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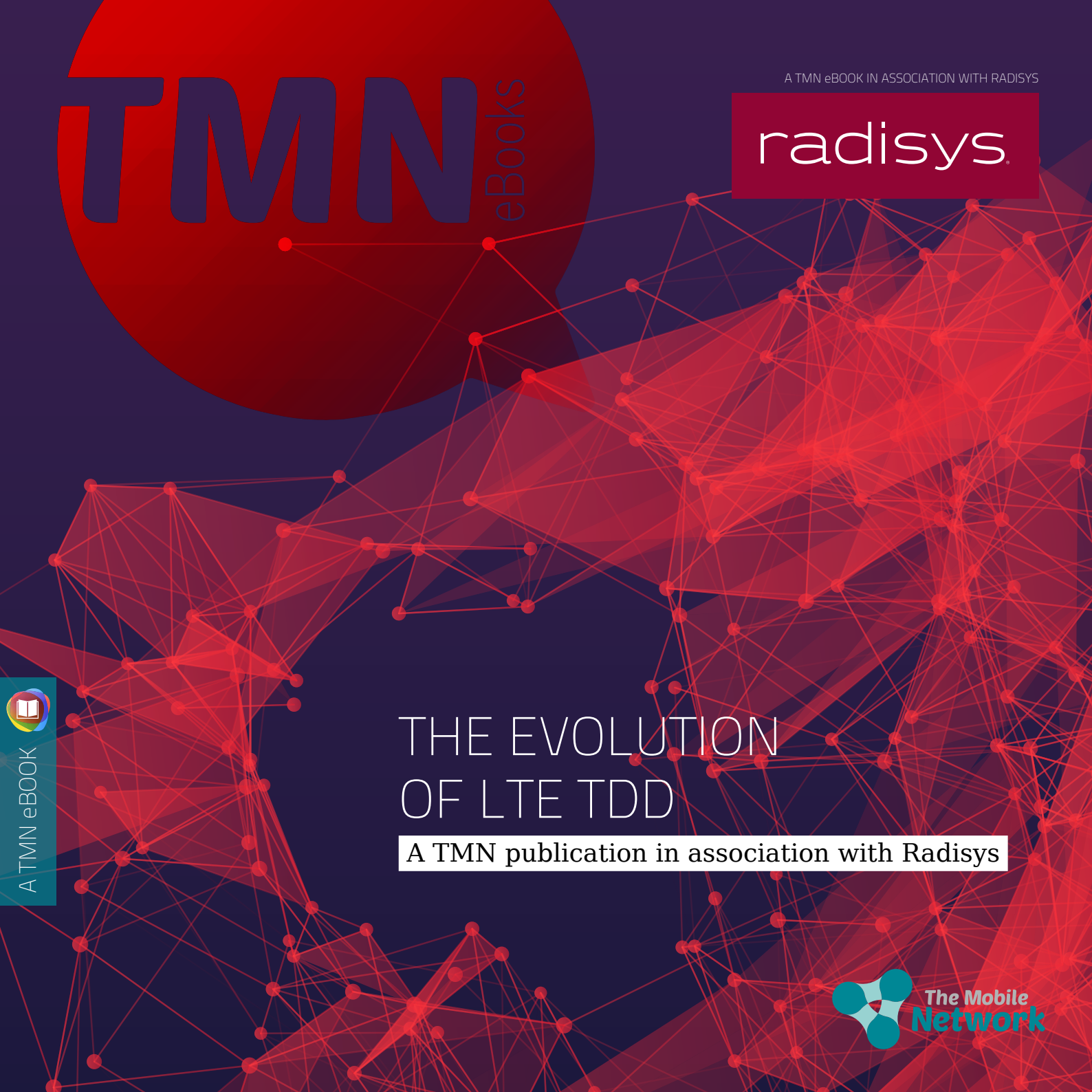

A TMN eBOOK

THE EVOLUTION OF LTE TDD

A TMN publication in association with Radisys

The Mobile Network

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INTRODUCTION

Todd Mersch, Senior Director of Software & Services, Radisys

Thank you for downloading this e-Book, one of a series Radisys has produced in association with The Mobile Network. LTE TDD is a technology that is rapidly gaining awareness globally, as operators seek to meet increasing user demands whilst extracting full benefits from their spectrum assets.

This eBook, through its lead article by Renuka Bhalerao and market infographic, provides an essential resource for all those interested in understanding the advantages LTE TDD can bring to the modern mobile operator.

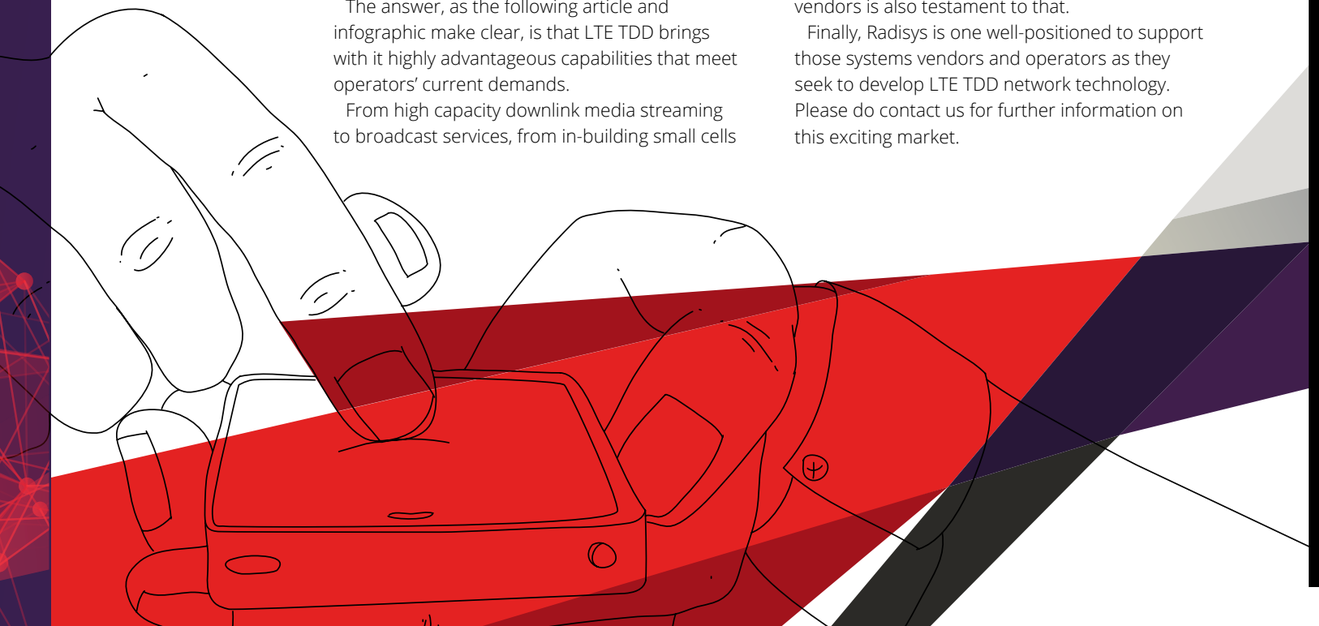
Perhaps the most important question this eBook seeks to answer is, why now for TDD? Why is this asymmetric mode rising up as a priority, when it was so little deployed within 3G networks?

The answer, as the following article and infographic make clear, is that LTE TDD brings with it highly advantageous capabilities that meet operators' current demands.

From high capacity downlink media streaming to broadcast services, from in-building small cells to backhaul, LTE TDD is a mode that enables operators to develop and support dynamic new use cases in a fashion that is interoperable with other 3GPP network standards and requires little additional infrastructure investment.

That is why we are now seeing increased market momentum and activity in the industry bodies to develop and deploy the technology. The growing ecosystem of chip, system, test and platform vendors is also testament to that.

Finally, Radisys is one well-positioned to support those systems vendors and operators as they seek to develop LTE TDD network technology. Please do contact us for further information on this exciting market.



THE EVOLUTION OF LTE TDD

With the emergence of smart devices, people are downloading content in unprecedented amounts, which is 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 going after bandwidth-consuming applications like YouTube and Netflix, leaving operators searching for technology to stay ahead of this ever-growing demand.

Many operators are looking to LTE as the de facto global standard for mobile broadband technology due to its cost savings, high spectral efficiency, mobility and interoperability. Even with LTE, however, operators see a need to offload their data traffic in order to provide users with wireline-like speed and capabilities. According to a recent report by Qualcomm[1], while LTE allows operators to use new, wider spectrum and complements existing 3G networks to handle even more mobile traffic, radio link improvement is fast approaching the theoretical limit and the spectrum available to operators is often limited and expensive.

In a race for providing a wireline-like experience to wireless users, operators are not leaving any stone unturned. Operators are already offloading data traffic via small cells and Wi-Fi, but have found that these solutions lack mobility. Wi-Fi is effective in improving user experience when a significant portion of users are located in the vicinity of hotspots – such as residential homes, airports and coffee shops – and the resulting data traffic can be offloaded to Wi-Fi applications, however it's not mobile. A mix of macro cells and small cells, also referred to as a Heterogeneous Network (HetNet), as well as small cell value added services like Local IP Access (LIPA) can ease pressure, but these solutions are also constrained to a specific location and number of users.

Just when operators are at a point where they have exhausted all possible data offload approaches, Time Division Duplex (TDD) in the form of LTE shines through. TDD has the potential to be positioned as a complementary solution to Frequency Division Duplex (FDD) networks, bringing additional capacity to congested areas, opening up a new way of data offload and backhaul for small cell deployments.

WHAT IS TDD?

There are two modes of operation for LTE technology: FDD and TDD, which are technically very similar and part of the same radio access specification.

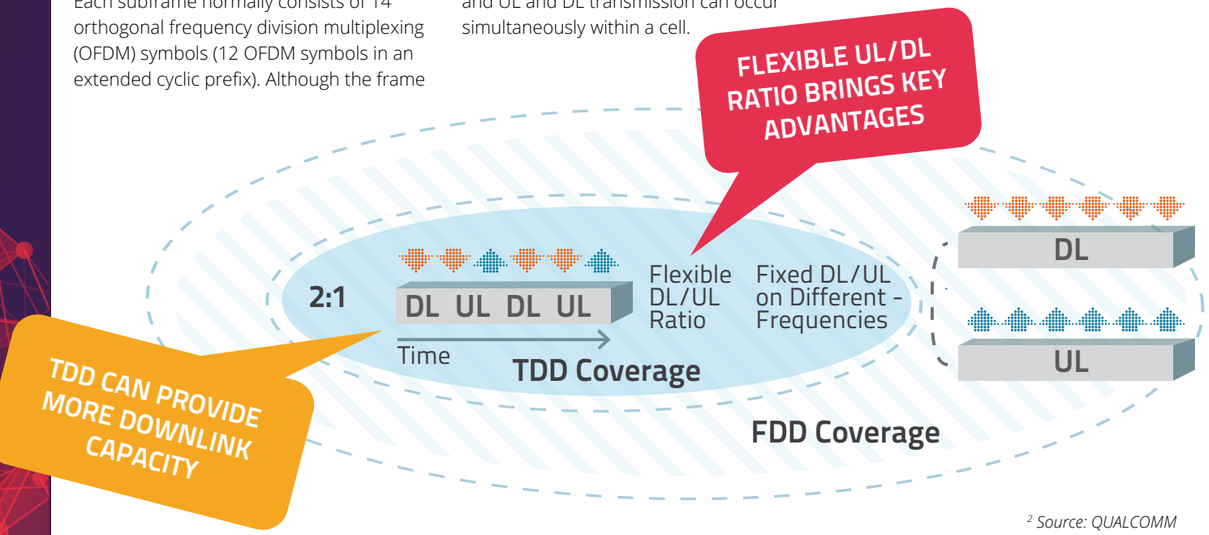
LTE FDD and TDD were both defined and introduced as part of the 3GPP specification in 2009 to make efficient use of paired and unpaired spectrum allocations over a common, core network architecture. The main differences are around the duplex method used.

In both LTE FDD and LTE TDD, the transmitted signal is organised into subframes of one millisecond (ms) duration and 10 subframes constitute a radio frame. Each subframe normally consists of 14 orthogonal frequency division multiplexing (OFDM) symbols (12 OFDM symbols in an extended cyclic prefix). Although the frame structure is, in most respects, the same for LTE FDD and LTE TDD, there are some differences between the two - most notably the use of special subframes in TDD. The subframes in TDD are allocated either for uplink (UL) or downlink (DL) transmission.

In the case of FDD operation, there are two carrier frequencies, one for UL transmission and one for DL transmission. During each frame, there are consequently 10 UL subframes and 10 DL subframes, and UL and DL transmission can occur simultaneously within a cell.

In TDD operation, there is only a single carrier frequency, and UL and DL transmissions in the cell are always separated in time. As the same carrier frequency is used for UL and DL transmission, both the base station and the mobile terminals must switch from transmission to reception and vice versa. Thus, as a subframe is either a UL subframe or DL subframe, the number of subframes per radio frame in each direction is less than 10.

FIGURE 1.
FDD can cover a larger area with the fixed DL/UL on different frequencies, but TDD can provide more DL capacity with the flexible DL/UL ratio[2].



[2] *Source: QUALCOMM*

LTE TDD'S RELATIONSHIP TO FDD

TDD makes it relatively easy to dynamically change the capacity ratio between UL and DL to reallocate time slots, which makes it well suited for today's DL-heavy traffic pattern.

In most instances, network operators will desire more DL capacity than UL since users more frequently download content like video and web pages than upload content they've created.

Beyond the regional deployments of TD-SCDMA, TDD wasn't deployed widely in 3G networks, but it has great potential in LTE. The operator community was originally hesitant to adopt this new technology due to its similarity to WiMAX, but has since discovered that TDD and FDD technologies can co-exist nicely and is now supportive of a new market with LTE TDD. Because they have common core network architecture, there is no additional CAPEX and the two technologies interoperate seamlessly. The main difference is the need for a specific radio frequency (RF) unit. Another significant difference is in the physical layer definition; the higher layers and the rest of network architecture remain applicable for the FDD.

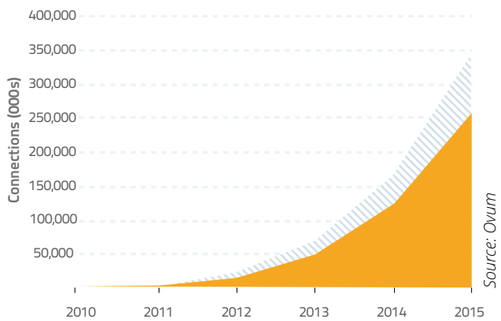
FDD is still leading the game, however. Most commercial LTE networks are based on FDD because the FDD ecosystem is more mature and is still where most of the spectrum allocation is done. All major operators around the world are already acquiring wide bands of FDD spectrum for their 4G LTE networks, which is well suited for voice because it is inherently symmetric in the UL and DL. In addition, FDD can provide better coverage of a larger area due to the fixed DL/UL on different frequencies.

However, some operators are able to exploit the TDD advantage by deploying the two technologies in tandem to offload traffic for very asymmetrical applications such as video or even newer areas like machine-to-machine (M2M) applications. For example, Vodafone has developed an innovative use case of LTE TDD being used as a backhaul for small cell deployments. As multimedia broadcast and multicast services (MBMS) pick up traction, it makes even more sense to effectively deliver this broadcast information in the DL using the unpaired TDD without impacting the user services delivered on FDD in parallel.

Existing FDD networks can leverage LTE TDD for targeted capacity expansions, ensuring a larger economy of scale by utilising common EPC network architecture wherever possible. TDD is excellent for hot-spot expansions (picocells and femtocells) and new LTE TDD networks plan for small nodes from day one.

LTE TDD is an excellent indoor complement for small nodes because it does not interfere with the FDD network. It is the ideal technology to leverage unpaired spectrum, which is typically available at higher frequency bands optimal for capacity expansion, making it less fragmented. Most FDD deployments use 2.6GHz, but some of the largest rollouts used other bands. The risk associated with a technology deployed in many different spectrum bands is that its adoption is hindered because manufacturers will not create as many devices to support it. TDD is in a much better position since most of the rollouts are expected in only two frequency bands: 2.3GHz and 2.6GHz. Chipset manufacturers are especially interested in 2.3GHz deployments for well-populated countries. TDD also enables a number

FIGURE 2.
Ovum estimates that LTE FDD will take-off around 2012–13, while TDD will take off around 2013–14 for LTE TDD[3].



of smart-antenna technologies such as beamforming. A mix of LTE TDD hot-spots with LTE FDD macrocells will boost capacity and expand coverage.

Most vendors in network infrastructure equipment and device chipsets support both TDD and FDD in their commercial products, indicating that they see a strong market potential for both flavors.

This simplifies implementation and minimises the additional OPEX/CAPEX costs to deploy LTE TDD. TDD is comparable to FDD in data throughput as well as latency measures, and handover (HO) procedures can be enabled from FDD to TDD and vice versa. This is the new beginning of the hybrid LTE TDD/FDD deployment model.

THE CURRENT STATE OF TDD TECHNOLOGY ADOPTION

LTE TDD is expected to be widely adopted in 2015, reaching 89 million connections and representing roughly 25 percent of the total forecasted LTE connections for that year.

It is defined for six carrier bandwidths ranging from 1.4 to 20MHz, although it is estimated that it will be most widely used in higher bandwidths, similar to FDD. The telecom community is already working on additional definitions for backward compatibility aspects and reselection. In addition the introduction of LTE to other markets such as public safety and health care brings the evolution of the TDD technology full circle - TDD actually started in these markets.

There's no shortage of TDD devices either. Qualcomm, the dominating player in the handset chipset market in the US, is ready to launch a multi-mode LTE FDD/LTE TDD chipset along with backward compatibility in 3G services. ZTE and many other companies are also working to ensure that devices will be available with FDD and TDD support at no extra cost.

TDD spectrum is already allocated in numerous countries. Several UMTS mobile operators in Europe and Asia received small chunks of TDD spectrum in the 2.1GHz band. The spectrum was allocated at the same time as larger channels of UMTS FDD spectrum and in most cases the TDD spectrum went unused. However, most operators are opting to roll out TDD on 2.3 GHz and 2.6 GHz. These bands offer the largest contiguous blocks of spectrum enabling the best possible performance.

While TDD is selling quickly, unpaired bands are still available and are not as expensive as FDD. For countries in Europe, Asia and Latin America, following the recommendations of the European Conference of Postal and Telecommunications Administrations (CEPT), this means that 50MHz of TDD should be integrated alongside 2x70MHz FDD for 2.6GHz auctions. Other countries are allowing operators to decide which technology to opt for. In addition, some markets distributed licenses that were technology-neutral, allowing licensees to use their spectrum for LTE TDD.

Vendors around the world have conducted interoperability tests (IOTs), making TDD technology more reliable, and many have announced plans to deploy LTE (FDD or TDD). For example, TDD is an option for WiMAX operators or greenfield operators with 2.3GHz or 2.5GHz spectrum, so there has been a trend for WiMAX operators to switch to LTE. The technical expertise gained from WiMAX development is also a valuable asset when it comes to developing LTE TDD solutions because both technologies are all-IP OFDM-based. These similarities provide an easy path for WiMAX operators transitioning to LTE.

TDD'S INTRODUCTION INTO DIFFERENT MARKETS AND REGIONS

TDD is already seeing momentum in Asia and Europe as many launches in these regions are including TDD in their network roll out plans. UK Broadband has launched LTE services in London, Reading and Swindon, using Huawei's LTE TDD solution. This is the first LTE TDD 3.5GHz deployment in the world and the first commercial LTE TDD deployment in the UK. Trading under the name now Broadband, UK Broadband also operates a wholesale model, working with partners to offer commercial services to businesses, consumers and the public sector.

In large cities like Beijing, many people live in high-rise apartment buildings made of concrete, which creates both coverage and quality challenges for mobile operators transitioning to frequency technologies such as 4G/LTE. To improve service, operators are circumventing the local FDD macrocell base station and using residential TDD femtocells to transmit calls over the household's broadband connection.

China and India are committed to deploying this technology and other operators in various countries are supportive primarily due to the economies of scale. TDD represents the future of China Mobile's broadband strategy and India's broadband wireless access (BWA) auction boosted the industry's interest in LTE TDD. Demand for equipment supporting TDD started primarily in China and Japan due to greater flexibility in how frames are transmitted over an open air interface. These countries are requesting TDD-based femtocells because it can more easily manage capacity and reduce interference compared to FDD. With three of the largest regions selecting LTE TDD deployments, it is likely that other countries will also vie for their share in this market. For example, Clearwire and Sprint have already taken TDD into the Americas.

For telecom equipment manufacturers (TEMs) seeking to serve all markets worldwide, Radisys Trillium LTE software is a safe choice because it supports both FDD and TDD. Radisys offers best in class LTE TDD solutions along with complete end-to-end LTE solutions. In a recent case-study a Tier-1 TEM incorporated Trillium TotaleNodeB LTE Femtocell Software and contracted PHY/MAC integration assistance from Radisys Services to save time and development costs compared to doing everything in-house, allowing them to get to market in six months rather than two years or more. The Trillium software was designed to support scaling from small to large deployments and has been optimised to run a single processor with limited resources on multiple architectures.

CONCLUSION

With plenty of data offload techniques, the introduction of the HetNet concept, the improvements in spectral efficiency and the innovative data plans now being offered, the mobile broadband dream of providing a wireline-like experience to wireless users is becoming a reality.

TDD technology emergence is a new beginning of the hybrid LTE TDD/FDD deployment model, opening up a new way for capacity addition and data offload. The industry is gravitating toward mixed LTE deployments where femtocells and small cells employ TDD and macro base stations use FDD to create a HetNet topology that eliminates interference issues. Implementing TDD on femtocells can lead to improved quality signal and optimised bandwidth allocation thus delivering a high quality experience to the end users. TDD has already demonstrated its potential to overcome the challenges wireless networks are facing today. Due to its affordable spectrum it will become a respite in congested areas, adding capacity for the offload of asymmetric data like video and M2M applications.

About the Author - Renuka Bhalerao, Sr. Product Line Manager
Renuka is a Senior Product Line Manager at Radisys Corporation with her primary focus on Small cell Technologies for 3G and LTE and is responsible for the Trillium software portfolio. Prior to this, Renuka held the position of Principal Systems Architect in a customer-facing role specializing in Telecom Software and Systems. Renuka has 17+ years of telecom industry experience with expertise in wireless and VoIP solutions. **www.radisys.com**

FOOTNOTES

QUALCOMM whitepaper, A Comparison of LTE Advanced HetNets and Wi-Fi, October 2011. http://www.qualcomm.com/media/documents/comparison-lte-advanced-hetnets-and-wifi

[2] *QUALCOMM presentation, LTE TDD, The Global Solution for Unpaired Spectrum, September 2011. http://www.qualcomm.com/media/documents/lte-tdd-global-solution-unpaired-spectrum*

[3] *Julien Grivolas, Principal Analyst, OVUM whitepaper, Global opportunities for LTE TDD, February 2011. http://www.lte-tdd.org/sites/default/files/Global%20Opportunities%20for%20LTE-TDD.pdf*

LTE TDD:

1. AN INTRODUCTION

The 3GPP LTE standard is designed to operate in paired spectrum (Frequency Divvision Duplex – FDD mode) or unpaired spectrum (Time Division Duplex – TDD mode).

The TDD mode uses unpaired spectrum, with a single carrier frequency used with downlink and uplink transmissions separated in time.

SPECTRUM:
The two modes deliver similar performance and benefit equivalently from evolution of the standard.

There are many LTE TDD bands, but the largest are at 2.3 GHz (100 MHz – band 40) and 2.6 GHz (band 38). These are the main bands for LTE TDD systems deployments in Europe, India, China and APAC, the Middle East, and Latin America.

Unpaired spectrum's flexible uplink/downlink ratio means it can be used dynamically to support asymmetric applications such as streaming and broadcast services

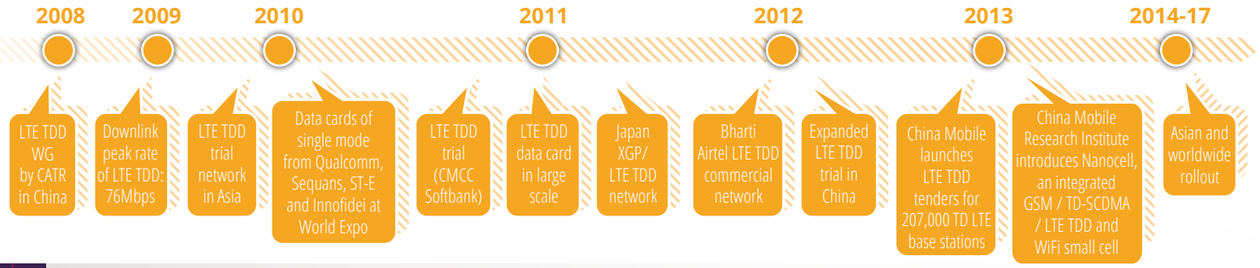
2. WHAT'S DIFFERENT?

3G also had TDD spectrum - largely unused.
What is different this time?

Operators are under more pressure than ever to optimise spectrum assets and to meet consumer and enterprise demand for increased bandwidths.

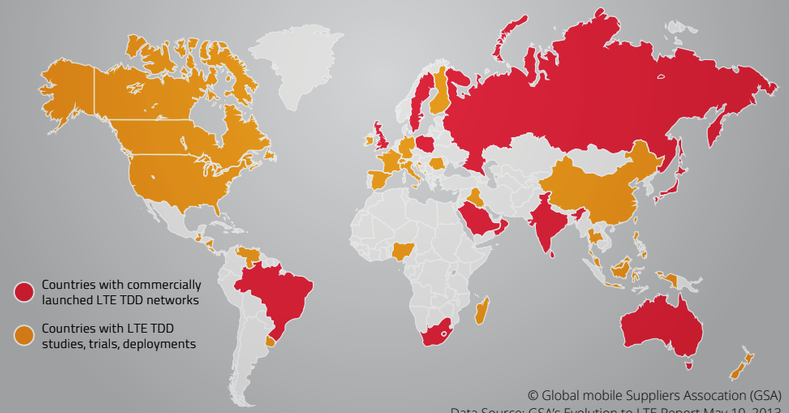
LTE TDD spectrum is often less expensive than FDD spectrum, making its deployment more cost-effective. It's not an either/or situation. LTE TDD and LTE FDD can work in harmony. Many radio platforms have up to 90% commonality. The industry is proposing intelligent offloading of traffic between LTE TDD and LTE FDD to increase capacity and optimise the utilisation of both.

TD LTE COMMERCIAL DEVELOPMENT TIMELINE



LTE TDD INVESTMENTS WORLDWIDE

16 commercial LTE TDD Systems and a further 38 LTE TDD Commercial networks in deployment or planned



© Global mobile Suppliers Association (GSA)
Data Source: GSA's Evolution to LTE Report May 10, 2013

PLANNED AND LAUNCHED
(18 launches) networks lists

Australia	NBN Co	Band 40
Australia	Optus FDD & TDD	Band 40
Brazil	On Telecommunicaoes	Band 38
Brazil	Sky Brazil Services	Band 38
Hong Kong	CMHK FDD & TDD	Band 38
India	Bharti Airtel	Band 40
Japan	Softbank XGP/LTE TDD	Band 41
Oman	Omantel FDD & TDD	Band 40
Poland	Aero2 FDD & TDD	Band 38
Russia	Megafon FDD & TDD	Band 38
Russia	MTS FDD & TDD	Band 38
S.Arabia	Mobily	Band 38
S. Arabia	STC FDD & TDD	Band 40
S. Africa	Telkom Mobile (8ta)	Band 40
Spain	COTA Murcia4G	Band 38
Sri Lanka	Dialog Axiata FDD & TDD	Band 40
Sweden	3 Sweden FDD & TDD	Band 38
UK	UK Broadband	Band 42,43

3. MARKET MOMENTUM

i. **Operator interest**
50 operators in Global LTE TDD Initiative (GTI)

ii. **Device and vendor ecosystem**
166 LTE devices from a total 821 LTE devices - 20% LTE devices have support for LTE TDD mode.
Major manufacturers support:
LG Optimus LTE TDD mode launched in Saudi Arabia 2013.
Most established support for Bands 38 and 40.
Nine companies bid for China Mobile's LTE TDD tender, showing widespread support for the mode amongst base station and platform vendors.

iii. **Increased support for spectrum**
harmonisation amongst operators and regulators. In October 2012, China's Ministry of Industry and Information Technology announced that the entire 190 MHz of spectrum in the 2.5/2.6 GHz band will be allocated for LTE TDD deployments in China, which harmonises its TDD spectrum with Japan and the US, two major LTE markets.

NOW AND IN THE FUTURE: LAUNCHES & TRIALS

i. Late 2011 and early 2012 sees launches from Softbank in Japan, Etisalat Mobily and STC in Saudi Arabia, and Bharti Airtel in India.

ii. Mid 2013, China Mobile launches tender for 207,000 base stations in 31 provinces across China.

iii. Telecom Asia reported that China Mobile plans capital expenditures of around €24 billion this year, of which more than half will flow into LTE TDD investments.

DID YOU KNOW?
LTE TDD is not just about access. Vodafone is using the spectrum to support small cell backhaul in Madrid and Barcelona, allowing it to deploy high capacity small cells exactly where they are required.

BUT IT'S NOT JUST CHINA...

i. By July 2013, there were 18 commercially launched LTE TDD networks. 54 operators have made LTE TDD commitments. 6 operators have launched combined FDD-LTE TDD networks.

ii. ARCChart predicts "massive" launches in, India, Brazil, Russia, Japan and USA, generating revenues of $91 billion by 2017.

CAN YOUR NETWORK BOOST THE BOTTOM-LINE?

MAXIMISE
SPECTRUM UTILISATION
with Radisys small cell solutions

With the deployment of small cells, the emergence of HetNet and improvements in spectral efficiency, the mobile broadband dream of providing a wireline-like experience to wireless users is becoming a reality.

Implementing LTE TDD can lead to a new way of capacity addition and optimised bandwidth allocation – increasing quality of experience and coverage and enabling operators to monetise mobile broadband.

Radisys is first to the market with LTE-TDD solutions, provides an accelerated TDD Roadmap and is actively supporting customers for TDD trials and deployments.

LTE TDD READY SMALL CELL SOLUTION

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