LTE TDD: The preferred choice for mobile broadband in unpaired bands Authored by Claus Hetting & Stefan Stanislawski, Ventura Team LLP

Significant spectrum and market opportunities are emerging now

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LTE TDD: The preferred choice for mobile broadband in unpaired bands[1]

The demand for mobile broadband is growing rapidly in mature and emerging markets alike. To meet this demand, mobile operators need to invest in significant additional frequency spectrum and new, more efficient mobile broadband technologies. One of the most important is LTE TDD, which will provide a range of significant benefits to operators, end users, and the global mobile broadband industry at large.

The time to act on LTE TDD spectrum is now:

The global move towards LTE is accelerating with spectrum auctions on the way in most significant markets worldwide. The large swaths of unpaired bands to be licensed represent a significant resource that can be effectively employed by LTE TDD to provide much-needed mobile broadband capacity and speed. Our analysis shows that *significant spectral resources* - a sum total of up to **325MHz** distributed across the globe - could be allocated for LTE TDD hereby creating strong market pull. In particular the largest band – **100 MHz at 2.3 GHz** – is in the process of, or will shortly be, licensed in a number of major markets.

LTE TDD offers global economies of scale:

LTE TDD is an integral part of the LTE/EPC standard, which is in the process of being adopted by hundreds of vendors and operators globally. LTE TDD will enjoy similar global economies of scale as LTE for paired bands. All of the infrastructure, chipsets, and device technologies will be readily available at competitive prices.

LTE TDD devices and networks will be commercially mature within only 18-24 months:

Network and device vendors - as well as some major mobile operators - have already committed to developing LTE TDD technology, and live network trials are already well underway. LTE TDD will become the unpaired band commercial technology of choice within the foreseeable future.

LTE TDD real world performance is comparable to LTE in paired bands – hugely improving the customer experience of mobile broadband: Tests and trials worldwide have shown that LTE TDD is fully capable of delivering the high data rate and capacity performance needed to meet the rapidly increasing market demand for mobile broadband. LTE TDD is at least as efficient as, or better than, competing single-band technologies.

[1] ***This paper has been written by Ventura Team LLP to highlight the benefits and opportunities of LTE TDD. The paper was commissioned by the GSMA but the opinions and conclusions are ours alone and do not necessarily represent the GSMA's policies or views.***

Introduction to LTE TDD

LTE or *Long Term Evolution* has been heralded as the next evolutionary quantum leap forward for the mobile broadband industry at large. While the technical capabilities and new business potential of LTE for paired frequency bands (LTE FDD) is already well known, this paper looks at the lesser known but equally important application of LTE broadband technology to unpaired frequency bands – the so-called *LTE TDD* (also called TDD-LTE).

Global economies of scale: LTE TDD is a fully specified and standardized high-performance TDD (Time Division Duplex) mobile broadband technology for both large-scale coverage deployment and a host of special applications, such as broadcasting, femtocells, and more. LTE TDD will leverage the *economies of scale* of the entire 3GPP and LTE community, and LTE TDD-capable infrastructure is already being deployed in trial networks today.

Competitive threat: Some national regulators have already auctioned TDD spectrum (most recently Finland in the 2.6 GHz band) and there is increasing momentum. This spectrum is a significant resource (very roughly one quarter or more of total mobile spectrum and with LTE technology, almost as efficient as FDD spectrum in terms of capacity) and the move to release this spectrum to market is gathering pace. However, TDD-LTE equipment is still 1-2 years from mass production as vendors have focussed on FDD initially. **This poses a dilemma for established mobile operators therefore - whether to secure spectrum now before it can be exploited or to focus on FDD and take the risk of competitors emerging with a significant resource?**

Main findings presented in this White Paper:

- LTE TDD will meet the rapidly increasing demand for bandwidth by providing end-user data rates that are *at least comparable to LTE FDD in similar bands*
- LTE TDD is defined for use with a wide swath of frequencies across the globe
- LTE TDD will leverage *similar economies and scale as LTE FDD* and become part of the LTE ecosystem of vendors, operators, application developers, etc.
- LTE TDD will likely form a part of a *convergent network & device solution* for both TD and FD versions of the LTE standard, which will allow *roaming and network sharing*
- China will be the first country to adopt LTE TDD for nationwide mobile broadband leading the way for further adoption of the standard

Standardisation & frequencies

LTE TDD has been standardized in **3GPP Release 8**, which was frozen and completed at the end of 2008. LTE TDD is the name of the radio access technology only, and LTE TDD generally forms a part of a larger family of standards that also includes LTE FDD and EPC (Evolved Packet Core), which greatly simplifies current core networks with a view to increasing mobile broadband speed and network efficiency. Further additions and improvements to the standard are expected to be implemented in 3GPP Releases 9 and forward[2].

Eight unpaired frequency bands have been identified by the 3GPP for use with LTE TDD, from those defined for TDD technologies by the ITU-R. The unpaired bands are shown below[3] together with their applicable geographical region.

3GPP Band No.:	Frequencies (MHz):	Region:
33	1900-1920	Europe, Asia (not Japan)
34	2010-2025	Europe, Asia
37	1910-1920	Former PCS-band (US)
38	2570-2620	Europe
39	1880-1920	China
40	2300-2400	Europe, Asia
41	3400-3600	-
42	3600-3800	-

The table above strongly suggests that *significant spectral resources* - a sum total of 325 MHz distributed across the globe - could be allocated for LTE TDD technology[4]. It is therefore possible for LTE TDD to be deployed widely, and that LTE TDD may carry a significant part of future global mobile broadband traffic.

Of particular current interest is band 40, which will be used for nationwide deployment in China by the mobile operator China Mobile[5]. But also other major operators – such as Verizon and Vodafone – have taken steps[6] towards a unified, convergent approach to developing LTE technology that includes both TD and FD varieties.

A distinguishing feature of LTE is its *flexible carrier bandwidths*. LTE TDD is defined for *six carrier bandwidths* exactly as for LTE FDD. The bandwidths are 1.4, 3, 5, 10, 15, and 20 MHz. Any of these bandwidths can be

[2] See www.3GPP.org website
[3] "3G Evolution: HSPA and LTE for Mobile Broadband", Wiley & Sons.
[4] Note: the table cites 3GPPs definition of bands for LTE TDD and that any decision as to whether these bands will or will not be used for LTE TDD in the various regions of course is up to national regulatory bodies.
[5] www.lightreading.com, June 26th, 2009
[6] www.cellular-news.com, February 19th, 2009.

used in LTE TDD, although it is likely that only the higher bandwidths will be applied in practice in order to reach the coveted higher data rates.

Key points on spectrum allocation:

- LTE TDD frequencies *have been defined for all regions of the globe*
- Frequencies defined for LTE TDD represent *a sizeable spectrum* for deploying significant mobile broadband capacity in the respective regions
- LTE TDD is best suited to urban environments in the higher frequency bands

Technology highlights

LTE TDD forms an integral part of 3GPP Release 8 specifying the overall LTE & EPC standard for mobile broadband radio access. LTE TDD shares its technical basis with LTE FDD, and in fact differs little from LTE FDD, except for details relating to the obvious change in the duplexing scheme. *In short this means that a large part of the global investment into the development of LTE technology will be applicable also to the LTE TDD variant*.

Downlink & uplink schemes for LTE TDD:

- Downlink scheme: OFDMA (15 kHz subcarriers) & QPSK, 16QAM, and 64QAM
- Uplink scheme: SC-FDMA (N*15 kHz single carrier), same modulation options

LTE TDD uses OFDMA for downlink and SC-FDMA for uplink exactly as LTE FDD, and applies the same modulation schemes up to 64QAM. These are robust multiple access schemes that ensure optimal radio conditions for high data rates and many concurrent users per cell.

In particular, LTE TDD (and LTE FDD) excels at being robust against *multipath fading* – damage to the radio signal due to multiple reflections – and is highly *scalable*. Strong resistance to multipath fading means that *LTE TDD inherently is capable of delivering a high useful data rate per unit bandwidth, i.e. offers high spectral efficiency (in bps/Hz)*.

LTE TDD technology also lends itself very well to inclusion of MIMO[7], which are intelligent ways of greatly boosting performance by including more transmit and receive paths. More details on the MIMO aspects of LTE TDD are provided in a later section.

LTE TDD uses a *single continuous frequency band* for both uplink and downlink data streams by splitting the signal in time. For this to work, a small time delay – *a guard frame* – is introduced to separate the send and receive periods of the data stream. In practice the guard frame ensures that the UE (device) and base station have sufficient time to switch between transmit and receive modes. The guard frame cannot be used for sending or receiving data, so this slightly detracts from the performance.

The common technical basis for LTE TDD and LTE FDD also makes it likely that devices (multi-mode terminals) and - in particular - infrastructure supporting both TD and FD modes will be developed. Reportedly, such efforts are already underway. *On the device end this will enable ease of international and national roaming between prospective operators*.

On the network side converged solutions will also make it possible for LTE TDD and LTE FDD service providers to operate combined TD and FD networks or even *share network infrastructure to cut CAPEX and OPEX*. The sharing of LTE network infrastructure has already been seen by some to be an attractive option. Current network sharing cases include the joint LTE network of Telenor and Tele2 in Sweden.

The latency (or delay) for the overall LTE TDD system is according to the LTE/SAE Trial Initiative[8] (LSTI) verified to be within the 3GPP design targets, meaning 20 milliseconds end-to-end, and identical to that of LTE FDD. The very low latency allows high-quality implementation of time-critical applications such as VoIP, etc. The call setup time is also very low at 100 milliseconds.

Technology highlights for LTE TDD:

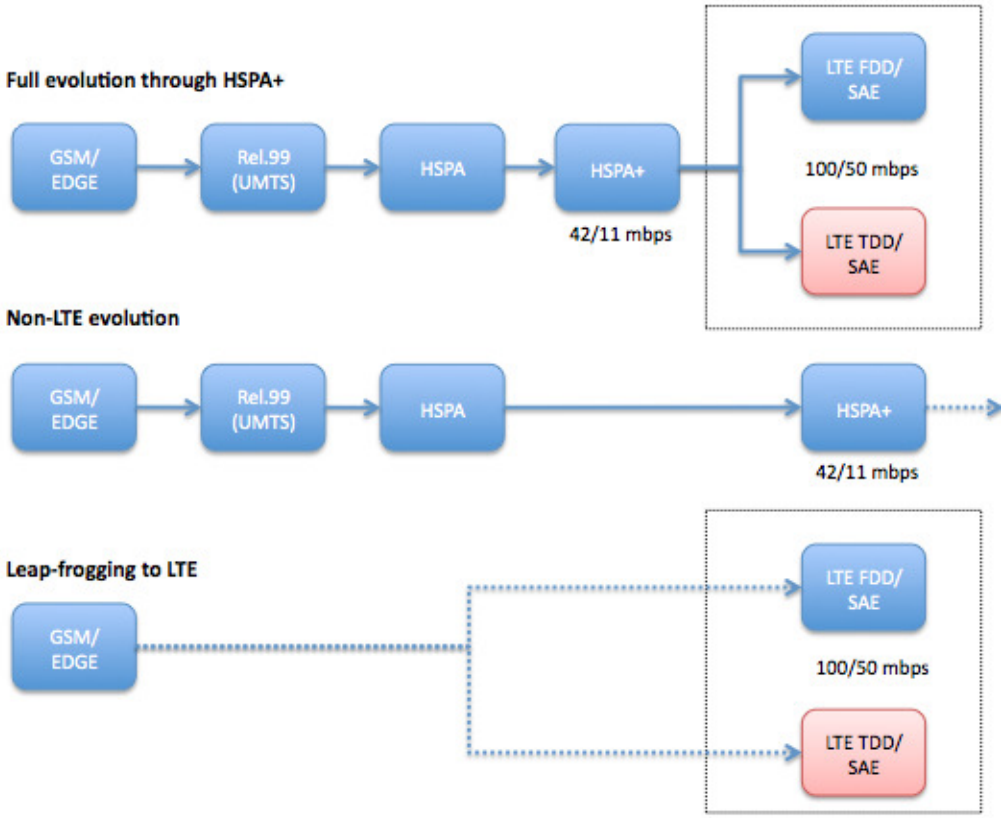
- *Robust radio performance* in challenging urban environments
- *Simpler device & network implementation* because of single-band operation
- Good prospects of *multi-mode devices for both TD and FD networks*
- *Simple implementation of MIMO* to boost end-user data rates & capacities
- Roaming and network sharing to *reduce CAPEX and OPEX* will be possible

[7] Agilent Technologies White Paper: ”3GPP LTE: Introducing single-carrier FDMA”
[8] See www.lstiforum.org for details

Positioning LTE TDD for mobile evolution

LTE TDD is a part of the 3GPP family of standards, which include current UMTS (also known as 3G, W-CDMA, or Release 99 mobile technology). But LTE TDD is clearly not the only option for evolving mobile networks to match the need for higher data rates and more capacity.

A simplified path diagram is shown below (only 3GPP-standard technologies are included) to illustrate various evolution options.



The first option is a full evolution from GSM through to LTE FDD and LTE TDD (either separately or combined) via HSPA+. This may or may not be a relevant evolution depending on the detailed business case for the particular operator, and will e.g. depend on the demand for data speeds and capacity in the given market as a function of time, CAPEX constraints, device evolution, etc.

The operator may also decide to skip HSPA+ and move directly to TD or LTE FDD (although HSPA+ does not usually imply major network upgrades and is typically a smaller investment that evolution to LTE).

The third option may prove relevant for operators in select markets, where 3G technology has not been rolled out yet. It is highly CAPEX efficient as it entirely leapfrogs Rel. 99 and HSPA technology. Leapfrogging

3G and moving directly to TD or LTE FDD would normally require that the mobile operator acquires LTE spectrum, although it is also technically possible that existing GMS/EDGE spectrum could be re-farmed for use with LTE. The second option – included for completeness - moves to HSPA+ only and delays any investments into LTE.

In any of the above cases *the LTE TDD constitutes a natural evolution of 3GPP-based networks as LTE TDD will provide interworking with existing systems*.

Asymmetry & Efficiency

An important feature of LTE TDD is its *asymmetry*: Uplink and downlink data rates can be varied dynamically (although at a relatively slow rate) to match different needs. The downlink rate can be up to nine times higher that the uplink rate by splitting the time durations correspondingly. *This is useful for e.g. broadcast or browsing applications that are naturally asymmetrical*.

Asymmetric downlink/uplink allocations for LTE TDD:[9]

Config. No.	Downlink/Uplink	Approx. peak data rates (DL/UL)
0	2:3	41 / 32 Mbps
1	3:2	62 / 22 Mbps
2	4:1	82 / 11 Mbps
3	7:3	64 / 15 Mbps
4	8:2	82 / 11 Mbps[10]
5	9:1	94 / 5 Mbps
6	5:5	57 / 27 Mbps

LTE TDD is theoretically more spectrally efficient than the LTE FDD. This is because LTE TDD *makes optimal use of the full available unpaired spectrum* for either uplink or downlink data as required by subscriber usage

[9] This is a rough estimate only applicable to 20 MHz bandwidth, 2x2 MIMO (downlink), 1x2 SIMO (uplink) and 16QAM modulation. The rate is calculated by applying a 10% reduction for account for guard rate (uplink-downlink switching) and peak rate measurements from the LSTI. See more details relating to performance below.

[10] There is a subtle technical difference between the 4:1 and 8:2 asymmetric modes: For 4:1 four time frames of downlink are followed by a single time frame of uplink, while for 8:2 eight frames of downlink are followed by two frames of uplink. The 4:1 mode is slightly less efficient than the 8:2 mode because it needs two guard frames while 8:2 only needs one within an identical overall period of 10 frames.

patterns, while LTE FDD is prohibited from using frequencies from the uplink band to boost downlink data rates when needed. This leads to LTE TDD networks using 20MHz being comparable to a mobile WiMAX 802.16e network using 60MHz and similar for a 10MHz FDD network (such as Dual Carrier HSPA+ or LTE FDD in 10MHz).

Theoretical performance

The official industry body for testing and verification of LTE – The LTE/EPC Trial Initiative (LSTI) – confirms that LTE TDD standardized target rates are reachable at least under controlled lab conditions.

Theoretical peak data rates for LTE TDD are determined by:

- Use of bandwidth (from 1.4 MHz to 20 MHz)
- Modulation type (QPSK, 16QAM, 64QAM)
- Use of MIMO (SISO, 2x2 MIMO, 4x4 MIMO for uplink & downlink)
- Uplink/downlink split according to asymmetric TD modes

The LSTI performed laboratory testing of LTE TDD already late last year[11] (November 2008). The results are listed below in a tabular format (assuming an idealized code rate of 1 and 2x2 MIMO for downlink, 1x2 SIMO for uplink). *Note that these are idealized but verified peak laboratory values only*.

Data stream	Modulation type	Efficiency	Peak rate at 20 MHz
Downlink	QPSK	2.8 bps/Hz	56 Mbps
Downlink	16QAM	5.7 bps/Hz	114 Mbps
Downlink	64QAM	8.5 bps/Hz	170 Mbps
Uplink	QPSK	1.4 bps/Hz	28 Mbps
Uplink	16QAM	2.7 Mbps	54 Mbps

The TD asymmetrical mode used in these tests has not been specified. Note that the table above clearly states that the *peak downlink spectral efficiency for LTE TDD at 8.5 bps/Hz is higher than that of competing technology of WiMAX at 7 bps/Hz*[12].

[11] LSTI Forum Update, November 2008
[12] As reported by Detecon on WiMAX Industry website.

Real LTE TDD data rates

Reported real performance figures for data rates range from 29 Mbps[13] (Huawei live LTE TDD trials in Shanghai, November 2009) and more than 100 Mbps[14] (Motorola demonstrations, February 2009), although in neither case have the technical details been disclosed. It is assumed that testing in near-real conditions - including the presence of multiple users in an urban environment – is likely to yield a figure somewhere between the two.

A more recent report (September 2009) from the LSTI[15] states cell-edge performance for LTE TDD is likely to be as low as 0.06 bps/Hz, which translates to 1.2 Mbps with 10 concurrent users. In general the LTE TDD test results align with the overall target that LTE TDD should support performance comparable to LTE in paired bands when using the same amount of spectrum.

The real performance of LTE TDD will depend on a number of factors not least of which are *cell loading and thus interference levels under live network conditions*. The difference between theoretical peak rates and real data rates is expected to be significant.[16] Because LTE TDD is more susceptible to in-band interference degradation than LTE FDD, it is likely that the difference between peak and real data rates on LTE TDD will be greater than for LTE FDD.

In summary: For macro-cell deployment it is fair to say that LTE TDD in 2.3GHz band will offer real data rates comparable to but somewhat lower than when LTE FDD is deployed in the primary 2.6GHz band. For microcell or femtocell short-range or indoor deployment, significantly higher rates are likely because of lowered radio interference and less signal degradation.

LTE TDD performance highlights:

- High theoretical peak user rates of 170 / 54 Mbps (downlink/uplink, 20 MHz)
- Asymmetric uplink/downlink rates to match traffic types for good efficiency
- Peak spectral efficiency *at least as good* as competitive standards (WiMAX)
- Real data rates comparable to LTE FDD for short range deployments)

[13] Huawei press release, November 2009
[14] Motorola press release, February 2009.
[15] www.cellular-news.com, September 27th:"LSTI Trial Initiative completes…."
[16] www.LSTIforum.org latest test results, October 2009

Infrastructure for LTE TDD

The development of LTE TDD networks has been underway since at least 2008 among major technology vendors. Concurrently, the successful testing and interoperability of LTE TDD has been ongoing under the auspices of the LSTI.

As LTE TDD shares much of its technical basis with LTE FDD (and EPC) the following points generally apply to LTE TDD networks regardless of vendor:

- A significant part of the radio network hardware will support both FD and TD varieties of LTE concurrently (but different frequency bands for TD and FD will require own implementation of RF carriers, power amplifiers, filters, antennas, etc.)
- Network architecture is identical for FD and TD including core elements (under EPC)
- Some software & feature differences between FD and TD solutions will apply and it is likely that the LTE TDD option may be sold as an optional feature

Commercially, all major vendors are seen to be developing equipment for LTE TDD including Huawei, Alcatel-Lucent, Nokia Siemens Networks, Ericsson, and Motorola. ZTE is reportedly developing LTE TDD radio network systems based on SDR (Software Defined Radio) principles.

From a business case point of view perhaps the most important development is this: In early 2009 mobile operating giants China Mobile (China), Verizon (U.S.A) and Vodafone (U.K.) announced *a joint effort to support the development of a so-called convergent FD/TD solution for LTE*, i.e. networks and devices supporting both access modes within a single, unified solution.

If successful, this initiative should improve LTE TDD economies of scale and revenue potential by - among other things - exploiting national and international roaming for broadband services as well as opening up for possible network sharing scenarios between operators. The expressed support of major operators also lends impetus to the overall drive towards the quick development of commercial LTE TDD equipment.

Vendor network announcements:

- Ericsson announced in January 2008[17] that it had demonstrated up to 90 Mbps of downlink speed (with 2x2 MIMO) using LTE TDD on a combined TD/LTE FDD base station. In November 2009 Ericsson

[17] Ericsson press release on www.ericsson.com

demonstrated network LTE TDD interoperability towards a user device provided by another vendor (a testing unit developed by Aeroflex).

- More recently – in late November 2009 – Ericsson showcased LTE TDD downlink data rates of 100 Mbps during a demonstration in Guangzhou, China.
- Huawei has since announced[18] that its infrastructure for LTE will support both TD and FD versions of the technology concurrently, i.e. within the same network equipment. The company has according to recent press releases (November 2009) successfully trialled a live LTE TDD network for China Mobile in Shanghai with downlink speeds of up to 29 Mbps.
- ZTE of China has reportedly also been contracted by China Mobile to build a LTE TDD network for Shanghai city in 2010.
- Alcatel-Lucent announced in November 2009[19] that it has been selected to supply a LTE TDD trial network for China Mobile in Shanghai. It has also announced that its LTE TDD network solution will be a common platform for both TD and FD varieties of LTE.
- Motorola announced November 17th 2009 that it has also been selected to provide a LTE TDD trial network for China Mobile, and that it is the first vendor to pass functionality testing on the platform[20].
- In October 2009 Nokia Siemens Networks announced successful LTE TDD data calls on an NSN radio network equipment trial setup at their R&D facility in Hangzhou, China.

LTE TDD infrastructure highlights:

- Identical architecture to LTE FDD with EPC for *cost-efficiency & high performance*
- Broad platform *synergy with general LTE/EPC networks* and economies and scale
- Convergence initiative for TD/FD announced by major operators
- LTE TDD live trials ongoing in China with at least Huawei, Alcatel-Lucent, Ericsson, Motorola, Nokia Siemens Networks, and ZTE
- Extensive testing ongoing with most major vendors

[18] Huawei press release on www.huawei.com
[19] Alcatel-Lucent press release, November 18th, on www.alcatel-lucent.com
[20] CNN Money.com news report November 17th, 2009

Chipsets & Devices

In addition to Huawei, which also provides LTE TDD capable devices, chipmaker Qualcomm of the U.S. has announced its intention to launch a multi-mode LTE FDD/LTE TDD chipset along with backward compatibility to 3G services.

Also chipmakers ST-Ericsson and Israeli-based Comsys have reported that they will support both TD and FD modes in their LTE chipsets. It is expected that Korean vendors LG and Samsung will follow suit.

In Japan NTT DOCOMO, NEC, Panasonic Mobile Communications, and Fujitsu have announced the joint development of an LTE mobile device platform and chipset. The announced chipset will be multi-mode capable across 2G, 3G and LTE mobile technologies.

Other chipset providers Infineon, Freescale, Wavesat, and NXP (Philips) have committed to provide LTE technology for devices and infrastructure, and most are expected to be multi-mode capable across 2G and 3G technologies up to and including LTE. Some have not explicitly mentioned LTE TDD capability, although this capability must be expected.

From a survey of current major vendors it appears that both TD and FD technology is on the roadmap and under development.

Applications: Voice services, broadcast, & femtocells

Voice Services over LTE TDD

A main weakness of the LTE standard – including both TD and FD varieties – is the lack of a specific standard for voice services. To address this shortcoming a group of vendors and operators jointly agreed to pursue an IMS-based solution for voice called “One Voice”.

The idea of this solution is to provide VoIP services on LTE networks over a reduced and more pragmatic version of IMS (IP Multimedia Subsystem). The One Voice solution referred to a part of the IMS standard defined by the 3GPP – enough to allow the efficient, high-quality delivery of voice over LTE TDD, while reduced so as to ease practical implementation.

At Mobile World Congress in February 2010, GSMA adopted the work on One Voice and relabelled it as the GSMA Voice over LTE initiative (VoLTE). GSMA brought much greater backing to the work (over 20 operators

and 20 vendors, plus backing from 3GPP, NGMN Alliance and IMTC). Support by operators for VoLTE is voluntary, but the weight of support from both the operator and vendor community means that VoLTE is likely to become the de facto standard for the industry, as the target solution that all operators migrate towards.[21]

Broadcast

The variable split between uplink and downlink makes LTE TDD an ideal technology for mobile broadcast applications, such as mobile TV over e.g. MBMS. For broadcast applications the operator may chose to employ nearly the entire unpaired spectrum (in e.g. a 9:1 configuration) to transmit in the downlink direction, i.e. digital mobile TV at high data rates.

In this manner the unpaired LTE TDD could be used effectively as the broadcast complement to LTE FDD in regions, where both will be licensed. When used as a complement in this manner, operators may capitalize on new revenue streams without adversely impacting quality and speed data services delivered on LTE FDD.

Femtocells

Femtocells are very small radio network base stations used for indoor coverage in residences, offices, or the like. Although this type of technology has so far not been deployed widely so far in 2G or 3G, femtocells may prove a real option for ensuring the continuous and seamless coverage for LTE TDD.

A challenge for all mobile operators is overcoming the signal-attenuating effect of walls and other structures. Indoor mobile broadband coverage is difficult and often requires a higher density of outdoor base stations, a higher power output, or other CAPEX-intensive methods. Femtocells circumvent all these issues by providing indoor coverage directly.

LTE TDD femtocells offer further benefits for LTE FDD operators: By using unpaired spectrum and LTE TDD femtocells for indoor coverage, operators would entirely avoid indoor coverage interfering with any outdoor LTE TDD network macro-layer.

[21] http://www.gsmworld.com/newsroom/press-releases/2010/4634.htm

In November 2009 Nokia Siemens Networks[22] reported that it had demonstrated the technical functioning of LTE TDD femtocells together with China Mobile. The intention is to provide a solution for combined indoor-outdoor coverage using femtocell base stations and regular macro base stations.

Application highlights:

- Voice over LTE TDD will likely be provided by IMS (*OneVoice* pragmatic IMS solution)
- Mobile TV or other broadcast (e.g. MBMS) well suited to LTE TDD asymmetric interface
- LTE TDD femtocells already in trial phase for high quality indoor coverage

Regional focus: LTE TDD for China Mobile

The world's largest mobile operator by subscriber – China Mobile – has had a challenging time in its transition to 3G mobile technology & services. Only 2.3 million subscribers out of a huge base of 513 million are currently on the China-specific TD-SCDMA standard, a homegrown TD-version of third generation CDMA-based networks. TD-SCDMA is standardized in 3GPP Release 4 but has to this date only been implemented in China.

The evolution path from TD-SCDMA to LTE TDD over a Chinese-specific version of HSPA adapted for TD (time division duplex) and standardized by the 3GPP in Release 7. But it is likely – even probable given recent events – that China Mobile will chose to skip general HSPA deployment and move directly to LTE TDD as it will offer greatly improved data rate performance and capacity.

The first serious step for China Mobile is building a trial LTE TDD network for the Shanghai World Expo to be held May-October 2010. According to a recent news report[23] speeds are expected to reach 60 Mbps.

[22] Nokia Siemens Networks press release November 18th
[23] "China Mobile Outlines 4G Plan", www.zacks.com

China Mobile's apparent commitment to LTE TDD is enormously important for the overall development of the ecosystem and economies of scale for LTE TDD, as China Mobile represents a huge number of potential LTE TDD subscribers.

LTE TDD and TD-SCDMA are closely aligned and designed to operate concurrently within one area, inside one network, and on adjacent bands. This is because LTE TDD and TD-SCDMA share the same time structure, and thus can be aligned to send and receive at the same time. Technically this is of significant benefit, because it reduces the need for a guard band, and thus saves spectrum.

China LTE TDD highlights:

- World's largest mobile operator China Mobile is committed to LTE TDD
- Trialling with LTE TDD networks is already ongoing for China Mobile (Shanghai 2010) with major providers including Ericsson & Chinese vendors
- Relatively simple migration for TD-SCDMA (current technology) to LTE TDD

Summary: LTE TDD highlights

Although LTE TDD is less known that its LTE FDD cousin, the global vendor and operator community is already well on its way to develop fully operational LTE TDD solutions and services. The list below shows the highlights and status of LTE TDD.

The highlights of LTE TDD:

- Eight bands and extensive swaths of spectrum already defined for global deployment
- Excellent spectral efficiency: at least as good bps/Hz values as for competing (non-3GPP) TDD mobile broadband technologies
- Real LTE TDD data rates expected to be comparable to LTE FDD in similar bands
- Very few technical differences relative to LTE FDD: LTE TDD will be a part of the same ecosystem as LTE FDD, and will benefit from economies of scale
- TD/FD multimode infrastructure and devices already confirmed by significant vendors
- Single band operation means sharing of hardware & lowered equipment costs
- Solutions for femtocells and VoIP (over IMS) announced
- Technology of choice for world's biggest mobile operator, China Mobile
- Trial networks and testing already ongoing

Acronyms

3GPP: 3rd Generation Partnership Project

LSTI: LTE/SAE Trial Initiative (see www.lstiforum.org)

OFDMA: Orthogonal Frequency Division Multiple Access

SC-FDMA: Single Carrier Frequency Division Multiple Access

TDD (TD): Time Division Duplex

FDD (FD): Frequency Division Duplex

EPC: Evolved Packet Core / System Architecture Evolution

MIMO: Multiple Input Multiple Output

SIMO: Single Input Multiple Output

SISO: Single Input Single Output

IMS: IP Multimedia Subsystem

VoIP: Voice over Internet Protocol

MBMS: Multimedia Broadcast Multicast Services

QPSK: Quadrature Phase Shift Keying

QAM: Quadrature Amplitude Modulation

UE: User Equipment (device or terminal)

HSPA: High Speed Packet Access

HSPA+: High Speed Packet Access Evolved

GSM: Global System for Mobile Communications

EDGE: Enhanced Data Rates for GSM Evolution