Inter-Cell Interference Management in DL/UL Control

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Venue:

IEEE 802.16m-08/016r1: Call for Contributions on Project 802.16m System Description Document (SDD).
Target topic: “Uplink Control Structures”.

Base Contribution:

C802.16m-08/443r3

Purpose:

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

Notice:

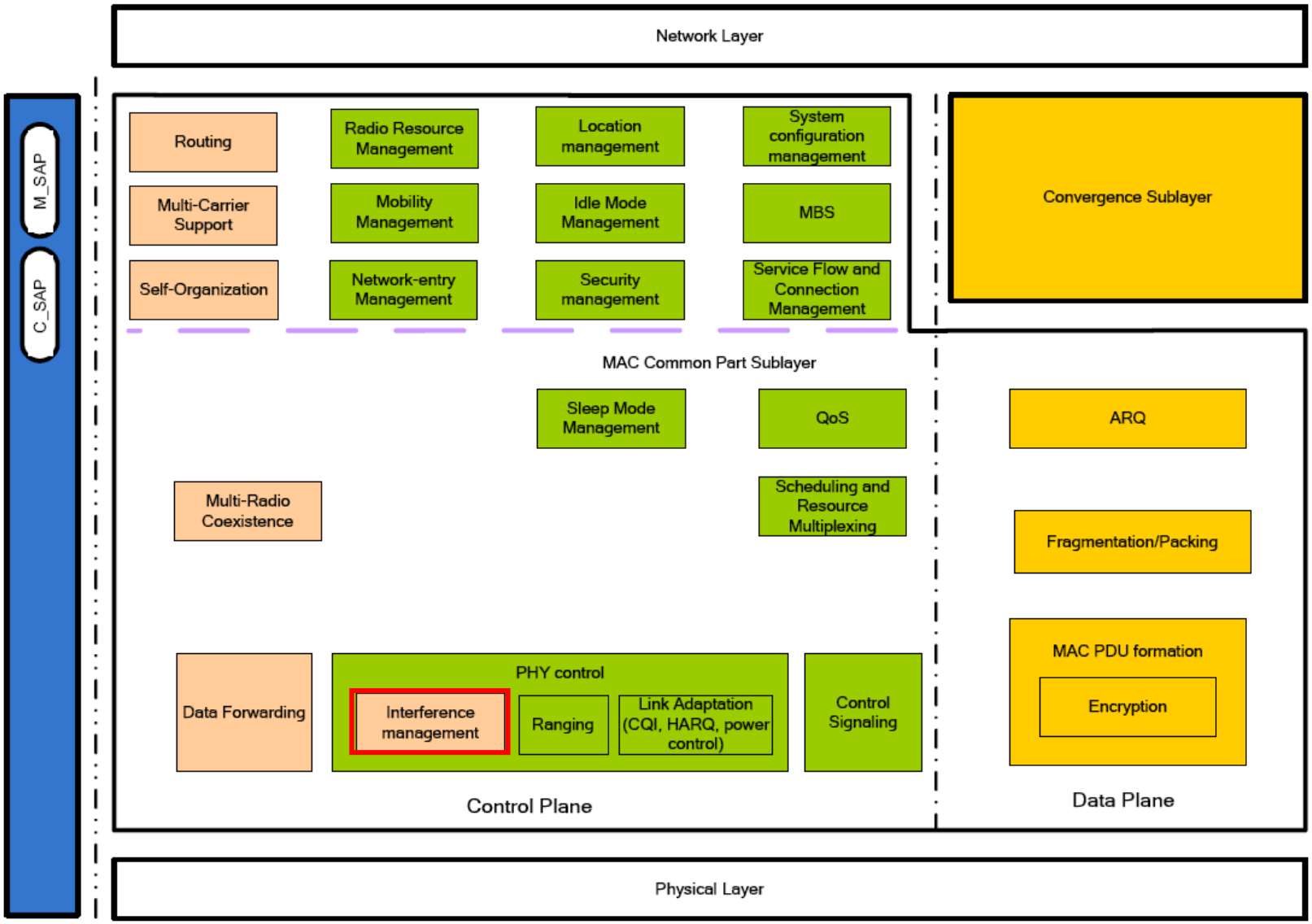
Release:

Patent Policy:

Introduction

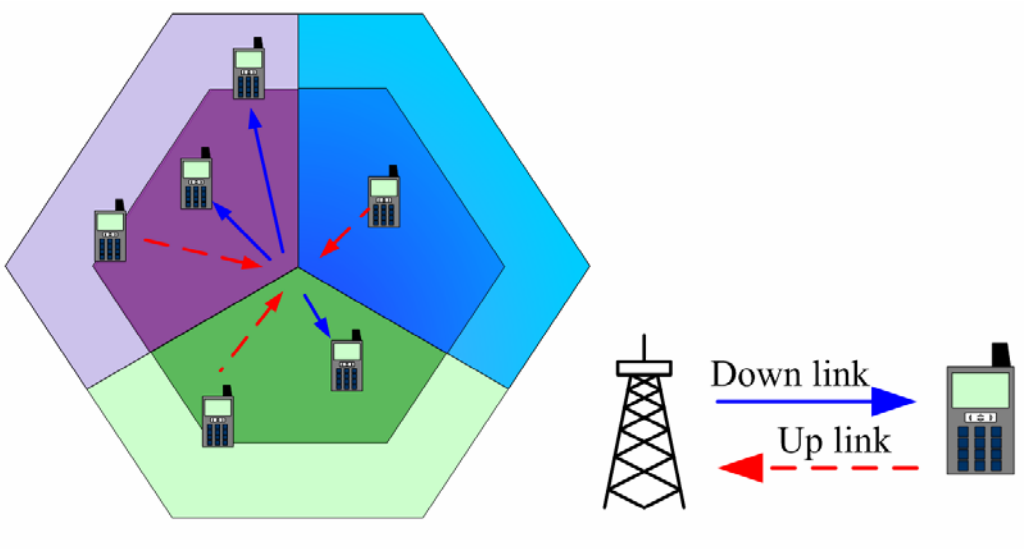
- Purpose
  - Propose several pilot formats for **Interference Management** to reduce interference at **Cell edge** or **Co-channel** between BS and BS, BS and MS or MS and MS.
- Scope
  - DL and UL control channel design for Interference Management
    - Cell edge zone
      - Interference reducing pilot
    - Cell central Zone
      - Common Pilot
  - Interference Management on TDD and FDD frame structure
    - Sub-Frame base design
  - Interference Management on different frequency reuse factor

The IEEE 802.16m Protocol Structure

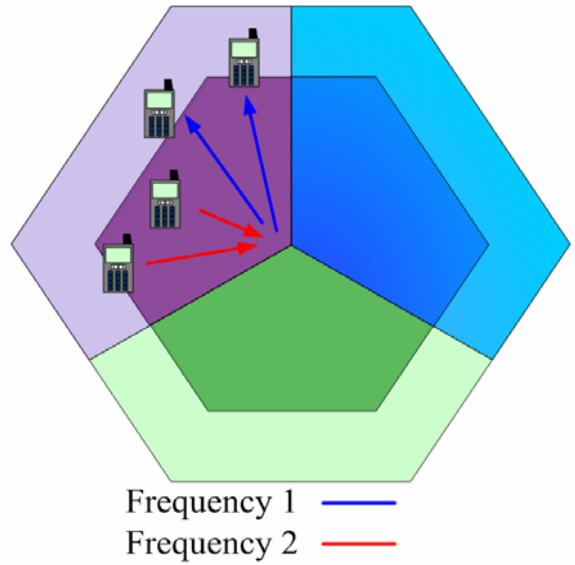


Interference Type: Data Transition

Data Transition Interference in TDD

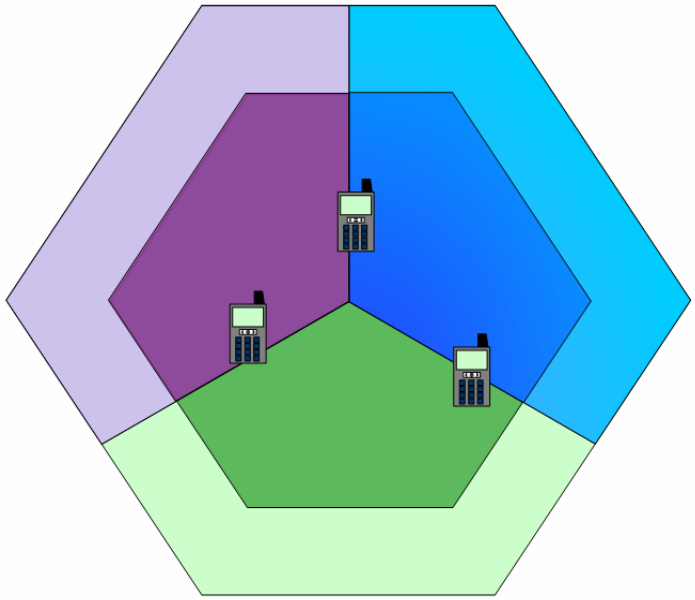


Data Transition Interference in FDD

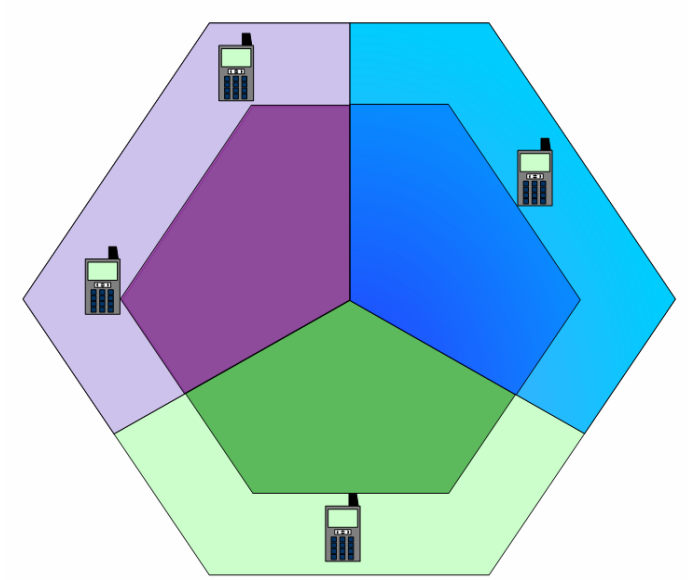


Interference Type: Sector and Cell Edge

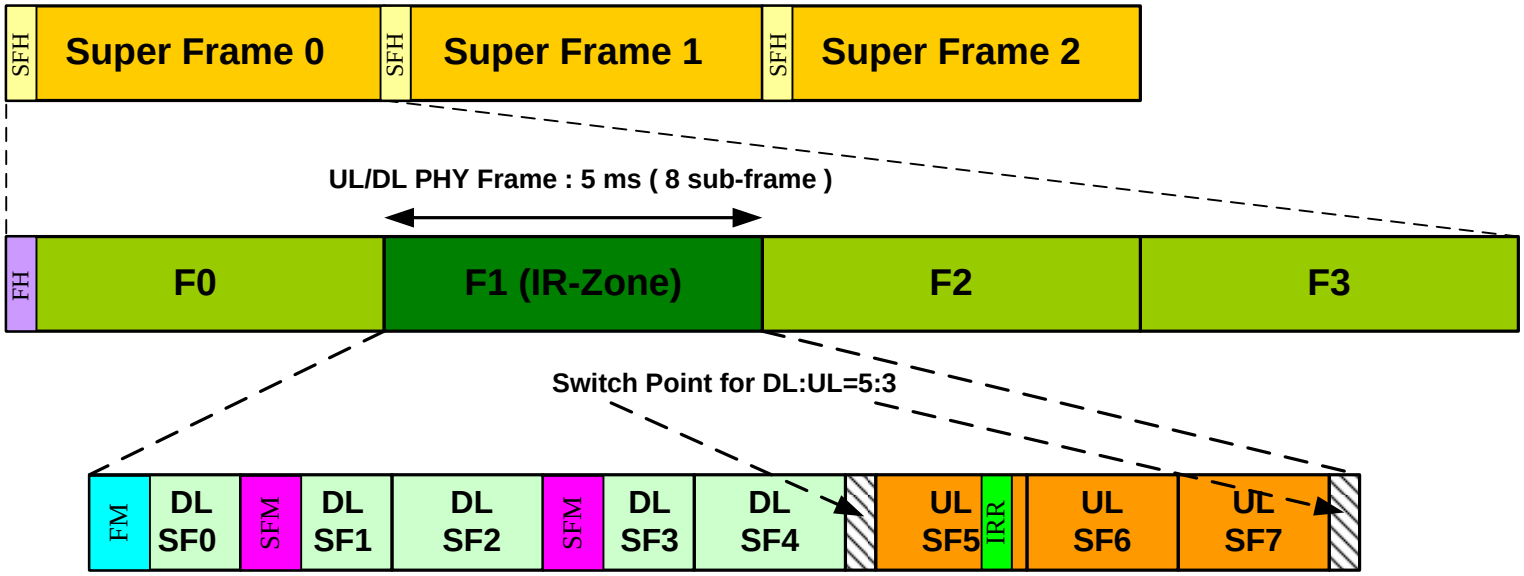
Location-oriented interference:
MS at the sector boundary



Location-oriented interference:
MS in the cell edge zone

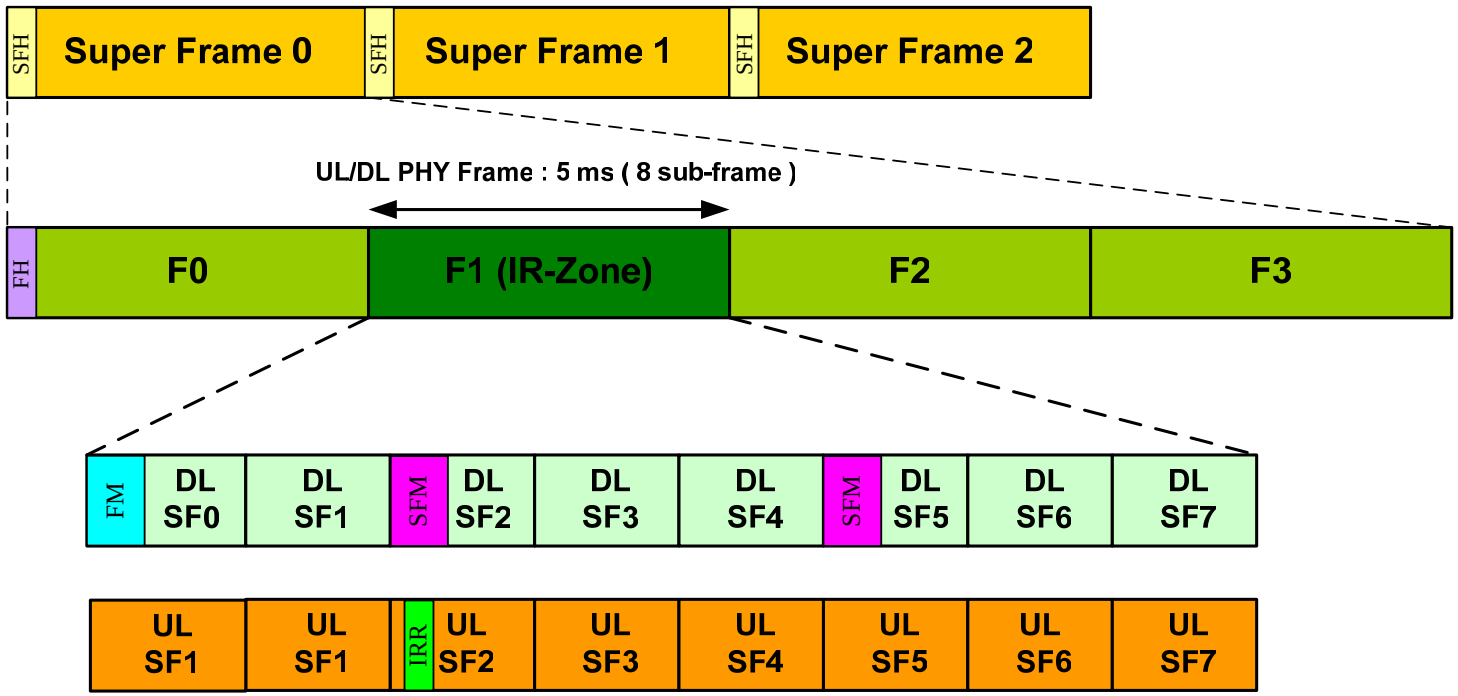


Frame Control Channel Structure for 16m (1/3)



Control channel structure for TDD

Frame Control Channel Structure for 16m (2/3)

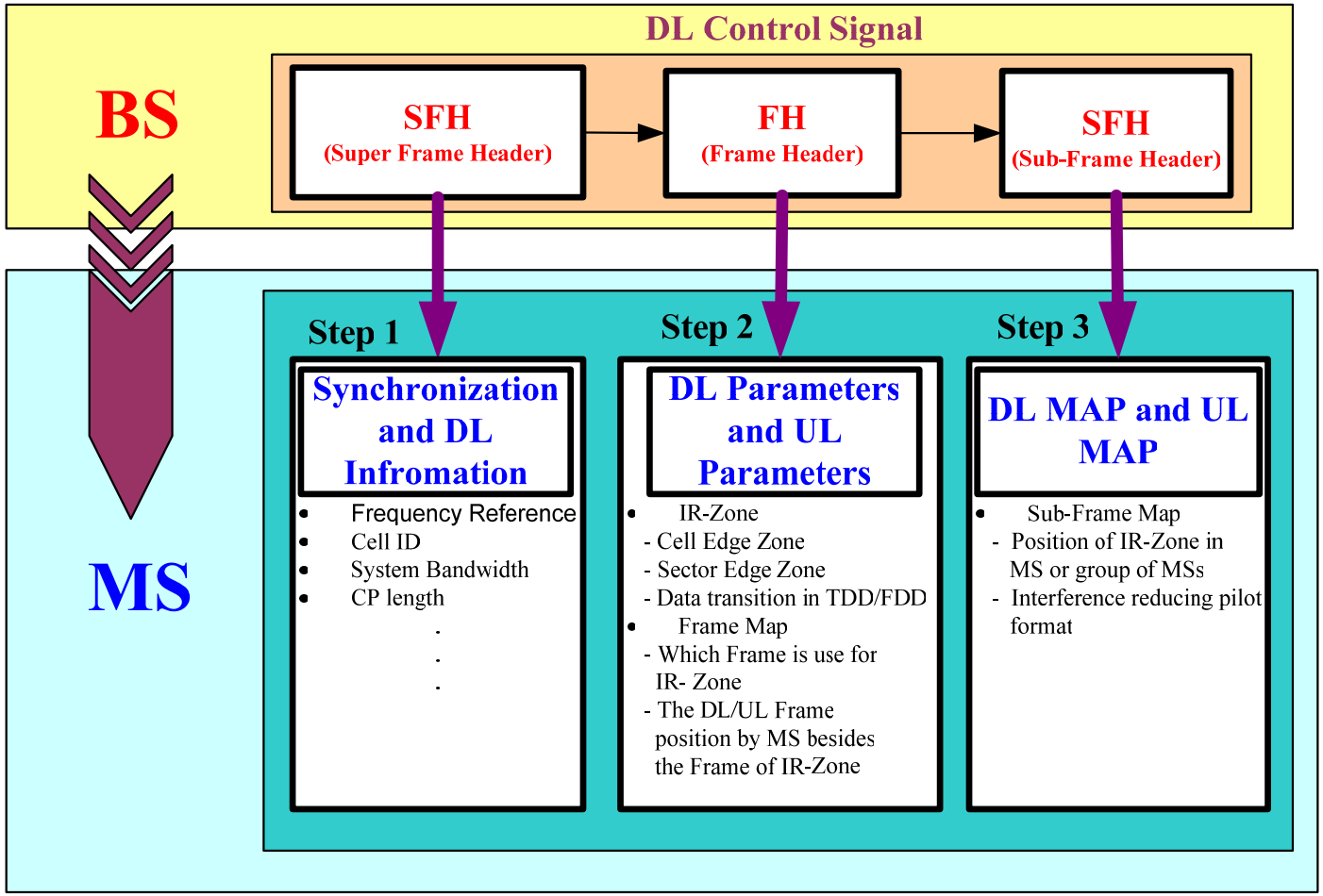


Control channel structure for FDD

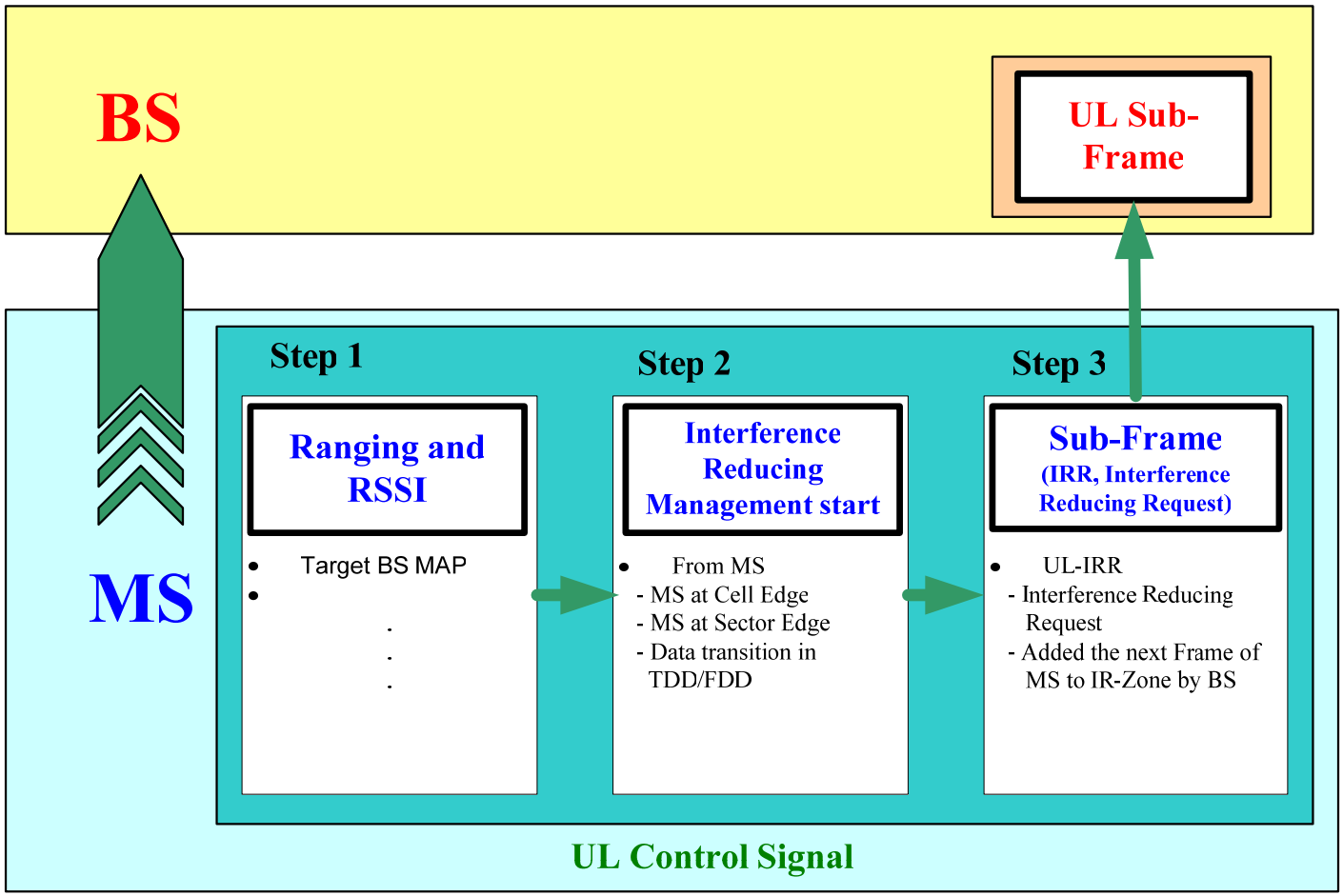
Frame Control Channel Structure for 16m (3/3)

- **Five types of control channels**
  - **SFH (Super Frame Header)**:
    - The SFH is used for the transmission of the information such as the synchronization, frequency reference, cell ID etc.
  - **FH (Frame Header)**:
    - The FH will identify which frame should activate an IR-Zone, and when this IR-Zone is activated the MS in this zone will receive the interference reducing service.
  - **FM (Frame Map)**:
    - This FM is used to designate MSs locations in the sub-frame for those MSs are not in the interference-reducing zone (IR-Zone).
  - **SFM (Sub-frame Map)**:
    - The SFM is used to designate which MSs in this zone need the interference reducing service. The MS designated can be a group of MSs or a single MS. It gives MS the information of the zone location, the orthogonal pilot pattern and it also will provide the relative location information of the UL- zone.
  - **IR-Zone (Interference Reducing Zone)**:
    - This zone is activated by the BS and it can be divided into UL and DL IR-zones. The zone's size and location are designated by the FH and the SFM and it also serves those MSs that need interference reducing services.
  - **UL-IRR (Uplink–interference Reducing Request)**:
    - The MS will send the instant interference reducing request in this frame and the BS will include this MS which sends this request in the IR-Zone in the next frame.

Cell Management Information in the DL control Channel

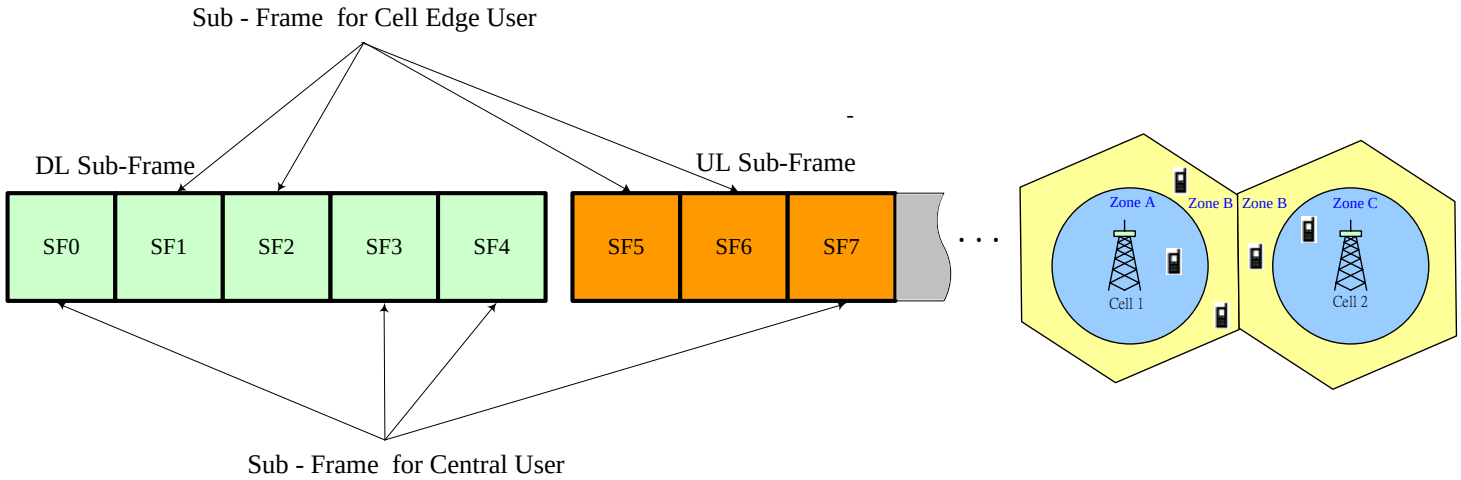


Cell Management Information in the UL control Channel

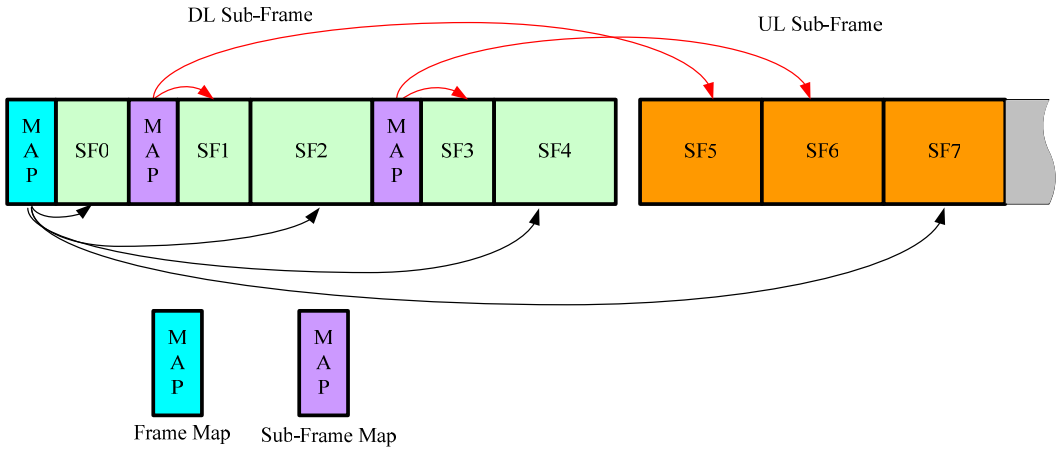


Interference Reducing for Sub-Frame

- Different sub-frames are allocated for users with different levels of interferences

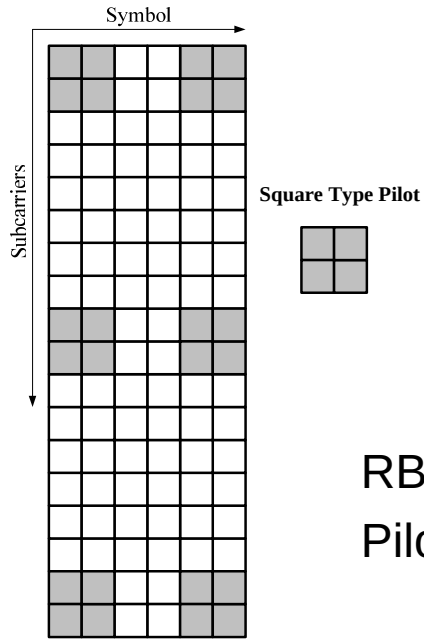


- MAP Define for Cell Edge User and Central User



Interference Reducing Pilot Type

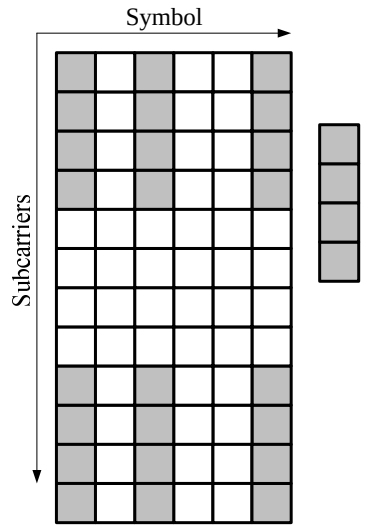
- Square Type Pilot



RB: 18X6

Pilot Density: 11.11%

- Line Type Pilot

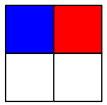


RB: 12X6

Pilot Density: 16.67%

Interference weight assignment for Square type pilot pattern (1/2)

BS Pilot Pattern



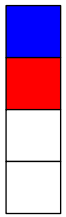
Type	Interference weight	Type	Interference weight
1	1	7	0.2
2	0.6	8	0.6
3	0.5	9	0
4	0.8	10	0.5
5	0.4	11	0.4
6	0.5	12	0.5

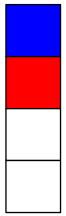
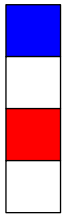
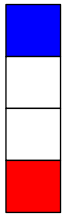
Interference weight assignment for Square type pilot pattern (2/2)

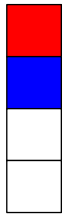
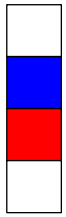
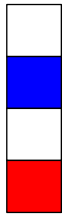
IR Pilot_MT / Pilot_BS	1	2	3	4	5	6	7	8	9	10	11	12
1	1	0.6	0.5	0.8	0.4	0.5	0.2	0.6	0	0.5	0.4	0.5
2	0.6	1	0.5	0.4	0.8	0.5	0.6	0.2	0.4	0.5	0	0.5
3	0.5	0.5	1	0.5	0.5	1	0.5	0.5	0.5	0	0.5	0
4	0.8	0.4	0.5	1	0.6	0.5	0	0.4	0.2	0.5	0.6	0.5
5	0.4	0.8	0.5	0.6	1	0.5	0.4	0	0.6	0.5	0.2	0.5
6	0.5	0.5	1	0.5	0.5	1	0.5	0.5	0.5	0	0.5	0
7	0.2	0.6	0.5	0	0.4	0.5	1	0.6	0	0.5	0.4	0.5
8	0.6	0.2	0.5	0.4	0	0.5	0.6	1	0.4	0.5	0.8	0.5
9	0	0.4	0.5	0.2	0.6	0.5	0	0.4	1	0.5	0.6	0.5
10	0.5	0.5	0	0.5	0.5	0	0.5	0.5	0.5	1	0.5	0.8
11	0.4	0	0.5	0.6	0.2	0.5	0.4	0.8	0.6	0.5	1	0.5
12	0.5	0.5	0	0.5	0.5	0	0.5	0.5	0.5	0.8	0.5	1

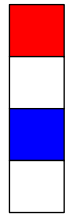
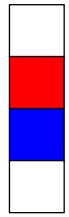
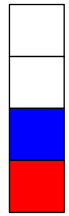
Interference weight assignment for Line type pilot pattern (1/2)

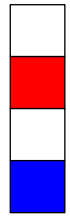
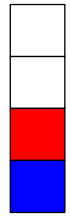
BS Pilot Pattern



Type	Interference weight
1 	1
2 	0.6
3 	0.5

Type	Interference weight
4 	1
5 	0.6
6 	0.5

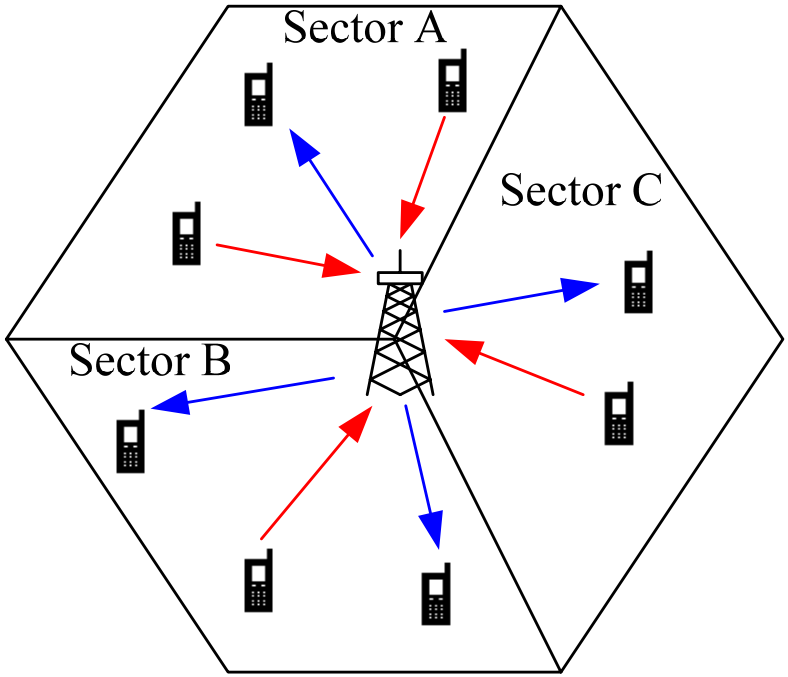
Type	Interference weight
7 	0.5
8 	0.5
9 	0

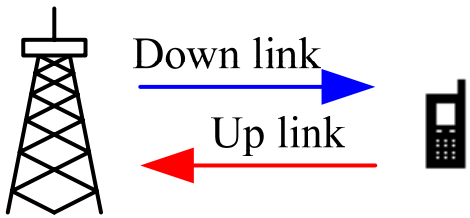
Type	Interference weight
10 	0.5
11 	0.5
12 	0.1

Interference weight assignment for Line type pilot pattern (2/2)

IR Pilot_MT / Pilot_BS	1	2	3	4	5	6	7	8	9	10	11	12
1	1	0.6	0.5	1	0.6	0.5	0.5	0.5	0	0.5	0.5	0.1
2	0.6	1	0.6	0.5	0.6	0.2	0.8	0.5	0.5	0.4	0.1	0.5
3	0.5	0.6	1	0.5	0.2	0.6	0.4	0	0.5	0.8	0.4	0.5
4	1	0.5	0.5	1	0.5	0.5	0.6	0.6	0.1	0.5	0.5	0
5	0.6	0.6	0.2	0.5	1	0.6	0.5	1	0.6	0	0.5	0.5
6	0.5	0.2	0.6	0.5	0.6	1	0.1	0.5	0.6	0.4	0.8	0.5
7	0.5	0.8	0.4	0.6	0.5	0.1	1	0.6	0.5	0.6	0.2	0.5
8	0.5	0.5	0	0.6	1	0.5	0.6	1	0.5	0.2	0.6	0.6
9	0	0.5	0.5	0.1	0.6	0.6	0.5	0.5	1	0.5	0.5	1
10	0.5	0.4	0.8	0.5	0	0.4	0.6	0.2	0.5	1	0.6	0.5
11	0.5	0.1	0.4	0.5	0.5	0.8	0.2	0.6	0.5	0.6	1	0.6
12	0.1	0.5	0.5	0	0.5	0.5	0.5	0.6	1	0.5	0.6	1

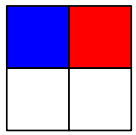
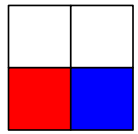
Pilot assignments in TDD segments

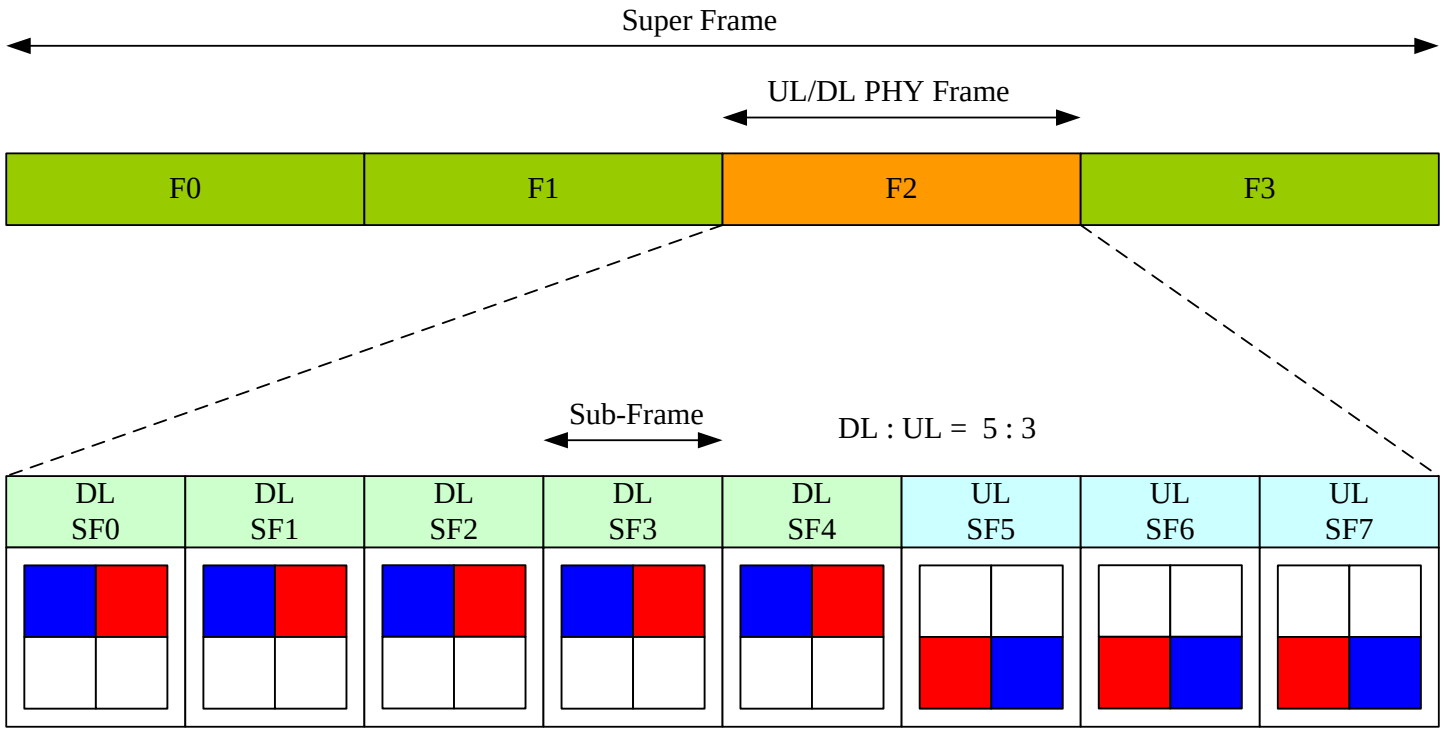




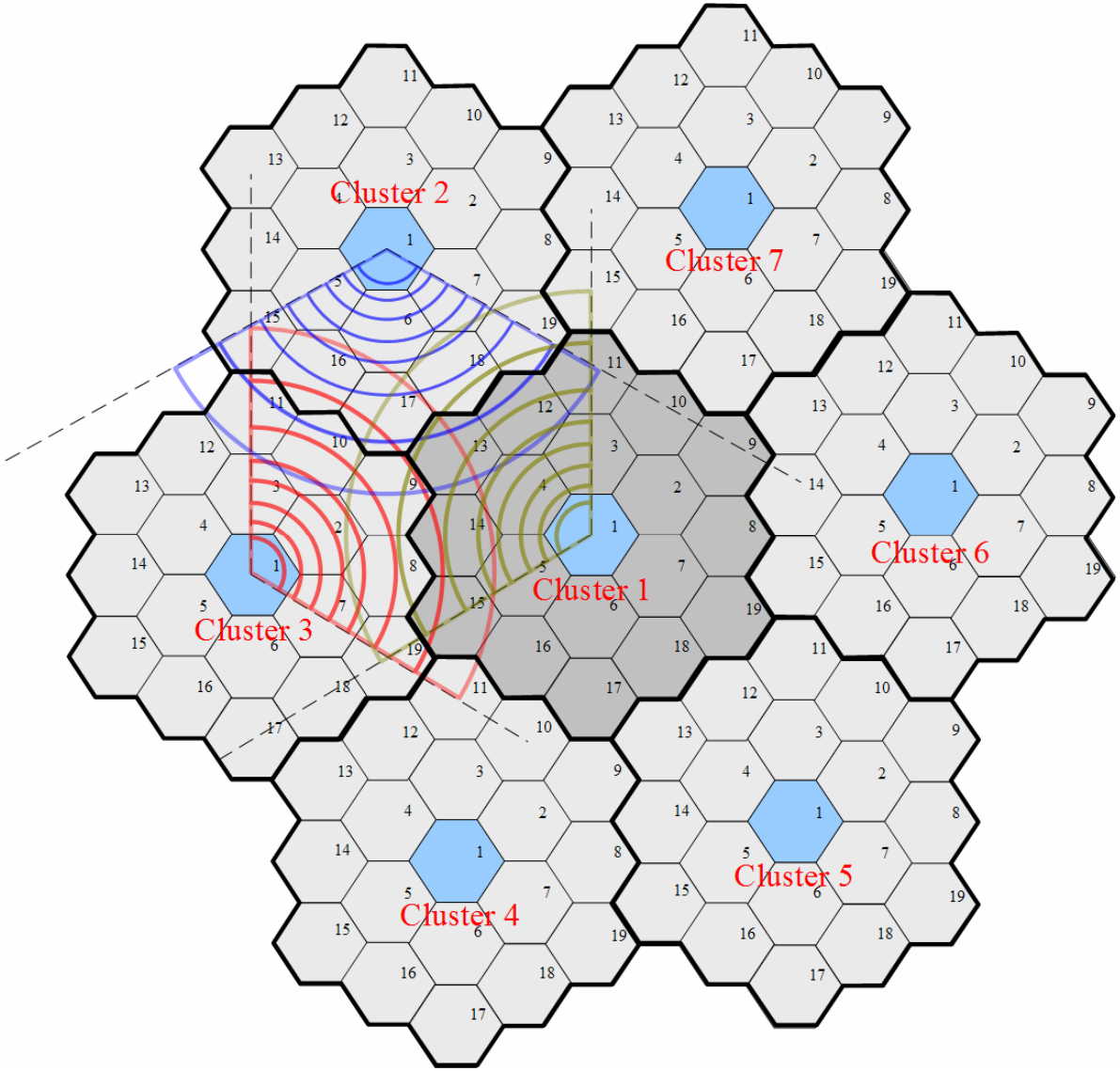
DL/UL / Sector	DL	UL
A	1	9
B	2	4
C	3	10

Pilots assignment in TDD subframes

Base Station / Sector	DL	UL
A	1 	9 

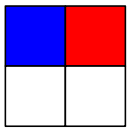
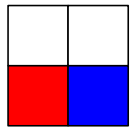
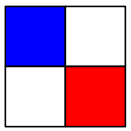
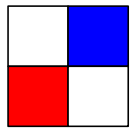
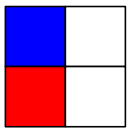
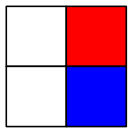


Interferences in Pilots Assignment in TDD



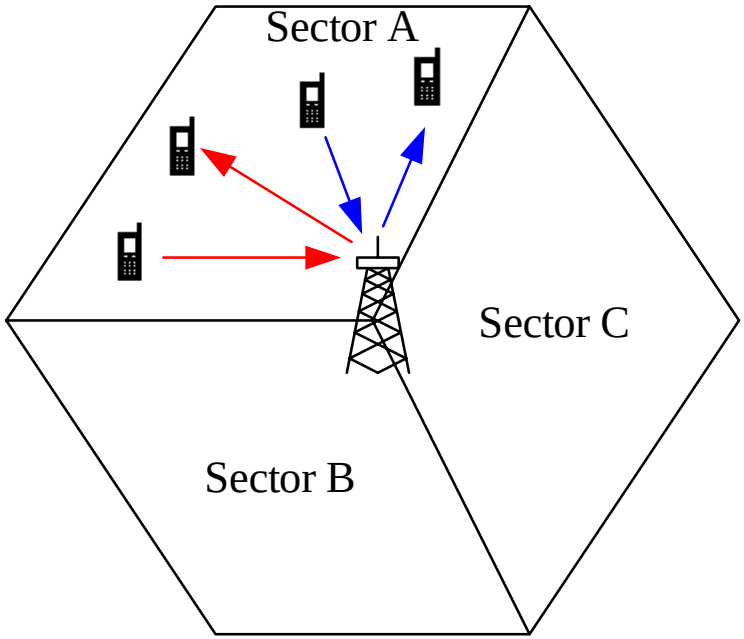
Cluster \ Base Station	DL	UL
Cluster1	1	9
Cluster2	2	4
Cluster3	3	10

Interference weight between any two pilot types assigned for the DL and UL among three clusters

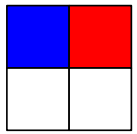
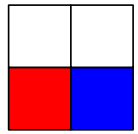
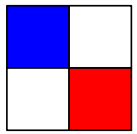
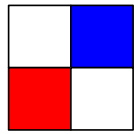
Base Station / Cluster	DL	UL
Cluster1	1 	9 
Cluster2	2 	4 
Cluster3	3 	10 

Interference Weight		Cluster 1		Cluster 2		Cluster 3	
		DL	UL	DL	UL	DL	UL
Cluster 1	DL		0	0.6	0.8	0.5	0.5
	UL	0		0.4	0.2	0.5	0.5
Cluster 2	DL	0.6	0.4		0	0.5	0.5
	UL	0.8	0.2	0		0.5	0.5
Cluster 3	DL	0.5	0.5	0.5	0.5		0
	UL	0.5	0.5	0.5	0.5	0	

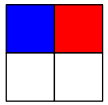
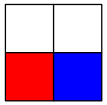
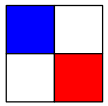
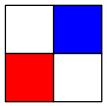
Pilot pattern assignment in FDD multiplexing

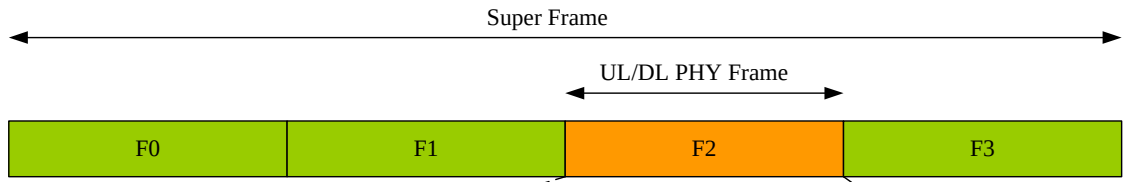


Frequency 1:
Frequency 2:

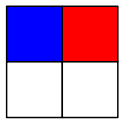
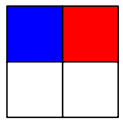
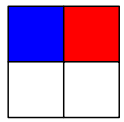
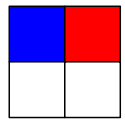
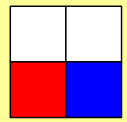
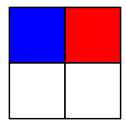
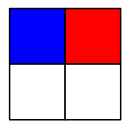
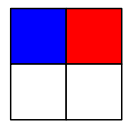
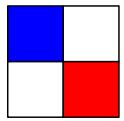
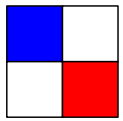
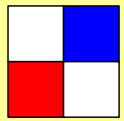
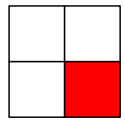
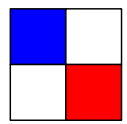
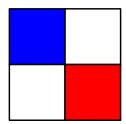
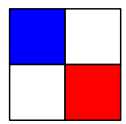
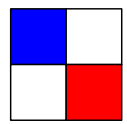
User / Frequency	User 1	User 2
1	1 	9 
2	2 	4 

Pilot pattern assignment for down link and uplink subframes in FDD multiplexing

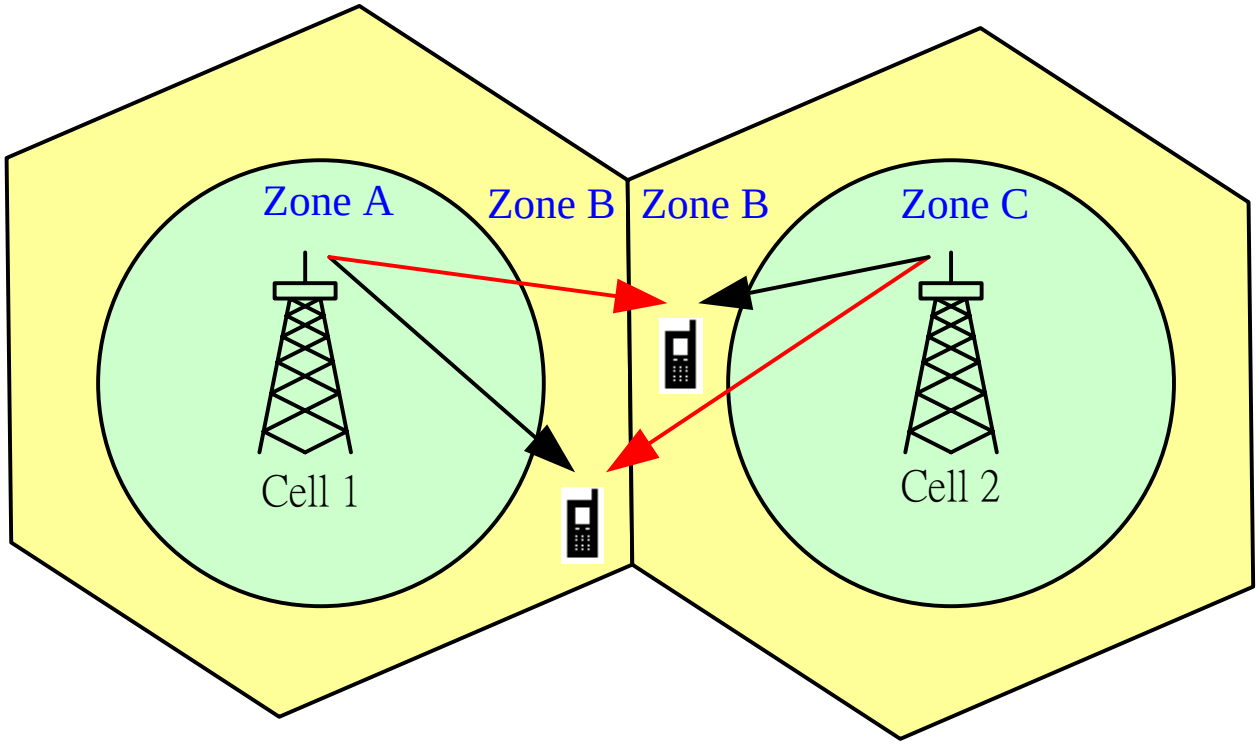
User / Frequency	User 1	User 2
1	1 	9 
2	2 	4 



Sub Frame

DL/UL frequency	DL/UL SF0	DL/UL SF1	DL/UL SF2	DL/UL SF3	DL/UL SF4	DL/UL SF5	DL/UL SF6	DL/UL SF7
Frequency 1	DL 	DL 	DL 	DL 	DL 	DL 	DL 	DL 
Frequency 2	UL 	UL 	UL 	UL 	UL 	UL 	UL 	UL 

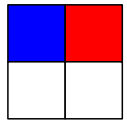
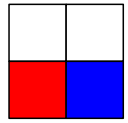
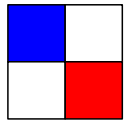
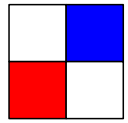
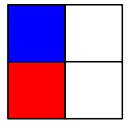
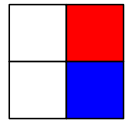
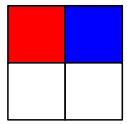
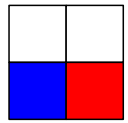
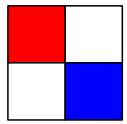
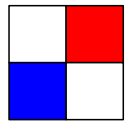
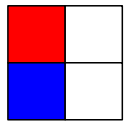
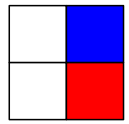
Cell edge interference



Signal Path:

Interference Path:

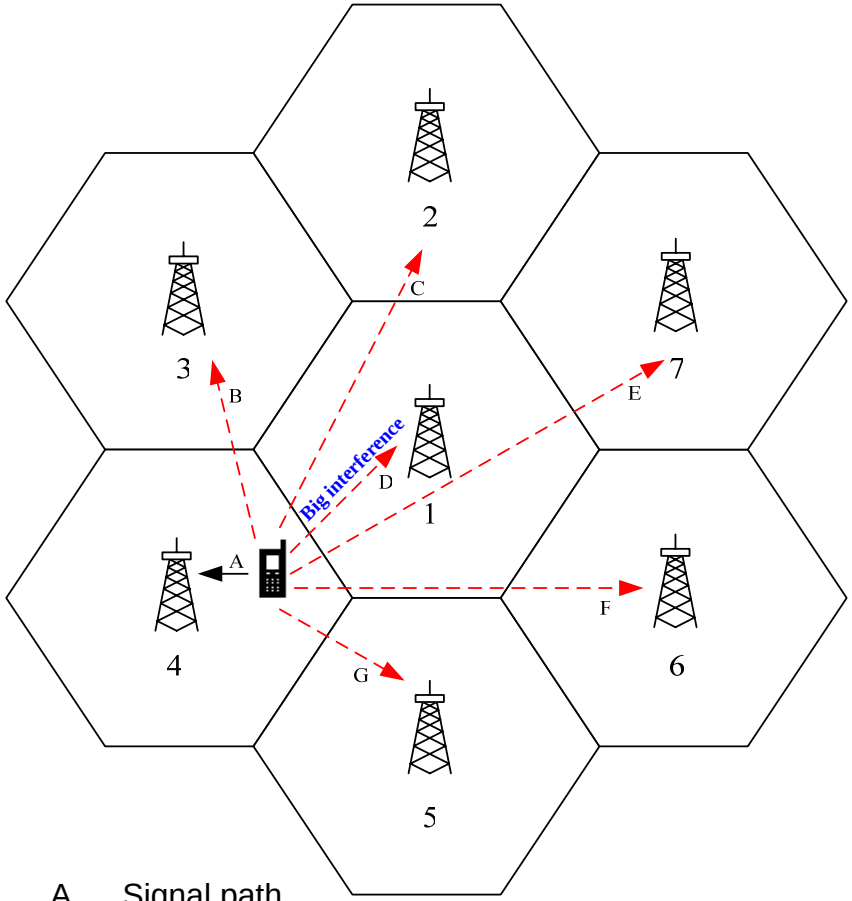
Orthogonal pilot pattern assignment for cell 1 and cell 2 when the MS is located at the cell edge

Base Station / Case	Cell1	Cell2	Interference weihgt
A	1 	9 	0
B	2 	4 	0
C	3 	10 	0
D	4 	7 	0
E	5 	4 	0
F	6 	10 	0

Using Interference Reducing Pilot structure by different BS

Parameter	*Value*
Carrier Frequency	2.5 GHz
System BW	10 MHz
BS Antenna Gain	17dB
MS Antenna Gain	0dB
BS height	32 M
MS height	1.5 M
Path Loss model	COST231 Hata model
Cell radius	500 M
Number of BS	7
Frequency reuse factor	1

Interference introduced from neighboring BSs to the MS



A. Signal path
B. Interference path (interference weight: 0.4)
C. Interference path (interference weight: 0.5)
D. Interference path (interference weight: 0)
E. Interference path (interference weight: 0.5)
F. Interference path (interference weight: 0.6)
G. Interference path (interference weight: 0.2)

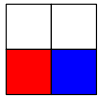
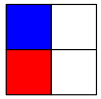
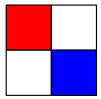
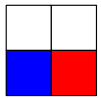
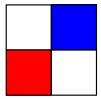
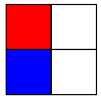
No. BS	Type	Sensitivity (dBm)
4		-119.6224
1		-131.9415
5		-135.7063
3		-135.7182
6		-143.4239
2		-143.4282
7		-145.5291

Serving BS = No. 4 Target BS = No. 1

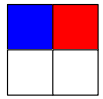
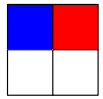
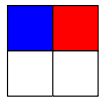
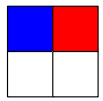
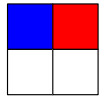
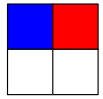
frequency reuse: 1

Resulting Interference levels by using and without using interference reducing pilots for BSs

IR Pilot

No. BS	Type	Sensitivity (dBm)	Interference weight
1		-131.9415	0
2		-143.4282	0.5
3		-135.7182	0.4
5		-135.7063	0.2
6		-143.4239	0.6
7		-145.5291	0.5

Common Pilot

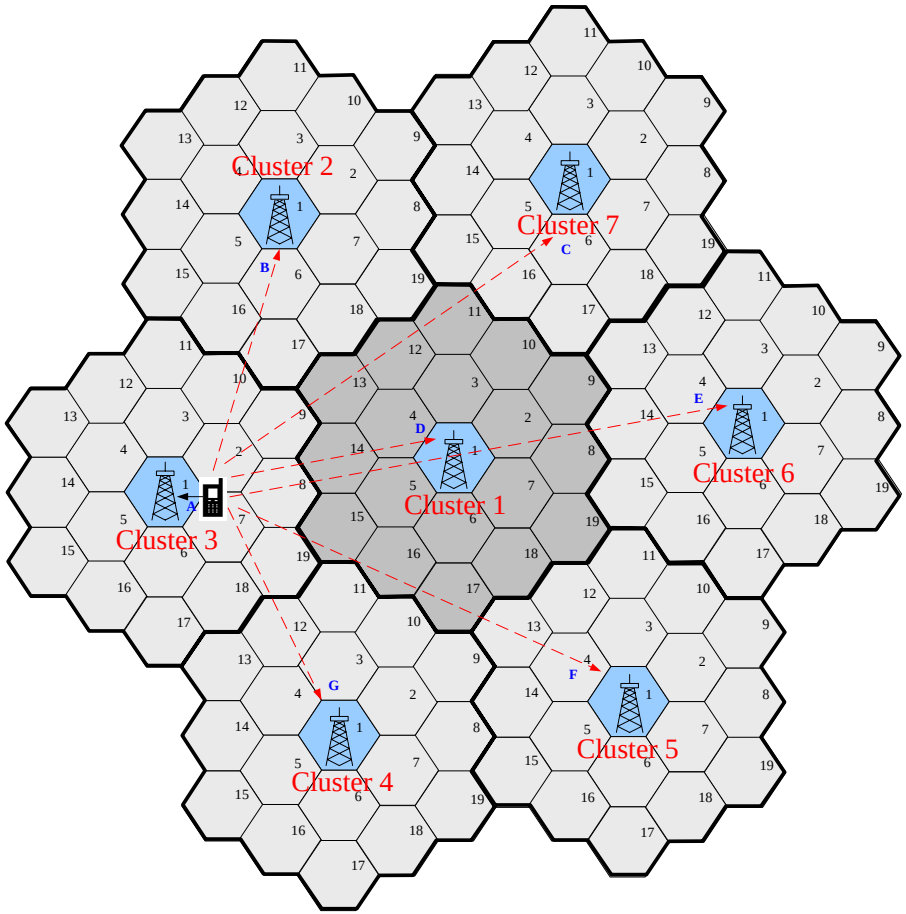
No. BS	No. BS	Sensitivity (dBm)	Interference weight
1		-131.9415	1
2		-143.4282	1
3		-135.7182	1
5		-135.7063	1
6		-143.4239	1
7		-145.5291	1

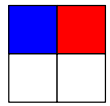
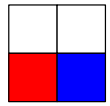
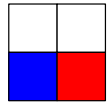
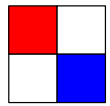
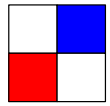
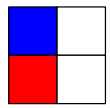
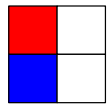
Pattern	Serving BS interference (dBm)
IR Pilot	-136.4793
Common Pilot	-128.8767

Using Interference Reducing Pilot structure by different Cluster

Parameter	*Value*
Carrier Frequency	2.5 GHz
System BW	10 MHz
BS Antenna Gain	17dB
MS Antenna Gain	0dB
BS height	32 M
MS height	1.5 M
Path Loss model	COST231 Hata model
Cell radius	500 M
Cluster	7
Number of BS	19
Frequency reuse factor	19

MS uses the same frequency to communicate with all cluster BSs



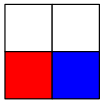
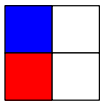
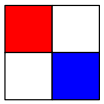
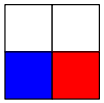
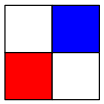
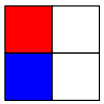
Cluster	Type	Sensitivity (dBm)
3		-135.4475
1		-156.5196
2		-158.5863
4		-158.5863
5		-166.6907
7		-166.6907
6		-168.8460

A. Signal path
B. Interference path (interference weight: 0.5)
C. Interference path (interference weight: 0.5)
D. Interference path (interference weight: 0)
E. Interference path (interference weight: 0.6)
F. Interference path (interference weight: 0.2)
G. Interference path (interference weight: 0.4)

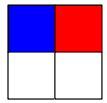
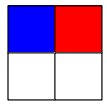
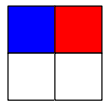
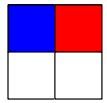
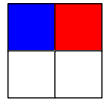
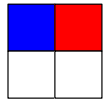
frequency reuse: 19

Resulting Interference levels by using and without using interference reducing pilots for BSs

IR Pilot

No. Cluster	Type	Sensitivity (dBm)	Interference weight
1		-156.5196	0
2		-158.5863	0.5
4		-158.5863	0.4
5		-166.6907	0.2
6		-168.8460	0.6
7		-166.6907	0.5

Common Pilot

No. Cluster	No. BS	Sensitivity (dBm)	Interference weight
1		-156.5196	1
2		-158.5863	1
4		-158.5863	1
5		-166.6907	1
6		-168.8460	1
7		-166.6907	1

Pattern	Cluster interference (dBm)
IR Pilot	-158.3135
Common Pilot	-135.3844

Summary

- When we introduced the interference reducing pilots for the various communication links we reduce the interference level by 7.5 dB for 7 base stations with frequency reuse factor 1 and the interference level reduce by 23 dB for 19 base stations when the use factor is 19.

Proposed Text for SDD (1/4)

11.X DL/UL control

11.X.1 Interference management

1) Frame structure for the control channel

Insert the following statements in the text

(1) SFH (Super Frame Header): the SFH is used for the transmission of the information such as the synchronization, frequency reference, cell ID etc

(2) FH (Frame Header): the FH will identify which frame should activate an IR-Zone (interference reducing zone), and when an IR-Zone is activated then the MS in this zone will receive the interference reducing service.

(3) FM (Frame Map): This FM is used to designate MSs locations in the sub-frame for those MSs are not in the interference-reducing zone (IR-Zone).

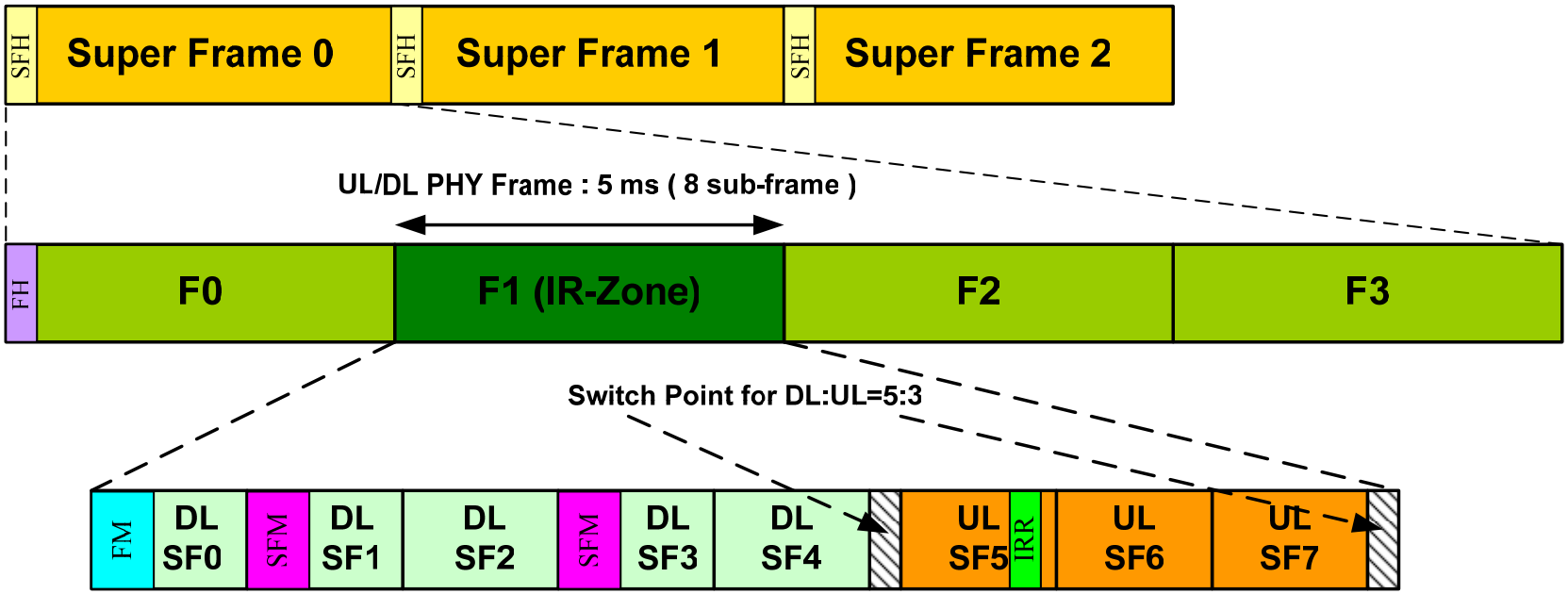
(4) SFM (Sub-frame Map): the SFM is used to designate which MSs in this IR-Zone need the interference reducing service. The MS designated can be a group of MSs or a single MS. It gives MS the information of the zone location, the orthogonal pilot pattern and it also will provide the relative location information of the UL- Zone.

(5) IR-Zone (Interference Reducing Zone): this zone is activated by the BS it can be divided into UL and DL IR-zones. The zone's size and location are described in the FH and the SFM, it also serves those MSs that need interference reducing services.

(6) UL-IRR (Uplink–interference Reducing Request): the MS will send an interference reducing request in this frame and the BS will include this MS which sends this request in the IR-Zone in the next DL frame.

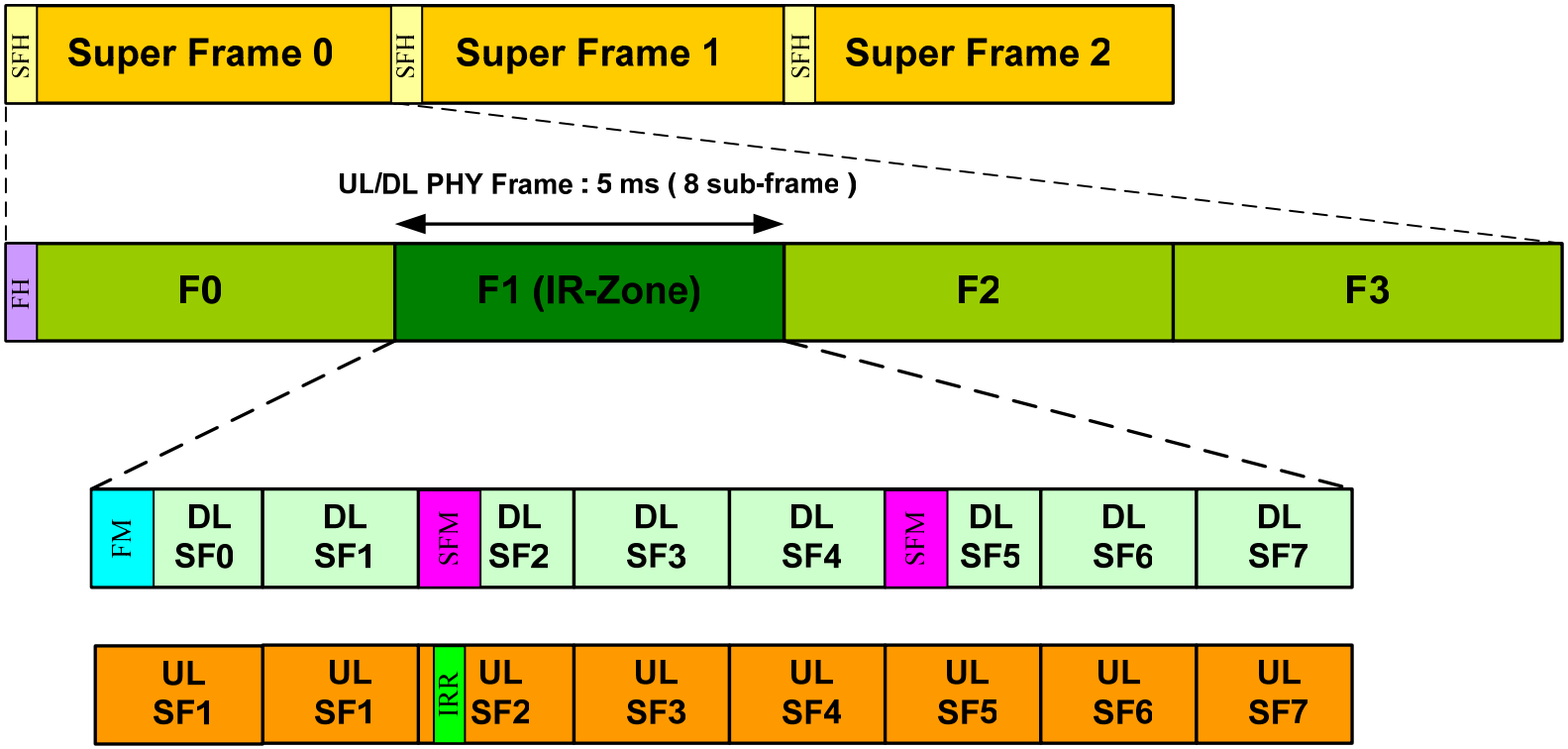
Proposed Text for SDD (2/4)

- **Control channel structure for TDD**



Proposed Text for SDD (3/4)

- **Control channel structure for FDD**



Proposed Text for SDD (4/4)

2) Interference Reducing Pilot Patterns

With properly designed pilot patterns that they have power interference weight between two any pairs of pilots we can have the system interference level lower than the system that has the same weight assigned for all pilots.

Reference(1/2)

[1] Zexian Li, Andrea Bacioccola Nokia Shashikant Maheshwari, Adrian Boariu, Yousuf Saifullah, Xin Qi, Xiaoyi Wang Nokia Siemens Networks , “Proposed Text from IEEE C80216m-08/224r2 for Downlink Control Structure in P802.16m SDD ” IEEE 802.16 Broadband Wireless Access Working Group, C80216m-08_017r1

[2] Sophie Vrzic, Mo-Han Fong, Robert Novak, Jun Yuan, Dongsheng Yu, Sang-Youb Kim, Anna Tee, Kathiravetpillai Sivanesan,Nortel Networks, “Proposed SDD Text on Downlink Control Structure “ IEEE 802.16 Broadband Wireless Access Working Group, C80216mDL_ctrl-08_023

[3] Kang Rui, Liu Ying, Guan Yanfeng, Lu ZhaohuaZTE Corporation ,” Proposed Text from IEEE C80216m-08/224r2 for Downlink Control Structure in P802.16m SDD ” IEEE 802.16 Broadband Wireless Access Working Group, C80216mDL_ctrl-08_024

[4] Fan Wang, Bishwarup Mondal, Mark Cudak, Amitava Ghosh, Tim Thomas, Fred Vook ,” Proposal on SDD Text on Downlink Control Structure ” IEEE 802.16 Broadband Wireless Access Working Group, C80216mDL_ctrl-08_025

Reference(2/2)

[5] Sun Changyin,Wangwenhuan,LiuminZTE CorporationYang Lian Huawei Technologies, “Proposed SDD Text of DL Control Structure based on IEEE C80216m-08/225r3 ” IEEE 802.16 Broadband Wireless Access Working Group, C80216m-08_027

[6] Youngsoo Yuk,Heejeong Cho, Jeongki Kim,Kiseon Ryu Ronny(Yong-Ho) Kim LG Electronics, ” Proposed Text for 16m SDD on Downlink Control Structure” IEEE 802.16 Broadband Wireless Access Working Group, C80216m-08_032r1