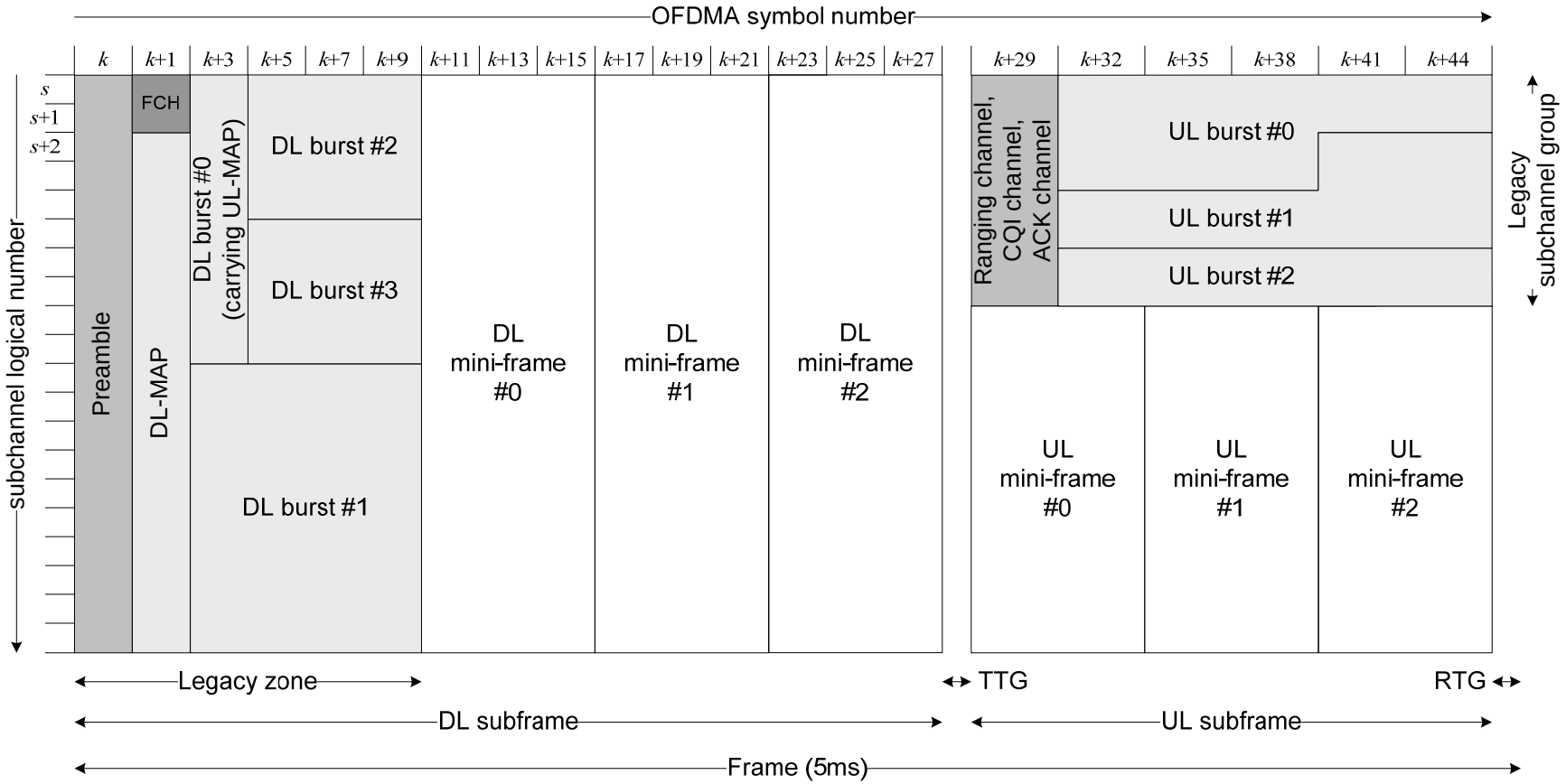


- Recommendation: Use Frequency Division in the uplink.

Recommendation

Downlink: TDM

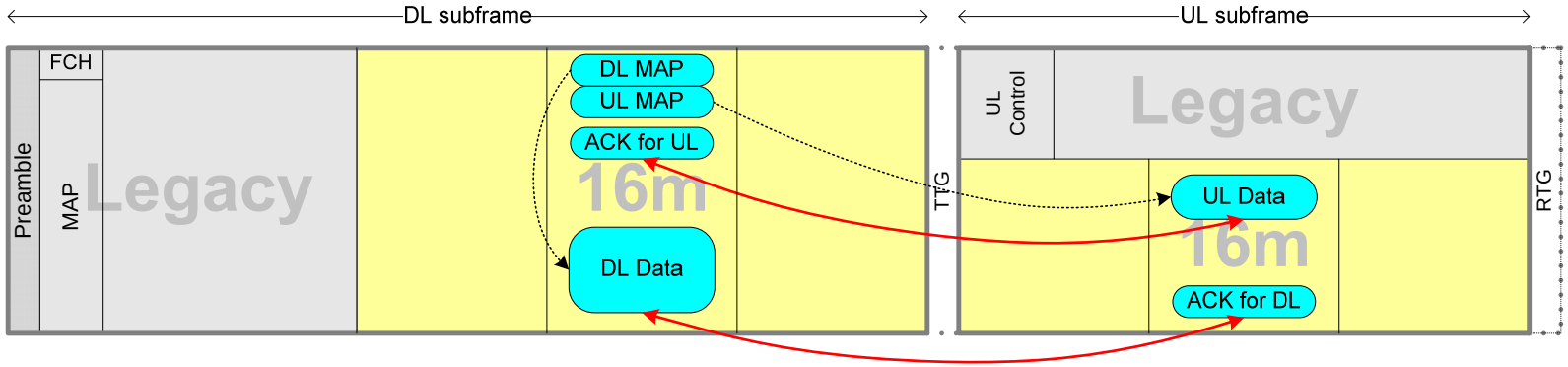
Uplink: FDM



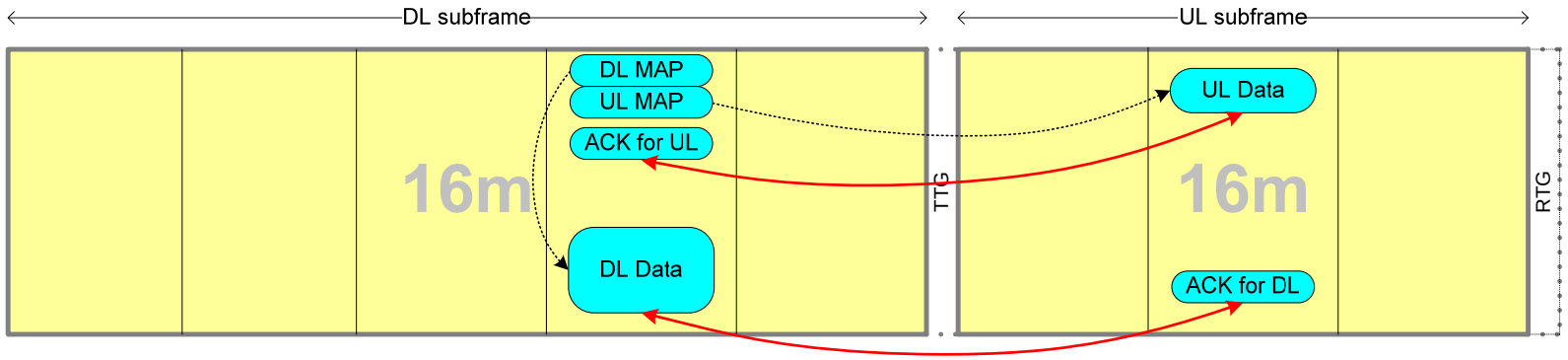
16m Operation Transparency in 16m only and Legacy Support Mode

DL/UL HARQ Operation

- Basic operation of DL/UL HARQ remains unchanged regardless of presence of legacy zone
  - Mixed 16m/Legacy mode



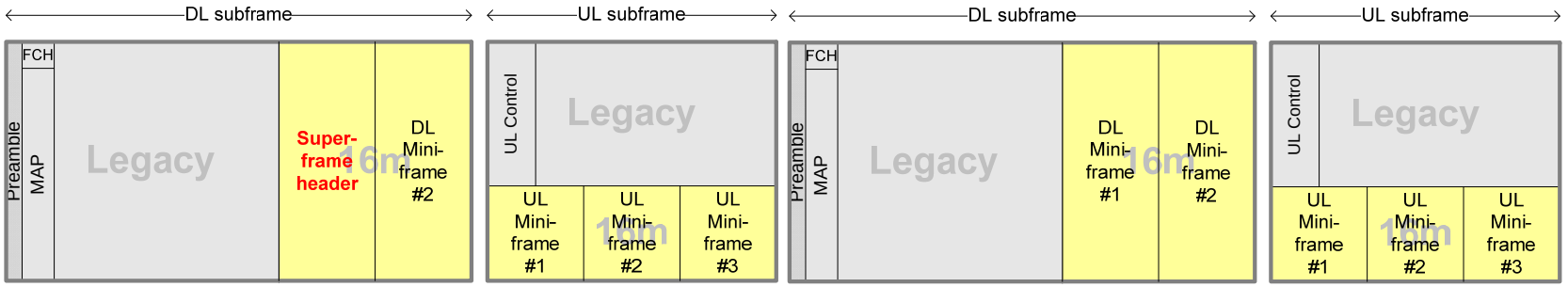
  - 16m only mode



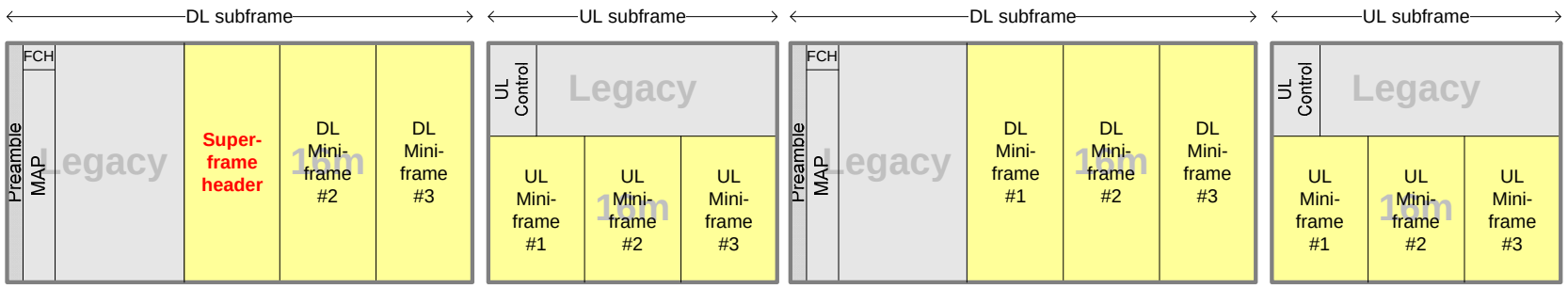
Super-frame Operation

- Super-frame structure is retained in the 16m only mode and 16m/legacy mode

16m:Legacy = 2:3

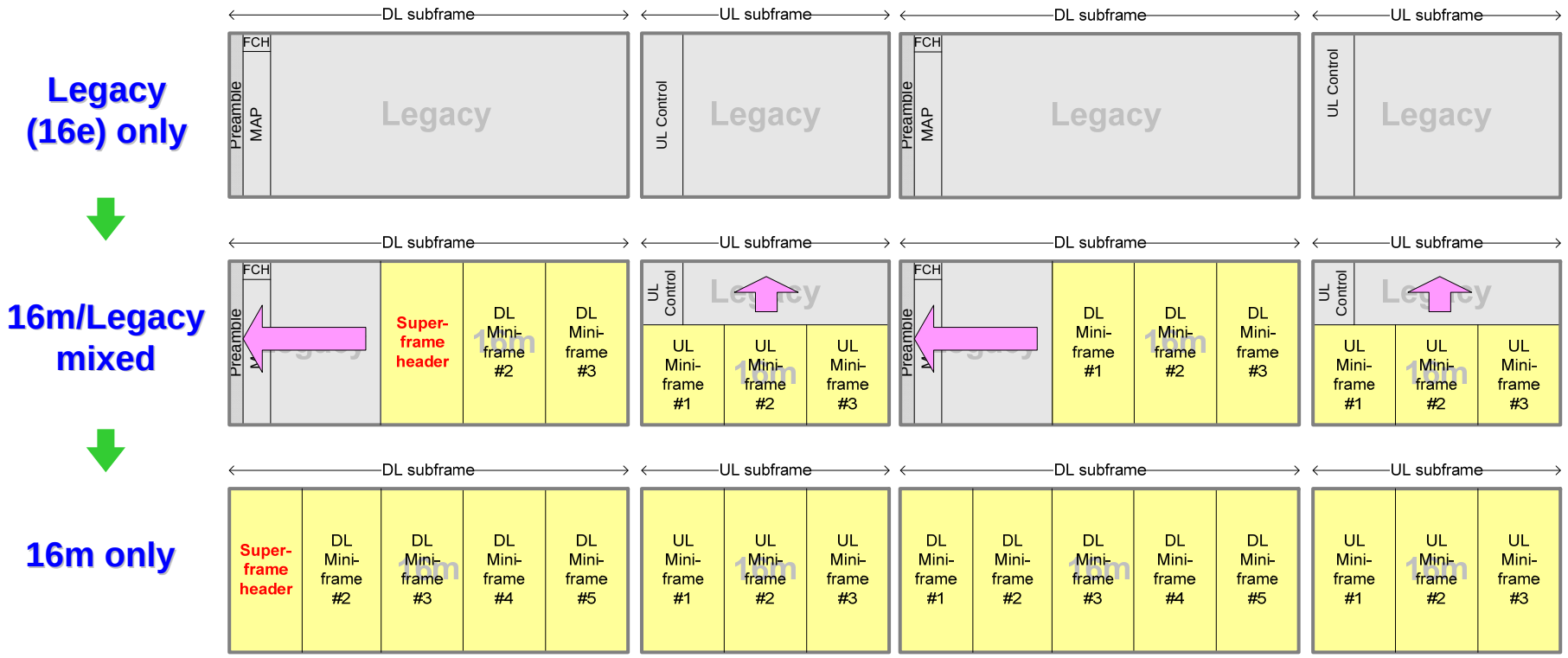


16m:Legacy = 3:2



Legacy Turn-off Supported

- Disable legacy support functions ⇒ 16m only operation mode
  - Turn off transmission of 16e preamble, FCH, and MAP
  - Move the super-frame header and DL mini-frames at the front of frame
  - Extend 16m UL mini-frames on subchannel domain



Rationale for Our Recommendation

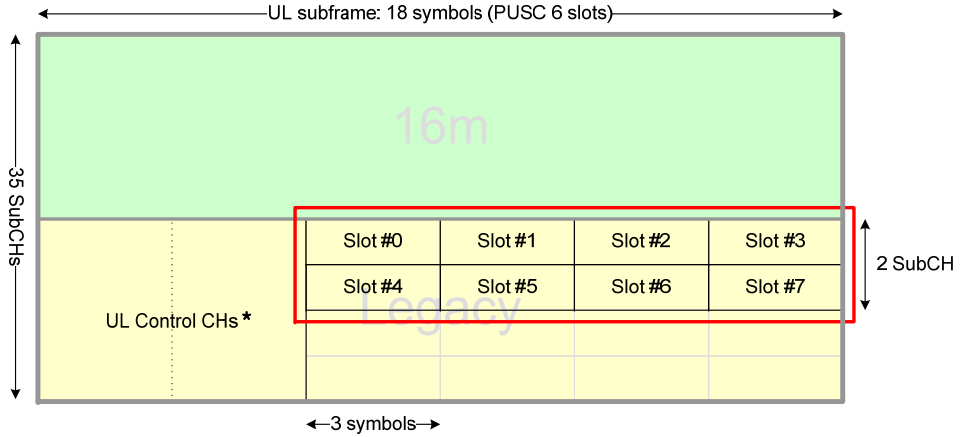
1. **Uncompromised Legacy Performance**
2. **Higher Granularity for 16m:Legacy**

UL Power Density of FDM vs. TDM

Key Issue

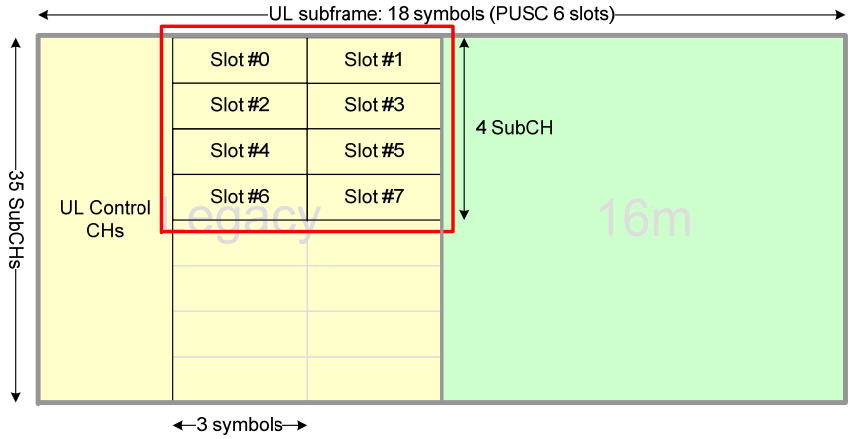
- Spread MS TX power over twice the number of sub-carriers in TDM
- Expected to impact on coverage and throughput
- Example of critical services
  - VoIP Packet Size (44~46 bytes);
    - AMR with Header Compression (in Table 36, EVM [IEEE 802.16m-07/037r2])
    - Required SubCHs in FDM
      - 8 slots (QPSK ½) (46 bytes / 6 bytes per slots ~= 7.67 slots)
      - 2 SubCHs
    - Required SubCHs in TDM
      - 8 slots (QPSK ½)
      - 4 SubCHs
  - MOB_MSHO-REQ msg. (41~55 bytes)

FDM



*** 6 OFDMA symbols length for UL control CH is just for fair comparison with TDM. Considering the reduced legacy loading, 3 OFDMA symbols length (same as 16e) may be enough.**

TDM



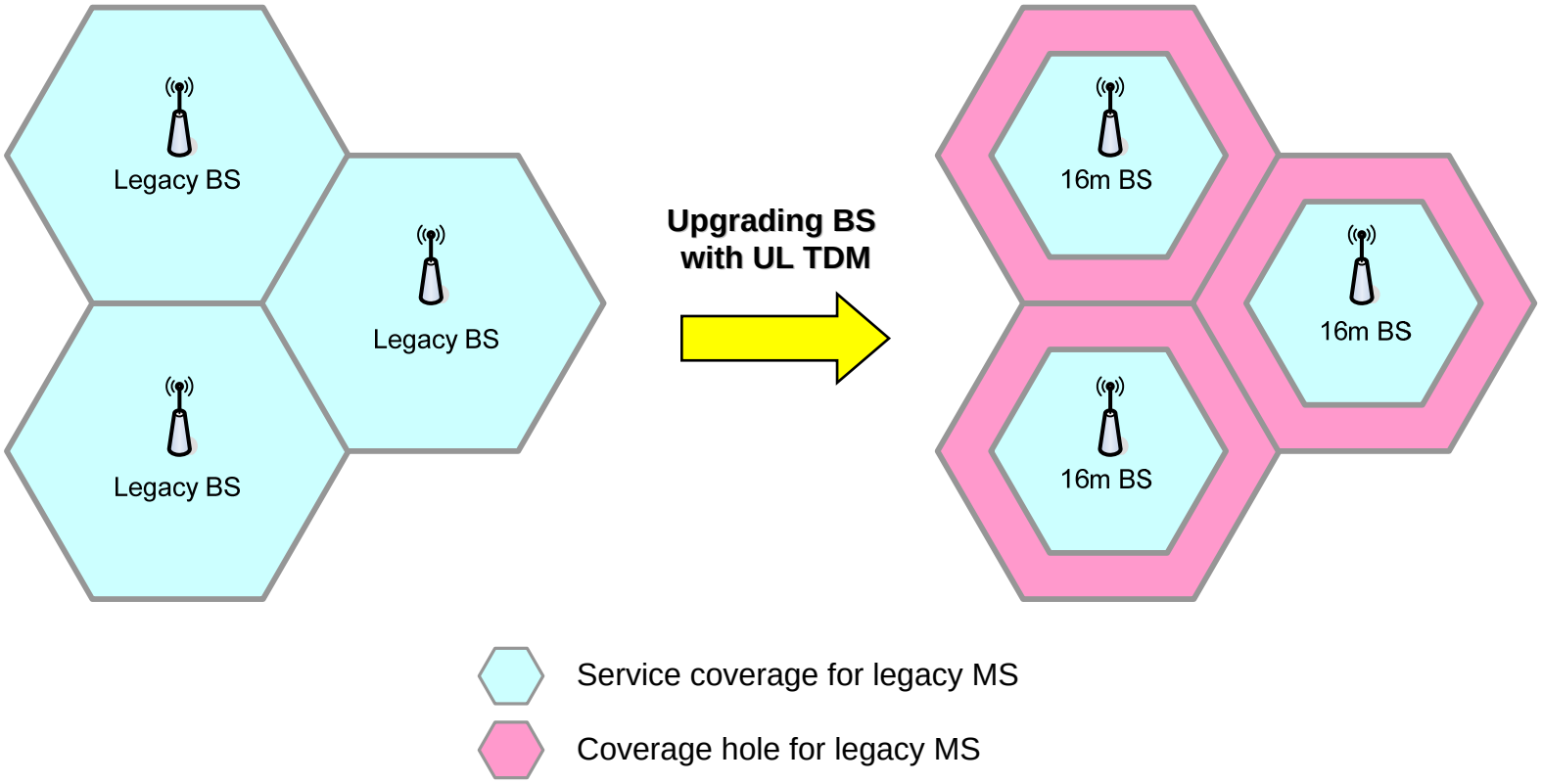
Legacy UL Coverage Analysis

Parameter	unit	FDM		TDM		Equation
		Value	Note	Value	Note	
MS Tx Power	mW	200.0		200.0		
	dBm	23.0		23.0		A
MS Cable Loss	dB	0.0		0.0		B
Body Loss	dB	0.0		0.0		C
MS Tx Antenna Gain	dBi	0.0		0.0		D
TX EIRP	dBm	23.0		23.0		E = A-B-C+D
BS RX Antenna Gain	dBi	17.0		17.0		F
BS Cable Loss	dB	2.0		2.0		G
BS Noise Figure	dB	5.0		5.0		H
Thermal Noise Density	dBm/Hz	-174.0		-174.0		I
Interference Density	dBm/Hz	-1000.0		-1000.0		J
Total Noise Interference Density	dBm/Hz	-169.0		-169.0		K=10 log(10^(H+I)/10 + 10^J/10)
Used Bandwidth	kHz	525.0	2 SubCH	1,050.0	4 SubCH	
	Hz-dB	57.2		60.2		L
Required SNR	dB	3.0	10% PER, PED-B	3.0	10% PER, PED-B	M
BS receiver sensitivity	dBm	-108.8		-105.8		N = M + K + L
Log-normal Fade Margin	dB	8.0		8.0		O
Penetration Loss	dB	10.0		10.0		P
Maximum Path Loss	dB	128.8		125.8		Q = E-N+F-G-O-P
Coverage						
- Maximum Range	m	895	EVM Baseline	744	EVM Baseline	R = (10^((Q-130.62)/37.6))*1000
- Coverage Efficiency	km2/site	0.801		0.554		S = (R/1000)^2

Legacy UL Cell coverage: 31% reduction !

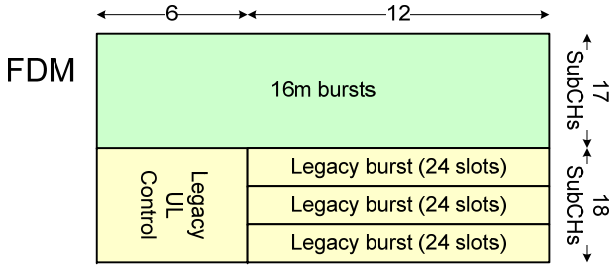
Impact on System Upgrade to 16m

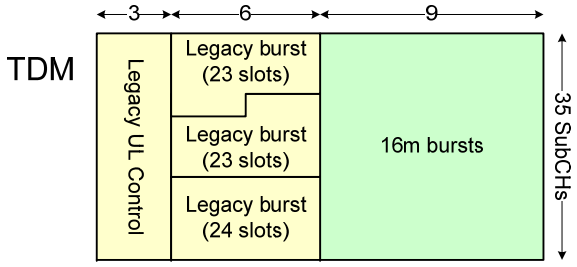
- System upgrading to 16m with UL TDM
  - ⇒ Generate coverage holes for legacy MS
  - ⇒ Need cell re-planning with additional sites



Legacy UL Throughput Analysis (1/2)

- 16m/legacy UL mixed model



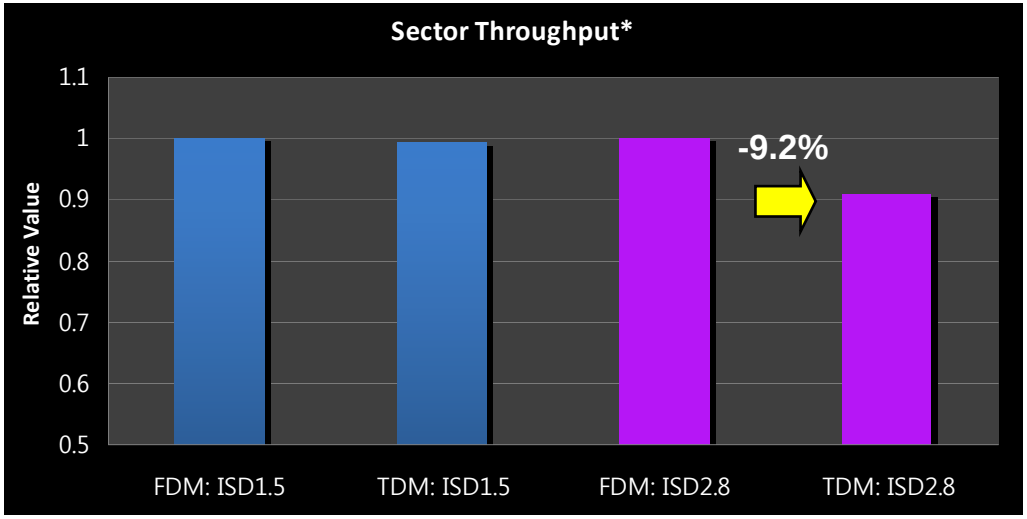


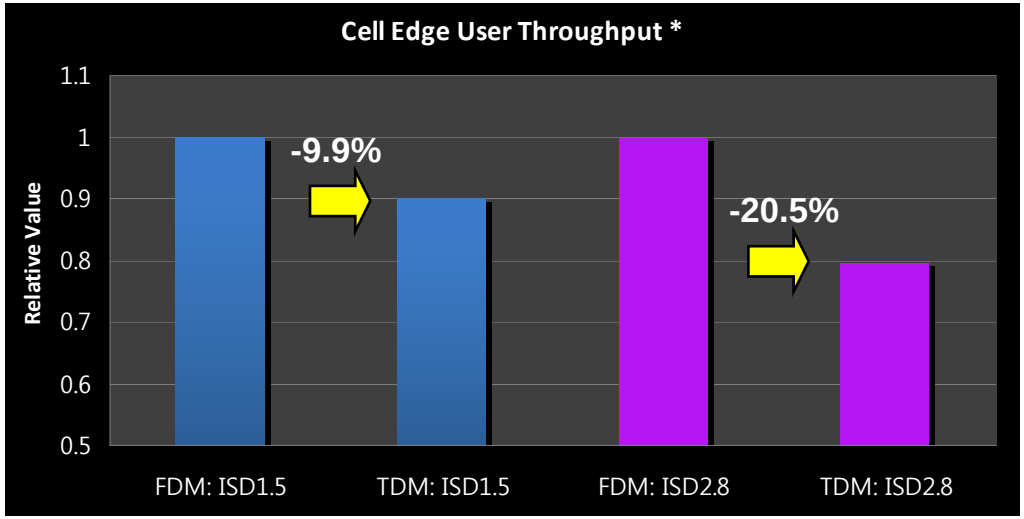
- Parameters and assumptions **(follow 16m EVM)**

Simulation assumptions	Descriptions
Frequency reuse	1
SubCH/Duplexing	PUSC/ TDD (29:18)
Ant/ Receiver structure	SIMO (1X2) / MMSE
Data channel coding	CTC
Scheduling	*RR for full buffer, 10 active users (16e-50%, 16m-50%), 6 partitions*
Coexistence mode	*TDM : 16e-35 Subch X 9 symbols, 16m-35 Subch X 9 symbols*
	FDM: 16e-18 Subch X18 symbols, 16m-17 SubchX18 symbols
Link adaptation	Dynamic (same as baseline)
HARQ	CC, MAX ReTX=4, ReTX latency=3 frame
Power control	OLPC
Interference model	Frequency selective model

Test scenario	Configuration
Site-to-site distance	1.5km, *2.8km*
Carrier frequency	2.5GHz
BS height	32m
MS Tx power	23dBm
MS height	1.5m
Penetration loss	10dB
Antenna Gain	BS: 17dBi, MS: 0dBi
Pathloss model	Loss(dB)=130.62+37.6log(R)
Lognormal shadowing STD	8dB
Channel mix	ITU Ped B 3km/hr – 60% ITU Veh A 30km/hr – 30% ITU Veh A 120km/hr – 10%
Spatial channel model	Uncorrelated

Legacy UL Throughput Analysis (2/2)





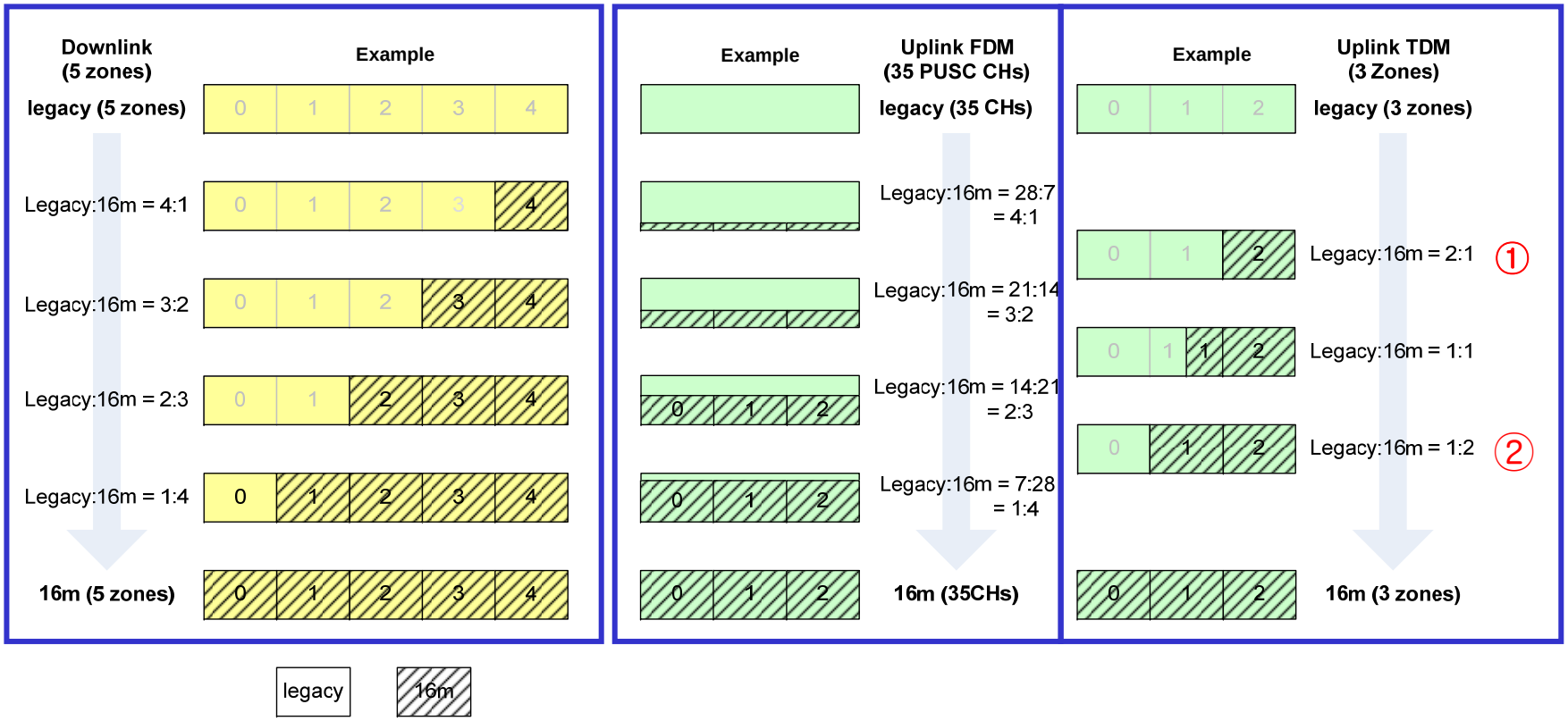
- Confirm a performance degradation with UL TDM
  - ~ 9.2% Sector throughput loss
  - 9.9 ~ 20.5% Cell edge user throughput loss
- Bigger impact on …
  - VoIP outage/capacity
  - Handover performance/latency
  - Freq Reuse = 3

*** Normalized by number of slots**

16m/Legacy Ratio Granularity

- FDM: Provide same 16m/Legacy ratio granularity for UL and DL.
- TDM: Poor granularity for 16m/Legacy resource divisions

  In addition, too short Tx duration for 16m in case ①, for legacy in case ②.



Conclusions

	Legacy MS Coverage	Legacy MS Capacity	16m/Legacy Ratio Granularity
FDM	No impact	No impact	Good (Symmetry DL/UL)
TDM	31% Cell Coverage loss	9.9% Sector T-put loss, 20.5% Edge T-put loss (ISD = 2.8km)	Poor

- Recommendation: FDM for 16m/legacy UL data burst multiplexing

Text Proposal for Inclusion in SDD

Proposed Text

Insert the following text into Physical Layer Clause (i.e. Chapter 11 in IEEE C802.16m-07/320r1):

---------- Text Start ----------

11.1. Framing Structure

11.1.X Legacy support

In the TDD mode, the generic frame structure shall be configured as follows to support the legacy MSs:

A subset of DL mini-frames is dedicated to the legacy operation to enable one ore more DL legacy time zones. The subset includes the 1st DL mini-frame to support the transmission of the legacy preamble, FCH, and MAP.

In UL subframe, a group of subcarriers (subchannels), spanning the entire UL subframe, are dedicated to the legacy operation. The remaining subcarriers, forming the new UL subframe, are dedicated to the new operation. In the new UL subframe, mini-frames are defined and all the mini-frames are used for the new operation.

Figure yy shows an example of frame configuration for the legacy support.

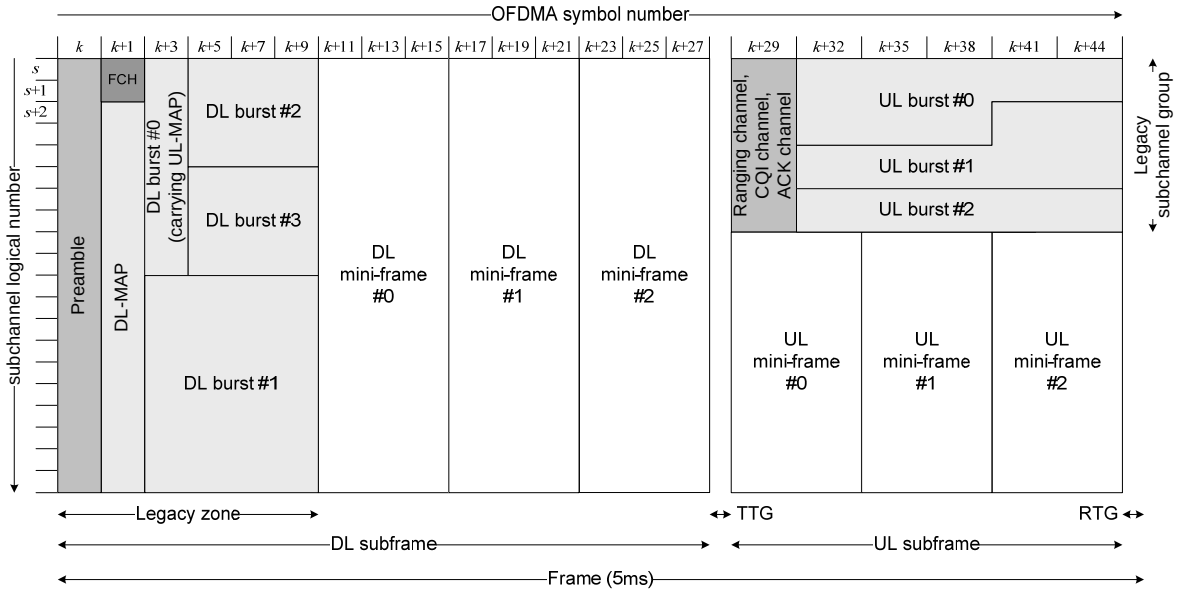


Figure yy Example of frame configuration for legacy support

---------- Text End ----------

Additional Thoughts on Expected Issues with FDM

Expected Issues with FDM

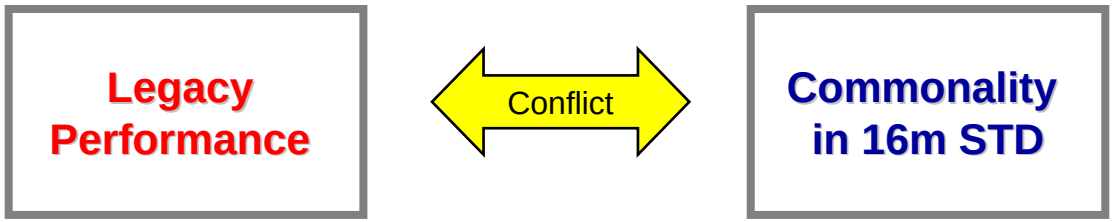
1. Constraint on 16m UL subchannelization

   ⇒ Suggest to have two kinds of 16m UL subchannelization;

   ① One for legacy support operation: Low pilot density,
   Compatible with UL PUSC 4x3 tile

   ② The other for 16m only operation: New design

2. The two 16m UL subchannelization



   ⇒ Suggest to keep the legacy performance (with the FDM) even with inconsistent UL subchannelizations between the two 16m modes