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X-Raying Time Division Duplexing (TDD) in Long Term Evolution (LTE)

B.I. Bakare[1] and J.E. Godwin[2]

[1, 2](Department of Electrical Engineering, Rivers State University, Port Harcourt, Nigeria.)

ABSTRACT: *With the emergence of smart devices, people are downloading content in unprecedented volumes, putting stress on the network. As a result, wireless operators globally are facing increasing demand for high speed mobile broadband services. More and more users are flocking to such bandwidth-consuming applications as YouTube and Netflix, leaving operators searching for technology to stay ahead of this ever-growing demand. LTE-Advanced (Long Term Evolution-Advanced) is used on fourth generation (4G) in mobile phone technology as many providers are beginning to augment their networks with LTE. As known, LTE traffic is divided into two parts: an uplink and a downlink transmission. This paper presents the LTE duplexing modes: LTE-TDD (Time Division Duplexing) and LTE-FDD (Frequency Division Duplexing). Where LTE-TDD is favored by a majority of implementations because of flexibility in choosing uplink to downlink data rate ratios, ability to exploit channel reciprocity, ability to implement in non-paired spectrum and less complex transceiver design. This paper focuses on role of TDD LTE Technology in mobile communication, its evolution and future for TDD LTE.*

Keywords - *Duplexing; Frequency Division Duplexing; Long Term Evolution; Time Division Duplexing.*

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I. INTRODUCTION

The United States began to develop the AMPS (Advanced Mobile Phone Service) network, while European countries were developing their own forms of communication. However, when Europeans quickly realized the disadvantages of each European country operating on their mobile network, it prevented cell phone use from country to country within Europe. With the emerging European Union and high travel volume between countries in Europe, this was seen as a problem. Rectifying the situation, the Conference of European Posts and Telegraphs (CEPT) assembled a research group with intentions of researching the mobile phone system in Europe. This group was called Group Spécial Mobile (GSM). In 1989 work done by the GSM group was transferred to the European Telecommunication Standards Institute (ETSI). The name GSM was transposed to name the type of service invented. The acronym GSM had been changed from Group Spécial Mobile to Global System for Mobile Communications [1]. In telecommunications, Long-Term Evolution (LTE) is a standard for wireless broadband communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies. It increases the capacity and speed using a different radio interface together with core network improvements. LTE is the upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks. The different LTE frequencies and bands used in different countries mean that only multi-band phones are able to use LTE in all countries where it is supported.

Long Term Evolution Time Division Duplex (LTE TDD) is the version of LTE that uses the TDD modulation scheme in unpaired spectrum, whereby the same frequency channel is used for both downlink and uplink communication and signals are timed to enable smooth delivery of data. In contrast, Long Term Evolution Frequency Division Duplex (FDD) is a paired spectrum, with a separate channel for uplinks and downloads. LTE-TDD and LTE-FDD also operate on different frequency bands with LTE-TDD working better at higher frequencies, and LTE-FDD working better at lower frequencies. Frequencies used for LTE-TDD range from 1850 MHz to 3800 MHz, with several different bands being used. The LTE-TDD spectrum is generally cheaper to access, and has less traffic. Further, the bands for LTE-TDD overlap with those used for WiMAX, which can easily be upgraded to support LTE-TDD.

With full coverage in the 3 GPP Release 8 specifications of both TDD and FDD modes of operation, LTE can effectively be deployed in both the paired and unpaired spectrum. LTE TDD and FDD modes have been greatly harmonized in the sense that both modes share the same underlying framework, including radio access schemes OFDMA in downlink and SC-FDMA in uplink, basic subframe formats, configuration protocols, etc. As clear indication of the harmonization, the TDD mode is included together with the FDD mode in the same set of specifications, including the physical layer where there are just a few differences due to the uplink/downlink switching operation. In terms of architecture there are no differences between FDD and TDD and the very few differences in the MAC and higher layer protocols relate to TDD specific physical layer parameters. Procedures are kept the same. Thus there will be high implementation synergies between the two modes allowing for efficient support of both TDD and FDD in the same network or user device. Coexistence would of course still require careful analysis. Another key feature of the LTE-TDD mode (known also as TDD-LTE) is the commonality with TD-SCDMA. Further, information related to both the link and system performance of the LTE TDD mode of operation [2]. TDD-based services are typically considered as more spectrum-efficient and better suited for "bursty" data services.

II. DUPLEX SCHEMES

Spectrum flexibility is one of the key features of LTE. In addition to the flexibility in transmission bandwidth, LTE also supports operation in both paired and unpaired spectrum by supporting both FDD- and TDD-based duplex operation with the time-frequency structures illustrated in Fig. 2. Although the time-domain structure is, in most respects, the same for FDD and TDD, there are some differences, most notably the presence of a special subframe in the case of TDD. The special subframe is used to provide the necessary guard time for downlink-uplink switching.

2.1 Frequency-division Duplex (FDD)

In the case of FDD operation (upper part of Fig. 1), there are two carrier frequencies, one for uplink transmission (*fUL*) and one for downlink transmission (*fDL*). During each frame, there are thus ten uplink subframes and ten downlink subframes, and uplink and downlink transmission can occur simultaneously within a cell [4]. Isolation between downlink and uplink transmissions is achieved by transmission/reception filters, known as duplex filters, and a sufficiently large duplex separation in the frequency domain. Even if uplink and downlink transmission can occur simultaneously within a cell in the case of FDD operation, a terminal may be capable of full-duplex operation or only half-duplex operation for a certain frequency band, depending on whether or not it is capable of simultaneous transmission/reception. In the case of full-duplex capability, transmission and reception may also occur simultaneously at a terminal, whereas a terminal capable of only half-duplex operation cannot transmit and receive simultaneously. Supporting only half-duplex operation allows for simplified terminal implementation due to relaxed duplex filter requirements. This applies especially for certain frequency bands with a narrow duplex gap.

Hence, full duplex support is frequency-band dependent such that a terminal may support only half-duplex operation in certain frequency bands while being capable of full-duplex operation in the remaining supported bands. It should be noted that full/half-duplex capability is a property of the terminal; the base station is operating in full duplex irrespective of the terminal capabilities. Hence, as the relevant transmission structures and timing relations are identical between full-duplex and half-duplex FDD, a single cell may simultaneously support a mixture of full-duplex and half-duplex FDD terminals. Half-duplex operation has an impact on the sustained data rates that can be provided to/from a single mobile terminal as it cannot transmit in all uplink subframes, but the cell capacity is hardly affected as typically it is possible to schedule different terminals in uplink and downlink in a given subframe. Since a half-duplex terminal is not capable of simultaneous transmission and reception, the scheduling decisions must take this into account and half-duplex operation can be seen as a scheduling restriction. If a terminal is scheduled such that downlink reception in one subframe immediately precedes a subframe of uplink transmission, a guard time is necessary for the terminal to switch from reception to transmission. This is created in such cases by allowing the terminal to skip receiving the last OFDM symbol(s) in the downlink subframe, as illustrated in Fig. 3.

2.2 Time-division Duplex (TDD)

In the case of TDD operation (Fig. 1), there is a single carrier frequency only and uplink and downlink transmissions are separated in the time domain on a cell basis [5]. As seen in the figure, some subframes are allocated for uplink transmissions and some subframes for downlink transmission, with the switch between downlink and uplink occurring in the special subframe (subframe 1 and, in some cases, subframe 6).

Like FDD, LTE TDD supports bandwidths from 1.4MHz up to 20MHz but depending on the frequency band, the number of supported bandwidths may be less than the full range. For example, for the 2.5 GHz band, it is not likely that the smallest bandwidths will be supported. Since the bandwidth is shared between uplink and downlink and the maximum bandwidth is specified to be 20MHz in Release 8, the maximum achievable data rates are lower than in LTE FDD. This way the same receiver and transmitter processing capability can be used with both TDD and FDD modes enabling faster deployment of LTE. The TDD system can be implemented on an unpaired band (or in two paired bands separately) while the FDD system always requires a pair of bands with a reasonable separation between uplink and downlink directions, known as the duplex separation. In a FDD UE implementation this normally requires a duplex filter when simultaneous transmission and reception is facilitated. In a TDD system the UE does not need such a duplex filter. The complexity of the duplex filter increases when the uplink and downlink frequency bands are placed in closer proximity.

In some of the future spectrum allocations it is foreseen that it will be easier to find new unpaired allocations than paired allocations with sensible duplex separation thereby increasing further the scope of applicability for TDD. However, since uplink and downlink share the same frequency band, the signals in these two transmission

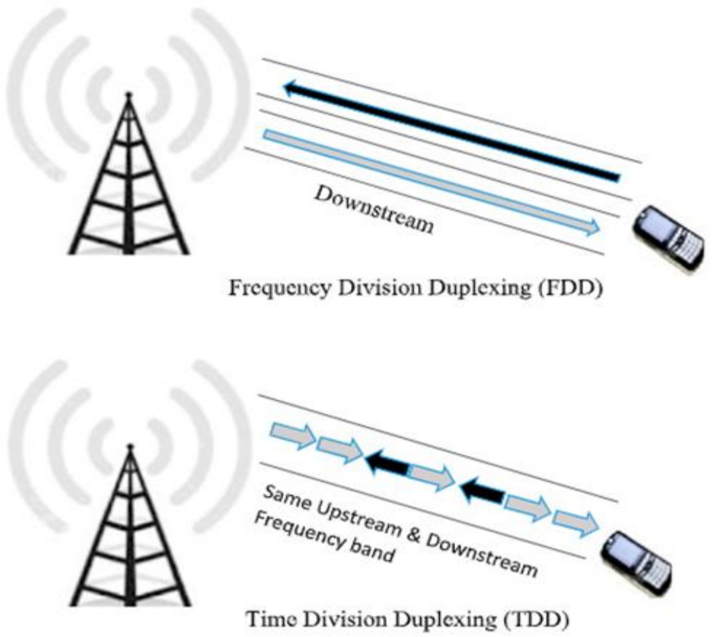

Fig. 1 Uplink and downlink directions

directions can interfere with each other. This is illustrated in Fig. 1, with the use of TDD on the same frequency without coordination and synchronization between sites in the same coverage area. For uncoordinated deployment (unsynchronized) on the same frequency band, the devices connected to the cells with different timing and/or different uplink/downlink allocation may cause blocking for other users. In LTE TDD the base stations need to be synchronized to each other at frame level in the same coverage area to avoid this interference. This can be typically done by using, for example, satellite based solutions like GPS or Galileo or by having another external timing reference shared by the LTE TDD base stations within the same coverage area. LTE FDD does not need the base station synchronization. There is no interference between uplink and downlink in FDD due to the duplex separation of the carriers.

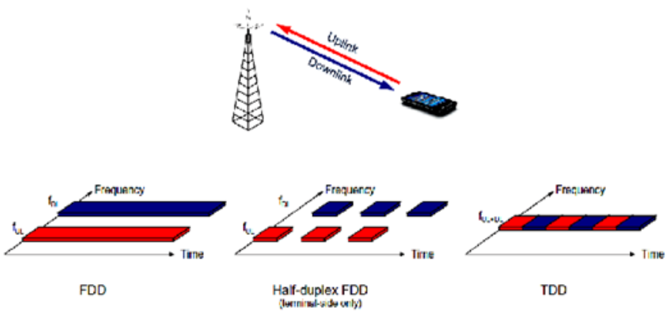

Fig. 2 Frequency & Time-Division Duplex

III. LTE OPERATION MODE

LTE has defined two duplex mode FDD and TDD. FDD utilize paired spectrum resources, where spectrum resources are divided into two identical bands. Uplink and downlink signaling and data are allocated to delicate band respectively and the guard band lays in-between the uplink and downlink band to prevent interferences. Due to the uplink and downlink have been assigned with own spectrum resources, FDD system is continuous in time domain for both uplink and downlink transmission.

TDD does not require paired spectrum, since it will assign all its bands to both uplink and downlink. To distinguish uplink and downlink transmission, TDD system split its time resources, and switch the system operation frequently between uplink and downlink mode. Due to the uplink and downlink transmission utilize the same frequencies, TDD system will assign a guard period between uplink timeslot and downlink timeslot in case that the synchronization is not accurate enough, which help prevent the interferences between uplink and downlink transmission. Therefore, TDD system is continuous in frequency domain, but discontinuous in time domain.

In LTE systems design, the difference between FDD and TDD mode are minimized. Besides the differences in physical layer, they have the same design and are transparent to the layers above. However, the tiny differences between TDD-LTE system and LTE FDD systems define the different characters, performances and applications. For instance, FDD have identical bandwidth for uplink and downlink, which suits the symmetric application. While TDD does not have to assign identical time-frequency resources to uplink and downlink, making it could facilitate asymmetric applications as shown in Figure 3

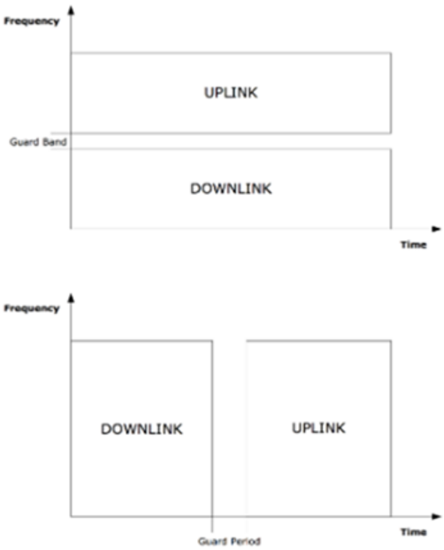

Fig. 3 TDD & FDD working principle

3.1 Introduction to Time Division Duplex

Time-division duplexing (TDD) is a method for emulating full-duplex communication over a half-duplex communication link. The transmitter and receiver both use the same frequency band but transmit and receive traffic at different times. TDD uses the same frequency band by assigning alternating time slots for transmit and receive operations. The information to be transmitted, whether it's voice, video, or computer data, is in a serial binary format. Each time slot may be 1 byte long or could be a frame of multiple bytes.

In time-division duplexing (TDD), time is used to separate the transmission and reception of the signals, rather than frequency (like in FDD), and thus a single frequency is assigned to a user for both directions. TDD provides a simultaneous bidirectional flow of information. Duplexers are therefore not required, and thus the cost of a TDD system is not very high, as the transmitter and receiver use the same components like filters and mixers.

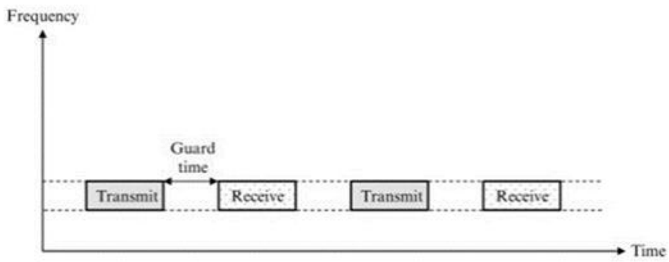

Fig. 4 Time- Division Duplex Operation

TDD uses two-time slots, one for upstream (transmission) and the other for downstream (reception). A guard time between transmit and receive streams is allocated. Time-division duplexing facilitates concurrent send and receive by assigning transmitted signals in the one-time slot and received signals in another time slot. They share the same frequency channel. Like FDD, LTE TDD supports bandwidths from 1.4MHz up to 20MHz but depending on the frequency band, the number of supported bandwidths may be less than the full range. For example, for the 2.5 GHz band, it is not likely that the smallest bandwidths will be supported. Since the bandwidth is shared between uplink and downlink and the maximum bandwidth is specified to be 20MHz in Release 8, the maximum achievable data rates are lower than in LTE FDD. This way the same receiver and transmitter processing capability can be used with both TDD and FDD modes enabling faster deployment of LTE [3].

For instance, in Internet access, download times are usually much longer than upload times so more or fewer frame time slots are assigned as needed. Some TDD formats offer dynamic bandwidth allocation where time-slot numbers or durations are changed on the fly as required. The real advantage of TDD is that it only needs a single channel of frequency spectrum. Furthermore, no spectrum-wasteful guard bands or channel separations are needed. The downside is that successful implementation of TDD needs a very precise timing and synchronization system at both the transmitter and receiver to make sure time slots don't overlap or otherwise interfere with one another. Timing is often synched to precise GPS-derived atomic clock standards. Guard times are also needed between time slots to prevent overlap. This time is generally equal to the send-receive turnaround time (transmit-receive switching time) and any transmission delays (latency) over the communications path.

3.1.1 Features of Time Division Duplex

- TDD's support in a Mesh system allows for significant improvements in spectrum efficiency, coverage and coexistence.
- Allows complete and dynamic flexibility in uplink/downlink traffic symmetry
- Improved coexistence by using time as a mechanism to avoid interference.
- TDD enables Adaptive Antenna Solutions
- TDD flexible asymmetry:
- Future traffic requirements trend towards bursty data for both data and voice in IP-based networks.
- Bandwidth adjusts dynamically to the demands of the user.
- TDD greatly reduces the need for inter-channel guard bands, increasing spectral efficiency.
- Allows system to change symmetry "on the fly".
- Enables advanced techniques, such as mesh networks and adaptive antenna arrayed.
- Effective for bursty, IP-based data. Can increase efficiency 60%.

3.1.1.1 Advantages of Time Division Duplex

- It is more spectrum friendly, allowing the use of only a single frequency for operation and dramatically increasing spectrum utilization, especially in license-exempt or narrow-bandwidth frequency bands.
- It allows for the variable allocation of throughput between the transmit and receive directions, making it well suited to applications with asymmetric traffic requirements, such as video surveillance, broadcast, and Internet browsing.
- Radios can be tuned for operation anywhere in a band and can be used at either end of the link. As a consequence, only a single spare is required to serve both ends of a link.
- The cost of TDD Systems is lower as they can use the same components for Tx and Rx functions.

3.1.1.2 Disadvantages of Time Division Duplex

- The switch from transmit to receive incurs a delay that causes traditional TDD systems to have greater inherent latency when compared to FDD systems.
- As TDD operates based on allocated time slots, it requires stringent phase/time synchronization to avoid interference between UL (Uplink) and DL (Downlink) transmissions.
- Multiple co-located radios can interfere with one another unless they are synchronize
- Traditional TDD approaches yield poor TDM performance due to latency.
- For symmetric traffic (50:50), TDD is less spectrally efficient than FDD, due to the switching time between transmit and receiving.

3.1.1.3 Examples of Time Division Duplex

- Half-duplex packet mode networks based on carrier sense multiple access.
- IEEE 802.16 WiMAX
- PACTOR
- Digital enhanced cordless telecommunication (DECT) wireless telephony
- Universal Mobile Telecommunications System 3G supplementary air interfaces
- TD-CDMA for indoor mobile telecommunications
- TD-SCDMA 3G mobile telephony air interface

IV. EVALUATION OF TDD-LTE SYSTEM

From market point of view, it may not be a difficult decision to upgrade MNO's current network to the latest technology towards 4G, especially for those operating in developed markets and many of the emerging markets, where decent data service becomes one of the main requests from the end users and the selling point for MNO. However, due to the factors like market strategy, available spectrum, capital strength, operational capability or regulatory condition, different operators may end up in several different mobile access technologies as their next generation network solution. Therefore, to identify whether TDD-LTE is a really proper choice for certain operators, much factors could be considered for the decision [4].

4.1 TDD-LTE Spectrum

ITU has defined the E-UTRAN spectrum bands for LTE FDD and TDD-LTE system respectively. As the deployment of LTE system continue to progress, 3GPP has increased the bands planned for both FDD and TDD system, from release 9 to release 11. Starting from release 11, Band 44has been included for TDD-LTE system, which is the lowest frequency band available for TDD-LTE by far. It is good news for TDD-LTE operators, especially for those who plan to construct a stand-alone TDD-LTE network; since Band 44 could help those operators to increase site coverage and reduce construction costs. However, in 3GPP specifications, FDD systems have been offered with more spectrum bands for operators to choose.

Availability and global harmonization of spectrum resources is important to radio system development. At the initial development phase of LTE system, the focuses of global telecom authorities and operators are mainly on LTE FDD systems. Those preferences have driven up the auction price of FDD spectrum resources, and with the continuous allocations of LTE FDD spectrum resources, the remaining FDD spectrums are becoming limited and even more precious. Based on the previous spectrum auction results, LTE FDD spectrums have higher price per MHz in most countries than TDD-LTE spectrums, however the low price advantage of TDD-LTE system could change, if more global operators plan to adopt the systems. Currently, the majority of TDD-LTE bands are 1.8G, 2.3G, 2.6G and 3.5G bands, while the 700M bands from release 11 has not became mainstream. Based on (TD Industry Alliance, 2013), Global operators from Asia Pacific and Europe mainly construct TD-LTE network in 2.3G and 2.6G bands, making them the most favorite bands for industry product development and international roaming. Comparing to LTE FDD system, current TDD-LTE adopters might have relative abundant spectrum resources, since TDD-LTE could utilize unpaired spectrum resources, which have not get enough attention before. For the popular 2.6G bands, 2570-2620MHz bands have been allocated to TDD-LTE operators in several European countries, while in Asia Pacific, some countries intend to allocate the same bands to TDD-LTE operation as their European counterparts, while others intend to allocate all 190MHz bandwidth to TDD-LTE operations (TD Industry Alliance, 2013). These allocations decisions show that global TDD-LTE deployment might enjoy large continuous blocks of spectrum resources, which is crucial to provide service with high capacity and data rates. Beside market advantages, TDD-LTE system could utilize fragmented spectrum resources left in previous deployments. This character will benefit telecom industry even more as carrier aggregation technology is implemented for LTE-A. However, in TDD-LTE systems, due to guard period, the length of cyclic prefix and different special subframe configuration could bring varied overheads to the system, and according to existing test results, the spectral efficiency of TDD-LTE is slightly lower than LTE

FDD, meaning that the capacity of TDD-LTE system is below to LTE FDD system, by using the same bandwidth and radio configuration.

4.2 TDD- LTE Coverage

It is often considered that TDD-LTE has less coverage range than LTE FDD system in the same condition. However, the coverage of radio system could be considered as control channel coverage and traffic channel coverage. The control channel coverage is the minimum requirement for UE to access the network; therefore the coverage range is relatively large. In this sense, TDD-LTE and LTE FDD have similar coverage. But since LTE system is a data oriented network, it is meaningless for end user to access the network without minimum data service guaranteed. When talking about the coverage with minimum cell edge data rate, it is often to select TDD-LTE system with DL/UL configuration 2:2 to compare with LTE FDD system, assuming the same transmitting power, antenna mode and equivalent bandwidth, for instance 10M for FDD and 20M for TDD. But in TDD-LTE system, the special subframe could not transmit uplink data; the efficient uplink bandwidth of TDD-LTE system is therefore lower than FDD LTE system. Therefore, for the same minimum cell edge user uplink data rate, TDD-LTE needs to decrease link budget to compensate for the losses in efficient bandwidth. In this sense, TDD-LTE has lower uplink coverage range but higher downlink coverage range than TDD-LTE system. Both TDD-LTE system and LTE FDD system is uplink limited, therefore the minimum uplink performance usually defines the coverage range. However, there are also other DL/UL configurations, meaning that the uplink and downlink traffic channel coverage could vary when given the same minimum cell edge user data rate. Therefore, it is not precise to say that TDD-LTE has lower coverage than LTE FDD system. The coverage range of TDD-LTE system differs with subframe configuration and system requirements of cell edge users.

4.3 TDD-LTE Asymmetric Character

Traditional voice service is a typical example of symmetric application, however the data services have shown different patterns. For LTE FDD system, it allocates the same bandwidth to both uplink and downlink transmission. Considering the spectral efficiency of uplink and downlink respectably on given scenario, the user peak data rate and system capacity are fixed in a certain ratio. However, the actual data traffic does not always follow the pattern given by the system, and fluctuate according to various factors like time or location, meaning the time frequency resources could be wasted in either direction. Therefore, the inflexibility of LTE FDD system could hardly satisfy the diverse traffic patterns, bought by mobile broadband service and applications with various natures. For TDD-LTE system, 3GPP has defined 7 different uplink and downlink subframe configuration, making it more flexible to different asymmetric scenarios. TDD-LTE system could support both strong uplink biased scenarios and downlink biased scenarios, as well as symmetric applications.

However, in the current setups, it is often recommend to configure TDD-LTE system downlink to uplink subframe rate and special subframe with identical value for all the cells under the same geographic area to prevent issues related to interference and synchronization. Therefore, it still needs to investigate the technical solution of co-existence of TDD-LTE cells with different subframe configuration, and possible self-adoptive algorithms to adjust the subframe configuration according to the feedback of network traffics. Therefore, TDD-LTE system brings potential to offer customized service and applications based on the user pattern and requirement with better utilization of time-frequency resources.

4.4 Synchronization

Radio systems require frequency synchronization and time synchronization. Frequency synchronization is relative easy to achieve, requiring the signal frequency of eNodeB is synchronized with the reference frequency. While time synchronization require the system to synchronize with coordinated universal time (UTC). For LTE FDD system, only frequency synchronization is required, but TDD-LTE also requires time synchronization with the accuracy of microseconds, otherwise uplink and downlink transmission could cause interference to each other.

For LTE FDD system, most eNodeB acquire frequency reference signal for IP based clock source, and such source could usually support hundreds of eNodeB at the same time. While in order for TDD-LTE system to synchronize, additional implementation are needed, for instance GPS or IEEE 1588 V2. GPS solution could achieve high accuracy of time synchronization, but each eNodeB required a GPS signal receiving system, which brings additional cost of installation and maintenance. Besides, GPS antenna requires clear sky view, which could bring deployment difficulties for some indoors sites. For IEEE 1588 V2, even though it is an IP based solution, it is still required to upgrade all the intermediate transmission equipment to support IEEE 1588V2 for time synchronization, which could bring large network upgrade cost and massive operation to some operators, Besides, the precision of IP based solution could be affected by the transmission network performance.

4.5 Channel Reciprocity

TDD-LTE system uses the same frequency bands for both uplink and downlink transmission, and the transmission slots are adjacent to each other, therefore the radio channel environment are highly correlated. eNodeB could estimate the downlink channel condition, based on the receiving uplink information. However, FDD based system use two separated bands to transfer uplink and downlink information, the frequency dependent channel fading characters could cause channel reciprocity hard to be exploited, unlike TDD-LTE system. The channel reciprocity could benefit inter cell interference mitigation and multi antenna beam forming technology, which could efficiently increase cell coverage, capacity and cell edge user performance. For equipment vendors, the channel reciprocity of TDD-LTE systems could also reduce the complexity of terminal and radio equipment transceivers.

4.6 Leverage from other systems

LTE FDD system has been selected by large amount of global operators as the solution for the next generation mobile broadband. Therefore, it has become a mature technology as vendors have gained more experiences for the product development and operators also gain increasing implementation know-how though countless scenarios and conditions. Due to the scale of LTE FDD system, the cost of both production and implementation has been reduced. The design of TDD-LTE and LTE FDD are same for most of the part, and only a few differences exist in the physical layer. The radio equipment vendors could develop TDD-LTE capable network products, based on their LTE FDD experiences. As for the core structure, TDD-LTE system could also share with LTE FDD system. The same situation applies to terminal products, as the TDD-LTE compatible and multi-mode chipset could be developed under the same platform of LTE FDD system. Therefore the network deployment and operation cost of TDD-LTE system could be eliminated, and TDD-LTE customers could have more selections on terminal products. As an evolved technology of TD-SCDMA, TDD-LTE could also leverage the development achievement of TD-SCDMA.

As a member of 3GPP standard technology, TDD-LTE could interoperate with other 2G, 3G technologies and FDD version of LTE. This brings flexibility for TDD-LTE deployment and application scenarios, as some of the implementation drawbacks of TDD-LTE system could be complement by other widely deployment technologies. Besides, international and domestic roaming becomes possible between TDD-LTE system and other 3GPP standard technologies.

V. CONCLUSION

Among the global TDD-LTE operators, many have also chosen LTE FDD systems to provide a convergent network solution, exploring the benefits of both systems. TDD-LTE and LTE FDD shares many similarities in system design, but issues of the convergence networks remain from aspects like network implementation to market strategies. TDD-LTE and LTE FDD could operate in multiple frequency bands, which could enhance the overall system capacity and performance in high demands areas. For instance, operator could implement one layer of LTE FDD system in lower bands for coverage, and complement the network capacity with TDD-LTE system and LTE FDD systems in some higher bands. Since the operating spectrum of TDD-LTE and LTE FDD are from different bands, the interferences between the two systems could be presumably mitigated. As for the mobility management, TDD-LTE and LTE FDD system share the same signaling procedures, and all mobility management functionality are supported within or between TDD-LTE and LTE FDD system, but the handover between TDD-LTE and LTE FDD system bring additional latency, which however could hardly be noticed by data traffic users. The technology maturity level and implementation experiences of TDD-LTE and LTE FDD convergence network grows over the time as more operators implement the solution, but it is still needed to position the two networks based on the technological and market strategies.. When the network loads of LTE FDD systems increase, users will be directed towards TDD-LTE network. Based on the counters of the present traffic of both systems, UE will be transited between networks and new users will be admitted to different networks according to load balancing principals. Operators could also position TDD-LTE network as the prior network, especially when operators possess decent amount of unpaired spectrum resources. TDD-LTE network could be deployed on the most densely populated areas and LTE FDD network will provide coverage for high-speed data services. UE will be admitted TDD-LTE network in prior for the better user performance when both of the network are presented, but when users travels to the outage area of TDD-LTE networks, they will be handover to the underlying network of LTE FDD. Due to the asymmetric character of TDD-LTE systems, operators could also define the admittance and balancing strategy based on the service of subscribers.

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