R1-050484

3GPP TSG-RAN1 Meeting #41

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Agenda Item:	**13.2**
Source:	**Nortel**
Title:	**Proposal for the Downlink Multiple Access Scheme for E-UTRA (Update)**
Document for:	**Discussion**

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>THIS IS **THE WAY**

Proposal for the Downlink Multiple Access Scheme for E-UTRA (update)

Nortel
May 11, 2005

>THIS IS NORTEL

Contents

> Introduction and background

> Design principle

> OFDM parameters

> DL frame structure

> DL pilot design

> DL channelization

> DL preamble

> DL scalability

> DL MIMO

> Summary and conclusion

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Introduction and Background

> DL OFDMA eliminates the intra-cell interference
- Orthogonal transmission is ensured

> Two types of the sub-channelizations
- Time-Frequency diversity sub-channel
  - Frequency hopping to mitigate the inter-cell interference
- Sub-band based sub-channel
  - To exploit multi-user diversity in frequency domain

> Adaptive coding and modulation

> Adaptive space-time coding modes

> Scalable OFDMA

> MIMO should capability should be enabled at day-one

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Design Principles

> OFDMA based air interface

> Backwards compatible with HSDPA
- Frame structure aligned with UMTS frame/slot structure
- Simple relation between sampling frequency and UMTS chip rate

> OFDMA sub-channel
- Dynamic allocation of two different types of sub-channel constructions to exploit the frequency diversity, multi-user diversity and the temporal selectivity

> Scalable OFDMA
- Support Bandwidth: 1.25MHz, 2.5MHz, 5MHz, 10MHz, 15MHz, 20MHz

> Support adaptive coding and modulation

> Support H-ARQ

> Support MIMO
- 2x2, 2x4, 4x2 or 4x4 antenna configurations support in DL
- To support divers Node-B and UE MIMO capability
- Embed into fundamental DL frame structure, pilot sub-channel design

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Frame Structure

> Frame
- The frame duration is 10 ms
- Each frame consists of 15 TTIs
- For the 1st TTI
  - The 1st OFDM symbol in each DL frame is used for preamble*
  - The 2nd OFDM symbol consists a BCH channel**
- The 2nd to 15th TTI maps
  - Shared pilot channels
  - DL traffic channels
  - DL control channel at first 2 OFDM symbols

> TTI
- The duration of TTI is 0.6667 ms
- Each TTI consists of 4 MIMO blocks

> MIMO block
- Consists of 2 OFDM symbols
- The MIMO block constitutes the constraint of the spatial dimension mapping

* For narrow band, more than one OFDM symbol can be assigned to preamble and BCH channel

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DL Frame Structure

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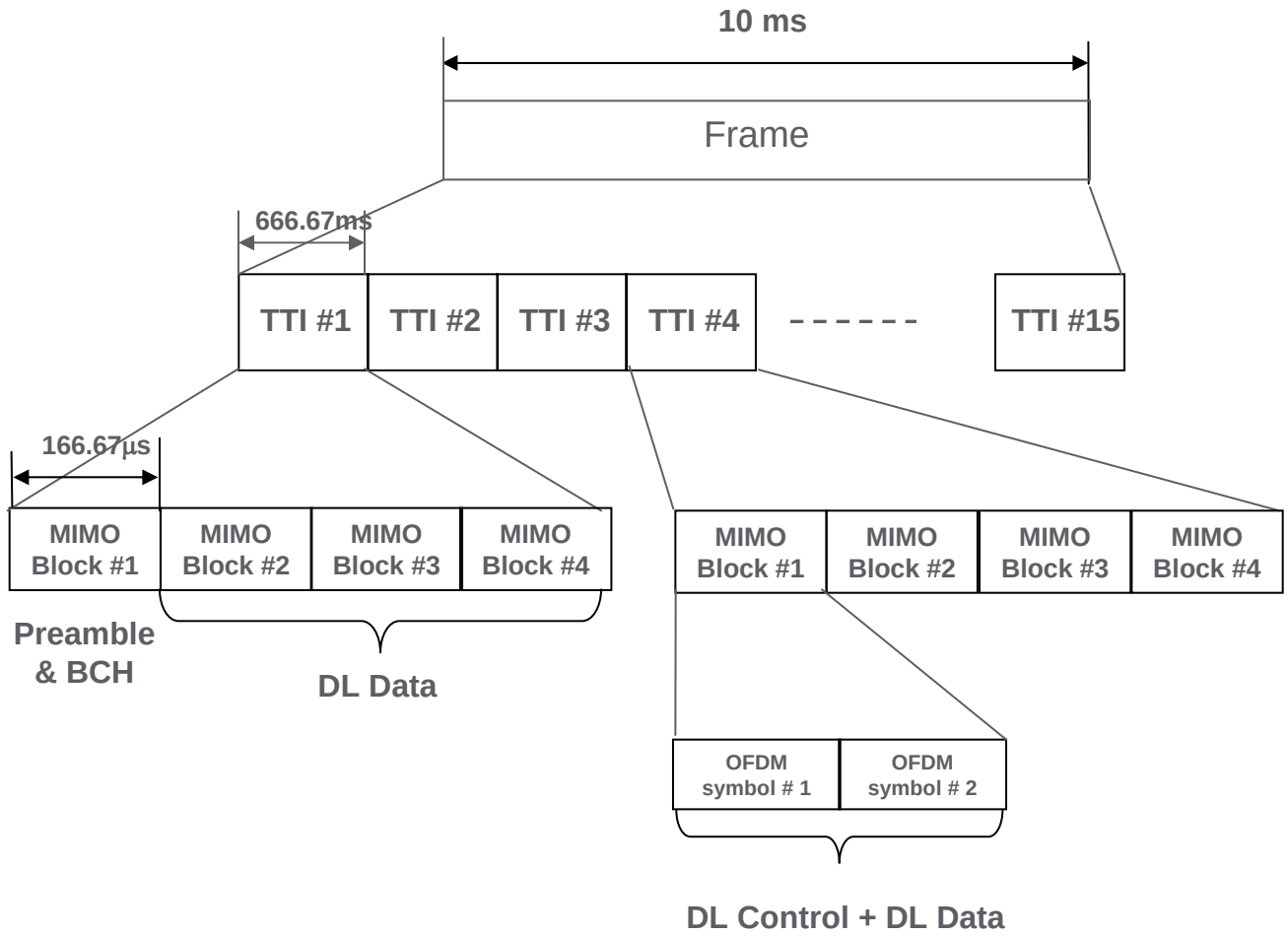

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OFDM Parameters Design Criteria

- Sampling Rate
  - Simple relationship with UMTS chip rate
- Number of Prefix Samples
  - Based on the RMS delay spread for unicast and broadcast modes
  - Based on SCM model
- Guard Time
  - Based on the prefix length and time windowing
- Sub-carrier Separation
  - To support 16QAM transmission at 350km/h mobility speed
- DC sub-carrier is not used
  - Avoid DC offset correction
- Guard sub-carriers is adjusted to support the spectrum mask requirement

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Unicast OFDM Parameters - (10 MHz Bandwidth)

- IFFT/FFT block = 1024
- Sampling rate = 13.44 MHz (=7/2*3.84 MHz)
- Number of prefix samples = 96
- Guard time = 7.14 us
- Number of samples per symbol = 1120
- Useful symbol duration =76.19 us
- Total OFDM symbol duration = 83.33 us
- Sub-carrier separation = 13.125 KHz
- Number of useful sub-carriers (N_{used}) = 704*
- The index of the first useful sub-carrier (K_{min}) = 160
- The index of the last useful sub-carrier (K_{max}) = 864
- Bandwidth = 9.25 MHz

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DL Pilot Design – (1)

> Two types of pilot sub-carriers
- Variable-located pilot sub-carriers, and continuous pilots

> Variable-location pilots

1. Scattered distributed across time-frequency plane
   - Enable 2-D simple time-frequency interpolation channel estimation
2. Power boost over average power
   - Trade-off channel estimation and data detection performance
3. Frequency domain orthogonal scattered pilots to support MIMO
   - Enable the channel estimations for up to 4 transmit antennas
4. The locations of the pilot in 4 adjacent OFDM symbols are identical
   - Identical channel estimation algorithm for all antennas
5. A set of scattered pilot patterns are created with offset in both time and frequency
   - 8 pilot sets for reuse planning reuse to avoid scattered pilot collision

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DL Pilot Design – (2)

> Continuous pilots
- Mapped onto fixed-location sub-carriers
- Can be mapped to up to four antennas
  - Orthogonal in frequency domain
- Enable frequency offset tracking
  - Fast frequency offset correction/tracking to support short burst
- Can be used for CQI estimation
  - Embed PN sequence for the signal and other cell interference estimation

> Assignment of pilots in DL
- Minimize the overhead of pilot
  - Support high speed mobility and frequency selective fading channel
- Support fast pilot extraction by Sub-set FFT
  - Reduced CQI estimation complexity
- Payload balance for all OFDM symbols for 4 transmit antenna case

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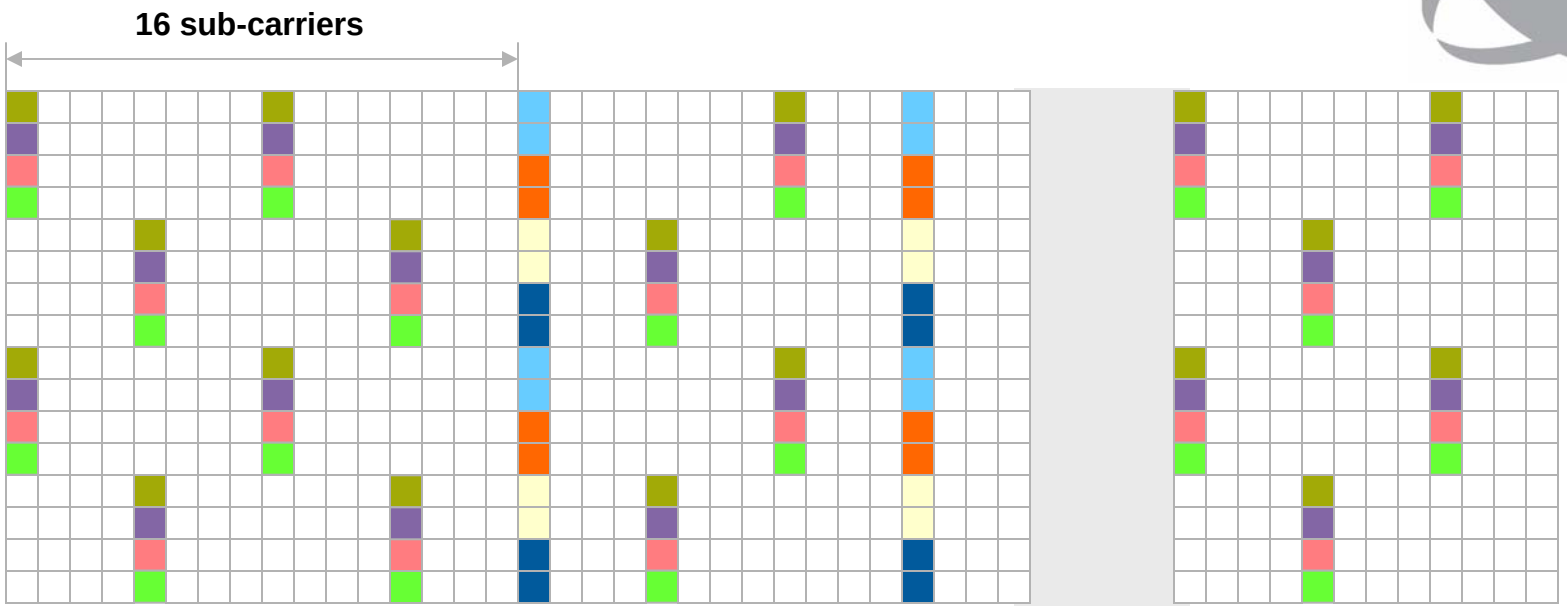
Assignment of Pilots in DL



	Data
	Scattered pilots for antennas 1,2,3 & 4
	Continuous pilots for antennas 1,2,3 & 4

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DL Channelization – (1)

> The DL sub-channel consists of variable units
- The basic DL channel resource is a basic access channels (BACH)
- Each BACH has 2N (for example N=24) data sub-carriers
  - N sub-carriers over 2 OFDM symbols in each MIMO block
  - Same sub-carrier assignment for 2 OFDM symbols

> The DL sub-channel resource allocation for each UE is based on the allocation of BACH

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DL Channelization – (2)

> Two types of BACH

- Diversity BACH:
  - Generated from distributed sub-carriers
    - Cell specific mapping sequence or interleaving can be applied to re-order the sub-carriers.
    - N sub-carriers in each OFDM symbol are selected from the re-numbered sub-carrier sequence with equal distance
  - To exploit frequency diversity
  - Support fast mobility UE
- Sub-band BACH:
  - Generated from adjacent sub-carriers
  - To exploit multi-user diversity
  - Support slow mobility UE
- Two types of BACH can be mapped onto same OFDM symbol

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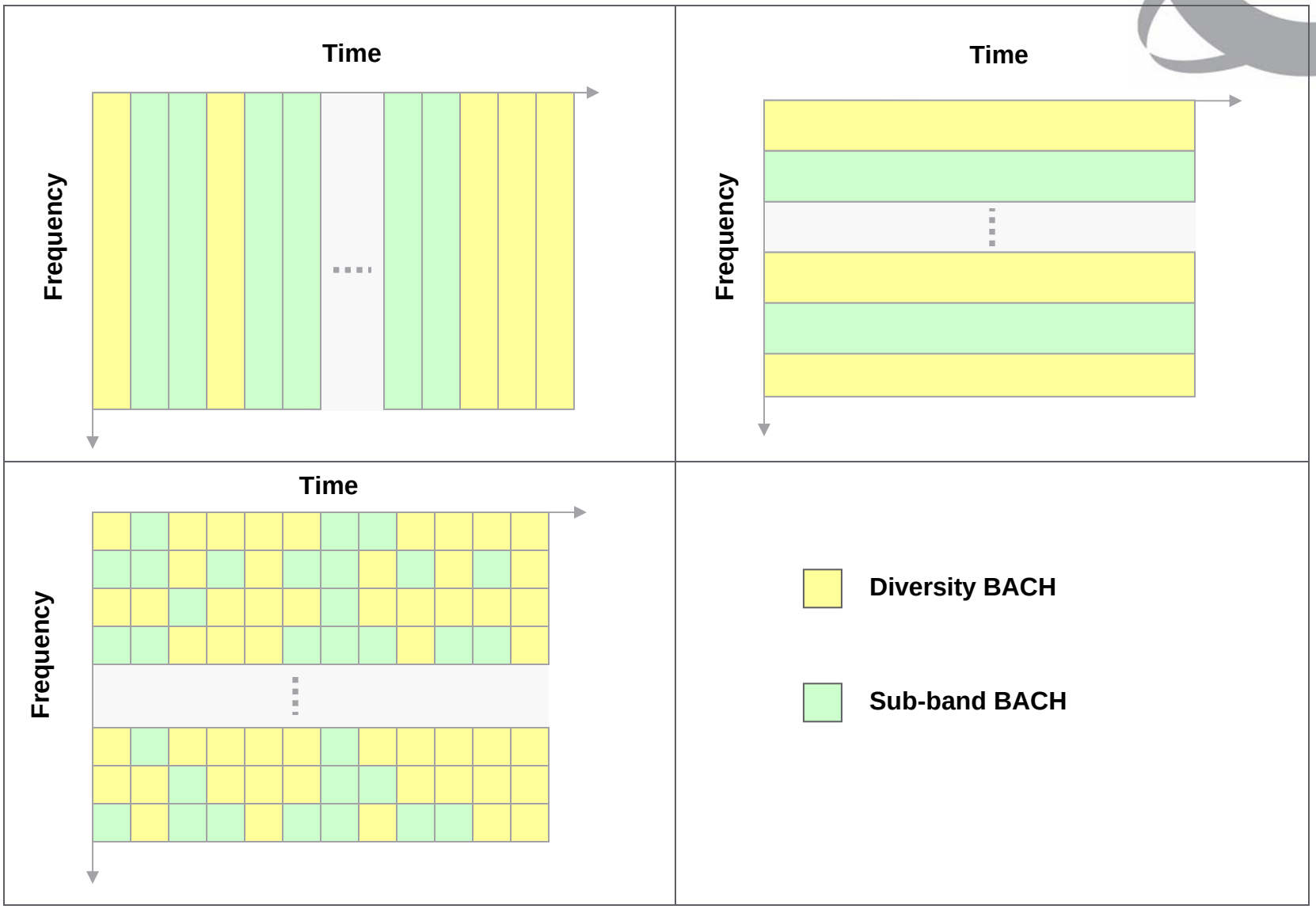
Hybrid Allocation of Diversity/Sub-band BACH



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DL Preamble

> Preamble is transmitted at the beginning in each frame to support
- Frame synchronization
- Timing synchronization
- Frequency synchronization
- Node-B identification
- Channel estimation

> To enable the fast system access and cell search
- Primary common SYNC channel (PSC) to carry common PN codes known by all cells
- Secondary cell specific SYNC channel (SSC) to transmit cell specific PN codes assigned to each cell
- The preamble consists of two identical head symbols plus prefix

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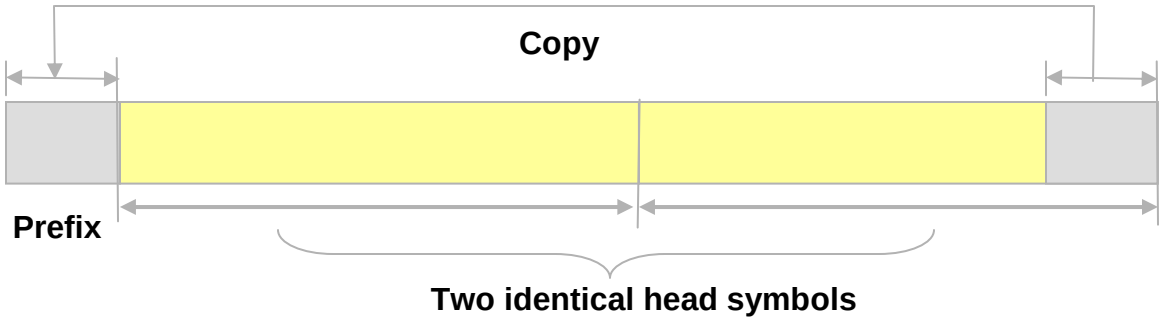
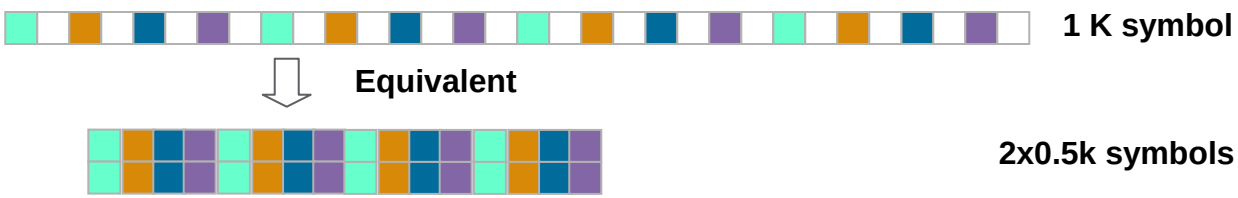
DL Preamble Structure (10MHz Bandwidth)

Time domain structure



Frequency domain structure



For 4 Transmit Antenna	Antenna 1	Antenna 2	Antenna 3	Antenna 4
For 2 Transmit Antenna	Antenna 1	Antenna 2	Antenna 1	Antenna 2
For 1 Transmit Antenna	Antenna 1	Antenna 1	Antenna 1	Antenna 1

Null

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Broadcast Channel and Paging Channel

> The 2nd OFDM symbol (or first MIMO block) in each frame is used for BCH (and PCH)
> QPSK modulation, Turbo code rate 1/5
> Segment the total useful sub-carriers into BCH unit consists of 16 contiguous sub-carriers
- One pilot sub-carriers plus 15 data sub-carriers per BCH unit
- Partition BCH unit further into 3 BCH channels, each cell assigned one BCH channel according to frequency reuse 1/3 planning.
- For BTS with multiple transmit antennas, BCH units assigned to each cell are transmitted cyclically by different antenna.
- FEC cross the whole BCH channel

> Scalability of BCH follows the scalability of regular transmission with reuse 1/3

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DL Scalability*

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Scalable up to 20 MHz and down to 1.25 MHz

System Bandwidth (MHz)	20	15	10	5	2.5	1.25
Sampling Frequency (MHz)	26.88 (7*3.84)	20.16 (21/4*3.84)	13.44 (7/2*3.84)	6.72 (7/4*3.84)	3.36 (7/8*3.84)	1.68 (7/16*3.84)
FFT Size	2048	1536	1024	512	256	128
Prefix Size	192 (7.14 us)	144 (7.14 us)	96 (7.14 us)	48 (7.14 us)	24 (7.14 us)	12 (7.14 us)
Sub-carrier Separation (KHz)	13.125	13.125	13.125	13.125	13.125	13.125
Number of Used Sub-carriers**	1472	1088	704	320	144	64
Number of Data Sub-carriers	1272	936	600	264	120	48
Number of Variable-location Pilots	184	136	88	40	18	8
Number of Continuous Pilots***	16	16	16	16	6	8
Number of BACH per MIMO Block	53	39	25	11	5	2

*The used sub-carrier number can be adjusted according to the filter requirement under different bandwidth
**Not include DC sub-carriers
*** Not coincidental with scattered pilots

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Broadcast/Multicast Mode

> Broadcast/Multicast from multiple BTSs in a cellular network will cause long multipath delays because of propagation delays from distant BTSs.

- Longer cyclic prefix is needed to compensate for the long delays.
- Same FFT size is used but with a longer cyclic prefix
  - Total OFDM symbol duration:100 us
  - Guard time: 23.81 us
- There are 20 broadcast OFDM symbols in 2 ms TTI (Rel5)

> Segment DL frame into non-broadcast TTI's and broadcast TTI's

- The Node B's are configured to transmit broadcast TTI's at synchronized times
- New pilot pattern to increase the pilot density because the channel is longer, but for only up to two antennas

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DL MIMO Modes

> MIMO modes designed to support diverse Node-B and U E antenna configuration capabilities

> MIMO modes is allocated on the TTI basis based on the BACH

> MIMO modes is dynamically allocated based UE CQI and/or MIMO channel eign condition feedback

> MIMO modes can jointly adapted in conjunction with MCS

> Closed MIMO can be enabled with modest UL feedback supports

MIMO Modes (Matrices)		BTS Capability	
		2-Transmit	4-Transmit
UE Capability	1-Receive	A	C
	2-Receive	A/B	C/D
	4 Receive	A/B	C/D/E

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DL MIMO Codes

2 transmits	4 transmits
Antenna Time or frequency $A = \begin{bmatrix} S_i & -S^*_{i+1} \\ S_{i+1} & S^*_i \end{bmatrix}$	$C = \begin{bmatrix} S_i & S_{i+1} & 0 & 0 \\ -S^*_{i+1} & S^*_i & 0 & 0 \\ 0 & 0 & S_{i+2} & S_{i+3} \\ 0 & 0 & -S^*_{i+3} & S^*_{i+2} \end{bmatrix}$
$B = \begin{bmatrix} S_i & S_{i+1} \end{bmatrix}$	$D = \begin{bmatrix} S_i & S_{i+1} & S_{i+2} & S_{i+3} \\ -S^*_{i+1} & S^*_i & -S^*_{i+3} & S^*_{i+2} \\ S_{i+4} & S_{i+5} & S_{i+6} & S_{i+7} \\ -S^*_{i+6} & -S^*_{i+7} & S^*_{i+4} & S^*_{i+5} \\ S_{i+8} & S_{i+9} & S_{i+10} & S_{i+11} \\ -S^*_{i+11} & -S^*_{i+10} & S^*_{i+9} & S^*_{i+8} \end{bmatrix}$
	$E = \begin{bmatrix} S_i & S_{i+1} & S_{i+2} & S_{i+3} \end{bmatrix}$

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Summary

> DL MIMO-OFDM frame structure is proposed

> DL MIMO-OFDM parameters are proposed
- FFT size, guard interval, sub-carrier spacing
- Scalability

> DL MIMO-OFDM L1 structure is proposed
- Pilot
- Sub-channelization (BACH)
- Preamble
- BCH/PCH

> DL MIMO-OFDM operation modes are proposed

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