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LTE FDD vs LTE TDD from a Qos Perspective

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Abstract: *Long Term Evolution (LTE) is the next step (fourth generation) mobile radio communication technology that succeeds the HSPA 3GPP standardization body. LTE is expected to be the most competitive radio technology in the future to provide high-data-rate transmission, low latency, improved service and reduced costs. As known, mobile phone traffic is divided into two parts: an uplink and a downlink. This paper presents the LTE two duplexing modes: LTE-TDD (Time Division Duplexing) and LTE-FDD(Frequency Division Duplexing).*

I. Introduction

The first release (Release 8) of the Long Term Evolution (LTE) has recently been standardized by 3GPP. LTE provides high peak data rates up to 300 Mbps, improved spectrum efficiency, and reduced radio access delays. One key requirement in the development of LTE has been spectrum flexibility; LTE can be operated in different spectrum allocations from 1.4 to 20 MHz and in paired or unpaired spectrum .
The Frequency Division Duplex (FDD) mode uses paired spectrum where different carrier frequencies are used for downlink (DL) and uplink (UL). During each frame, there are thus ten uplink subframes and ten downlink subframes, so uplink and downlink transmission can occur simultaneously within a cell.
while TDD implies that downlink and uplink transmission take place in different, non overlapping time slots. Thus, TDD can operate in unpaired spectrum, whereas FDD requires paired spectrum.

II. Methodology:

This paper focuses on the main difference between LTE-FDD and LTE-TDD in how they divide the single channel to provide paths for both uploading (mobile transmit) and downloading (base-station transmit) and their influence on the quality of service.

Time Division Duplexing (TDD):

The communication is done using one frequency, but the time for transmitting and receiving is different. This method emulates full duplex communication using a half duplex link.The key advantages of TDD (known also as TD-LTE) are usually seen in conditions where the uplink and downlink data transmissions are not symmetrical. Moreover, since the transmitting and receiving is done using one frequency, the channel estimations for beamforming (and other smart antenna techniques) apply for both the uplink and the downlink. A typical disadvantage of TDD is the need to use guard periods between the downlink and uplink transmissions. The following features are unique to TDD-LTE:

1. Frame structure – a special sub frame that allows switching between downlink and uplink transmission.

2. ACK/NACK – Multiple acknowledgements and negative acknowledgements are combined on the uplink control channels. This ultimately leads to increased control signaling and lower spectrum/resource utilization.

3. Guard periods – These are used in the center of special sub frames. They allow for the advance of the uplink transmission timing.

Frequency-division Duplex (FDD):

In the case of FDD operation, there are two carrier frequencies, one for uplink transmission (fUL) and one for downlink transmission (fDL). During each frame, there

FDD uses lots of frequency spectrum, though, generally at least twice the spectrum needed by TDD. In addition, there must be adequate spectrum separation between the transmit and receive channels. These so-called guard bands aren’t useable, so they’re wasteful. Given the scarcity and expense of spectrum. there are some different between FDD and TDD:

FDD-LTE	TDD-LTE
Uses Frequency-Division Duplex	Uses Time-Division Duplex
Generally better suited for applications like voice calls that have symmetric traffic, because traffic in both directions is always constant.	Is better at reallocating traffic than FDD-LTE such as Internet or other data centric services.
It requires paired spectrum with different frequencies with guard band.	Does not require paired spectrum since transmit and receive occurs in the same channel
Is appears when planning sites for base stations. Because FDD base stations use different frequencies for receiving and transmitting, they effectively do not hear each other and no special planning is needed.	With TDD, special considerations need to be taken in order to prevent neighboring base stations from interfering with each other.
Allows for easier planning than TDD LTE.	It is cheaper than FD LTE since in TDD-LTE no need of duplexer to isolate transmission and receptions.
FDD LTE is full duplex this means that both the upload and download are always available.	TDD LTE is half duplex as either upload or download can use the channel but not at the same time.
With FDD, the bandwidth cannot be dynamically reallocated and the unused bandwidth is wasted.	TDD can allocate more time for the part that requires more bandwidth, thereby balancing the load
FDD-LTE every downlink subframe can be associated with an uplink subframe	TD-LTE the number of downlink and uplink subframes is different and such association is not possible.
An FDD system uses a duplexer and/or two antennas that require spatial separation and, therefore, cannot reuse the resources. The result is more costly hardware.	In TDD, both the transmitter and receiver operate on the same frequency but at different times. Therefore, TDD systems reuse the filters, mixers, frequency sources and synthesizers, thereby eliminating the complexity and costs associated with isolating the transmit antenna and the receive antenna.
FDD cannot be used in environments where the service provider does not have enough bandwidth to provide the required guard-band between transmit and receive channels.	TDD utilizes the spectrum more efficiently than FDD.
It is requires two interference-free channels.	It is requires only one interference-free channel.

Table (1) Comparison between FDD-LTE and TDD-LTE.

Simulation Model

The simulations are done with an Atoll software to compare between the affect of using FDD and TDD with the same other parameter and analyze the affect in throughput, coverage area and the simulation parameter are:

Parameter	Value
Environment	Suburban
Bandwidth	10 MHz
Frequency	2100 MHz
Number of sites	14
Number of cells per site	3
Hexagonal Radius	5000 m
Antenna type	120 sectoring
Antenna height	30 m
Propagation Mode	COST-Hata

Cost Hata Mathematical Formulation

The COST-Hata-Model is formulated as:

$$L_{50}(\text{urban}) = 46.3 + 33.9\log f_c - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d + C_M$$

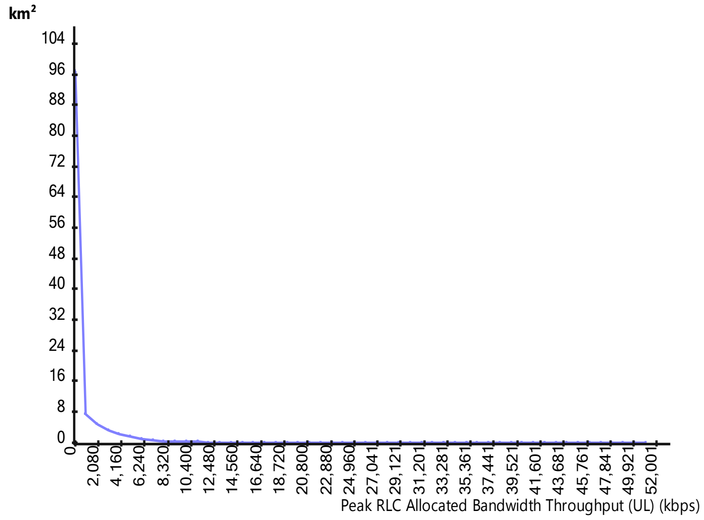
$$a(h_{re}) = (1.11\log f_c - 0.7)h_{re} - (1.56\log f_c - 0.8)$$

$$C_M = \begin{cases} 0\ dB\ for\ medium\ sized\ city\ and\ suburban\ areas \\ 3\ dB\ for\ metropolitan\ centers \end{cases}$$

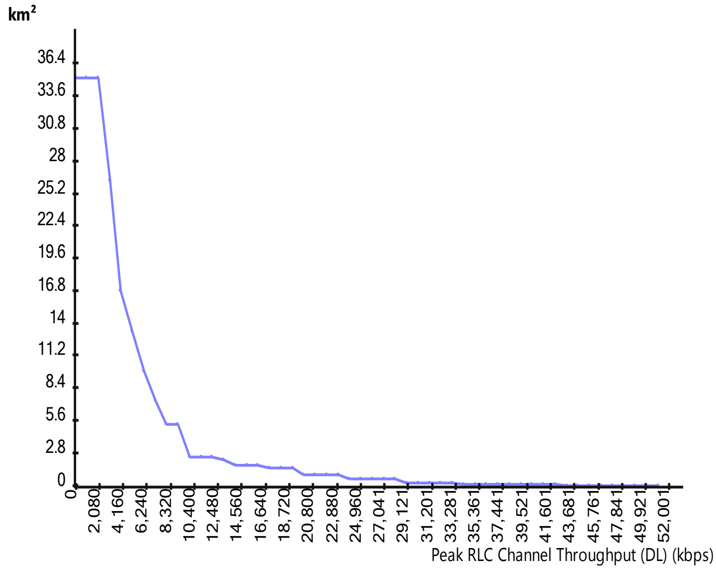
Where,

- L_{50} = Median path loss. Unit: Decibel (dB)
- f_c = Frequency of Transmission. Unit: Megahertz (MHz)
- h_{te} = Base Station Antenna effective height. Unit: Meter (m)
- d = Link distance. Unit: Kilometer (km)
- h_{re} = Mobile Station Antenna effective height. Unit: Meter (m)
- $a(h_{re})$ = Mobile station Antenna height correction factor as described in the Hata Model for Urban Areas.

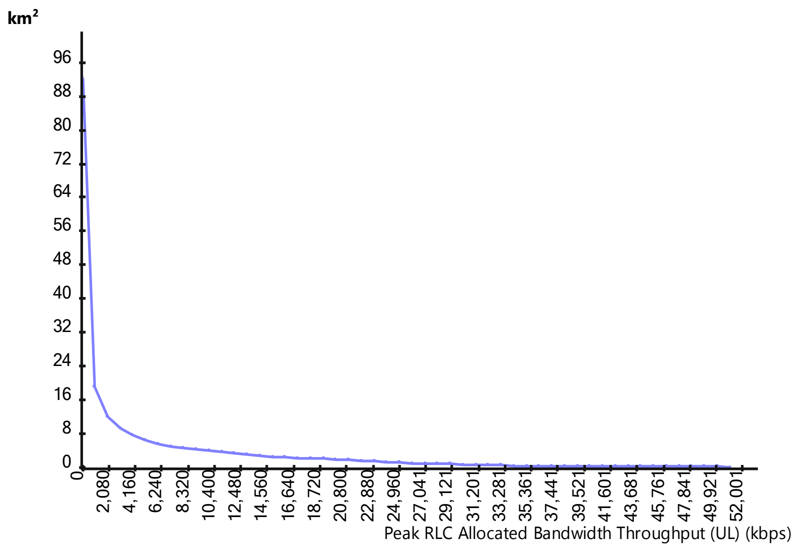
The Simulation Result



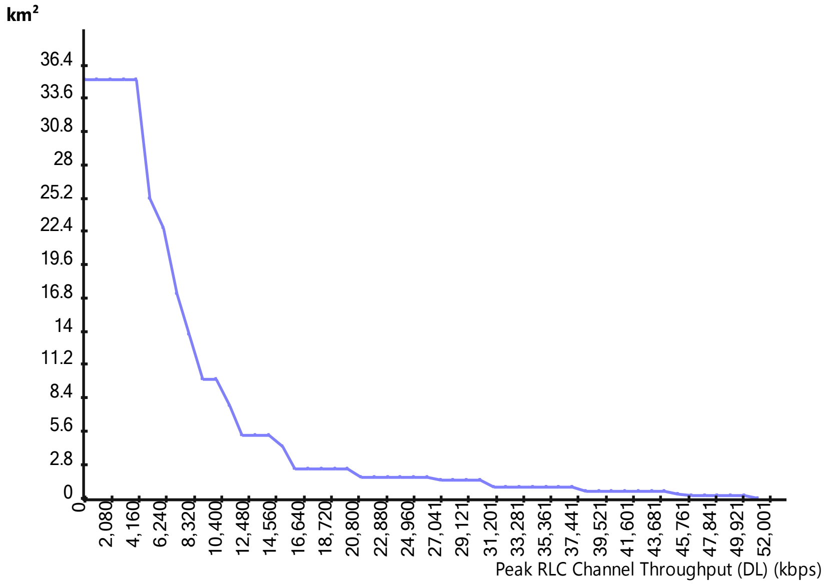
TDD – 2100 Covered area / Throughput (UL)



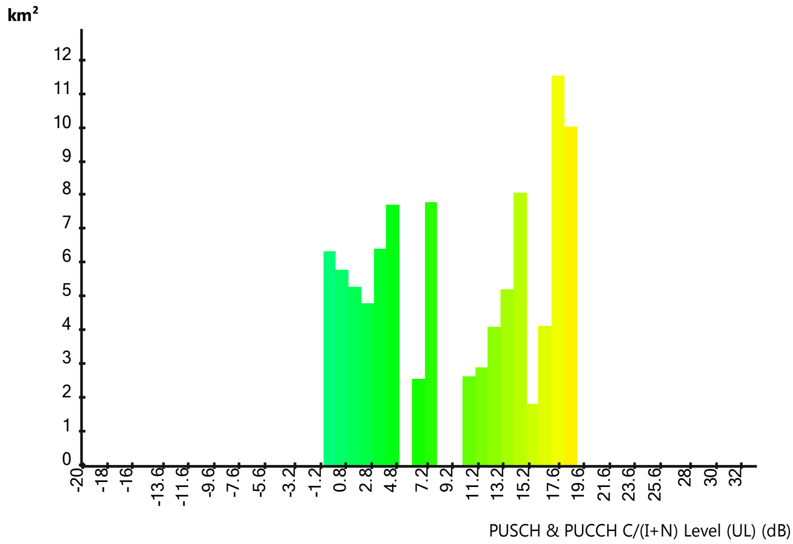
TDD – 2100 Covered area / Throughput (DL)



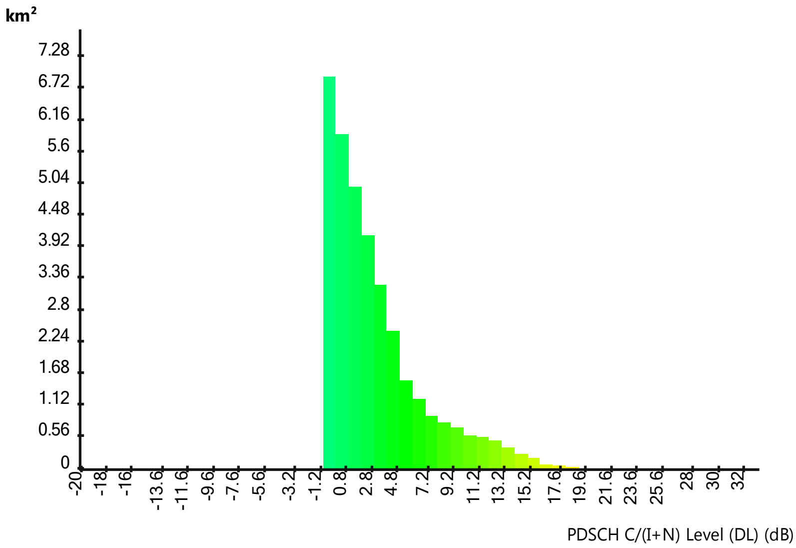
FDD – 2100 Covered area / Throughput (UL)



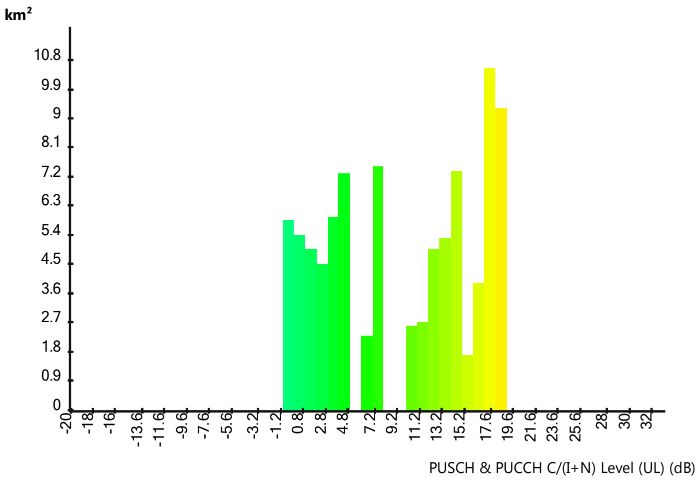
FDD – 2100 Covered area / Throughput (DL)



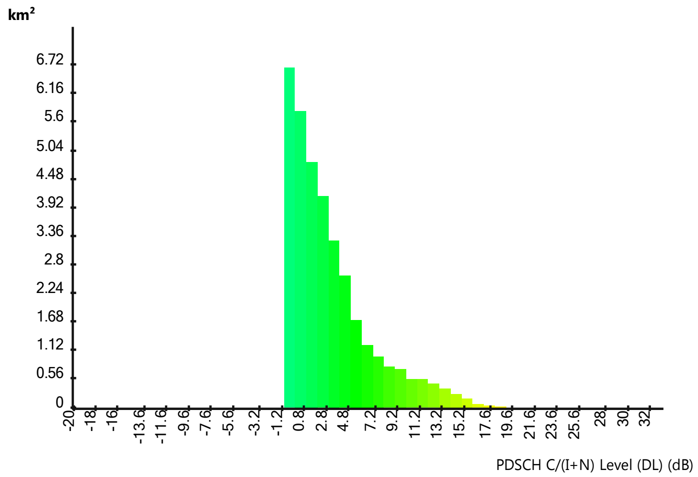
TDD – 2100 Covered area / Carrier-to-noise ratio (UL)



TDD – 2100 Covered area / Carrier-to-noise ratio (DL)



FDD – 2100 Covered area / Carrier-to-noise ratio (UL)



FDD – 2100 Covered area / Carrier-to-noise ratio (DL)

III. Conclusion

This paper demonstrates that the main difference between LTE-FDD and LTE-TDD is how they divide the signal channel to provide paths for both uploading (mobile transmit) and downloading (base-station transmit), Hence the preference for one over the other is essentially depends on the purpose of using the system, therefore:

- If the goal of the system is the coverage, it's preferable to work with TDD.
- If the goal of the system is the Throughput, it's preferable to work with FDD.
- The Carrier-to-noise ratio is the same in both TDD and FDD.

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