Field Trial of BWA-LTE on 2300 MHz in Dense-Urban Environment

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***Abstract*—In this paper, the devices test and trial results of the performance of Broadband Wireless Access (BWA) with Long Term Evolution (LTE) technology on 2300 MHz in the dense-urban environment are described and analyzed. The performance of this test is explained by downlink and uplink throughput results via video streaming, FTP server transferring, web browsing, VOIP and online gaming. The test results of this trial will help operators to gain more experience to implement BWA technology and utilize communication devices effectively. Moreover, the performance analysis of the devices test and field trial will support the NBTC as the regulator to regulate BWA services properly and effectively.**

***Index Terms*—BWA, LTE, field trial, performance, dense-urban, 2300MHz.**

I. Introduction

Long Term Evolution (LTE) is a radio platform technology that permits operators to achieve higher peak data than what is currently afforded by 3G. The two types of LTE which are LTE TDD and LTE FDD shares similar characteristics such as comparable performance and spectral efficiency. They differ in terms of the physical layer and therefore the version implemented is transparent to the higher layer which permits them to coexist. All major chipset vendors including ST-Ericsson, Altair and Qualcomm have already released chipsets that support both LTE TDD and LTE FDD. Therefore, LTE TDD is gaining popularity in all regions as it is a vital part of 3GPP standards and is therefore considered an evolution in wireless cellular TDD technology. It is expected to reach maturity stage as in the case of LTE-FDD in the long-term.

"The 2300MHz band has already been defined as a 3GPP eUTRAN band (band 40) based on a Time Division Duplex (TDD) scheme" [1] and Dense-Urban Environment. In Canada, the 2300-2400 MHz band is allocated to the fixed, mobile and radiolocation services [2], and to the broadcasting-satellite service in the band 2310-2360 MHz [2]. The 2305-2320 MHz and 2345-2360 MHz portions were specifically identified and designated for WCS applications in fixed and mobile environments. In particular, operators in India and China have been conducting field trials and demonstrations of LTE TDD technology through joint ventures with manufacturers and chipset vendors [3].

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A significant ecosystem for LTE devices is expected to emerge in the 2300 MHz band, given that global interest is growing—especially in Asia-Pacific countries—to deploy broadband systems in this band. Moreover, According to Huawei, "multi-band, multi-mode LTE-TDD dongles and CPEs are commercially available from all major chipset and device manufacturers, including the 2300MHz band (3GPP band 40), 2600-TDD (3GPP band 38)" [3]. It is expected that by 2014, several LTE networks with time-division duplexing (LTE TDD) using the 2300 MHz spectrum will be launched in the form of new deployments and WiMAX-to-LTE TDD migration — predominantly in China, India, Malaysia, Australia and South Korea [3]. More than 60 countries have assigned the 2300 MHz to mobile operators to deliver broadband wireless services or at least have announced that they intend to deploy LTE on 2300 MHz in the next two year [3]. Therefore, evidence suggests that equipments for LTE-TDD on 2300 MHz will achieve economies of scale.

It is expected that operators will utilize the entire spectrum that they have access to because capacity requirements for BWA is extremely high. Similarly spectrum shortage in Thailand is currently too critical to neglect. Therefore, with the global trend supporting LTE TDD on 2300 MHz, and with LTE TDD equipment for 2300 MHz certain to achieve economies of scale, it is more critical than ever for Thailand to conduct this trial.

The National Broadcasting and Telecommunications Commission (NBTC) as the regulator of Thailand plays very important role to manage broadband spectrum for operators to create benefits for the country. To solve spectrum shortage in Thailand in the near future, temporary licenses for BWA trial are issued to operators to motivate Thai telecommunication industry to gear towards to broadband services.

In August 2012, NBTC cooperated with telecommunication operators and conducted a BWA-LTE devices test and field trial to move quickly on constructing an BWA-LTE system as a field-proven platform for the dense-urban area.

II. Test Configuration and Methodology

The objective of this trial is to measure and study the performance of BWA with LTE on 2300 MHz in the dense-urban environment. We selected a very busy business area in Bangkok which is categorized as a dense-urban environment. We set a complete BWA-LTE network which is composed of access network and core network.

eUTRAN consists solely of eNodeB on the network side and performs tasks similar to that of eNodeB5 and RNC

(Radio Network Controller) in cooperation with UTRAN. The purpose of distinguishing this similarity is to reduce latency of all radio interface operations.

The different LTE UE category parameters provided by the 3GPP Rel 8 standard is given in the Table I below [4].

TABLE I: DIFFERENT LTE UE PARAMETERS BY 3GPP REL 8

Category	1	2	3	4	5
Downlink	10	50	100	150	300
Uplink	5	25	50	50	75

eUTRAN NodeB, also known as Evolved NodeB, (abbreviated as eNodeB) is the hardware that communicates directly with mobile handsets (UEs), like a base transceiver station (BTS) in GSM networks.

To achieve the objective of the test and trial, we measured the downlink and uplink throughput via multimedia applications video streaming, FTP server transferring, web browsing, VOIP and online gaming. Specifically, the test was designed to:

- Demonstrate that BWA-LTE performance under realistic BWA-LTE deployment scenarios in the dense-urban environment.
- Explore throughput rates in a single and multi-user environment.
- Test the latency performance by transmitting data packet and measure Round Trip Time (RTT)
- Test the performance of UE speeds on link performance.
- Test user's applications on BWA-LTE services such as web service, VOIP, Streaming Video, and Game online.

Mobile terminals were installed in vans for the drive test. While UEs also installed in the vans are connected to antennas which are located on the roof of the van. This provides variable SINR as channel conditions changing along the drive route. The same test configuration is used in lab tests; however, in lab tests transmission is via the air interface, the LTE base station (eNodeB). Also, UE are connected to a channel simulator that implements various radio channel characteristics and noise situations. The antenna is mounted on a pole on the roof of buildings at various heights above the ground, as shown in Table II. It is a commercial 3-sector cross-polarized wideband antenna with 65 degree directivity operating in a frequency range of 2310 to 2330 MHz. The system can support MIMO implementing an antenna gain of about 18 dBi.

TABLE II: EXPERIMENTAL PARAMETERS

Frequency	2310-2330 MHz
Bandwidth	20 MHz
Antenna Bandwidth	18 dBi , 65 degree
RRU output Power	43 dBm
CPE Capability	UE Type
Test Area	Outdoor / Dense-Urban
Lab Test Site	3 Locations
Field Test Site 5 Locations (Height ; m)	eNodeB1 = 25 m (drive test) eNodeB2 = 42 m eNodeB3 = 30 m eNodeB4 = 24 m eNodeB5 = 30 m

The test performed adopted BWA-LTE Development platform, which consists of BWA-LTE base station (eNodeB) that consists of BWA-LTE test terminal, GPS receivers and various laptops to act as a local maintenance terminal, application services and application clients +[5]. The overall scenario consists of 5 base station sites, each of them with three sectors (30°, 150°, 270°).

III. TEST RESULTS

A. Drive Test

The drive test was performed along a public area in the area from eNodeB1 (located at Latitude: 13°44′ 41.6″ N and Longitude: 100° 31′ 50.5″ E) as shown in Fig. 1. The aim of this research is to illustrate the download link data throughput at low UE speeds in a typical urban BWA-LTE cell with cell radius of 700 meters and under conditions that antenna signals are may be affected by high buildings [5]. The DL throughput measured by transferring DL 100 Mbytes files with FTP server.

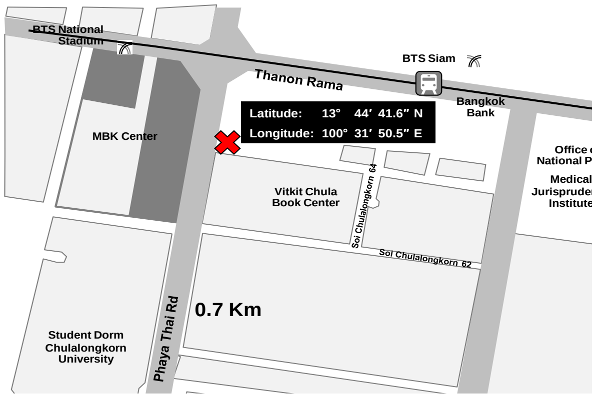


Fig. 1. Route and drive test.

The test conducted in this research measures the DL throughput rate result that are attainable in dense-urban cells under varying channel conditions and typical urban speeds. Fig. 2 shows the received DL throughput along the dense-urban route. The measurement in this research is performed at a time with high traffic and there were several stops at several traffic lights junction. The average speed attained was therefore only 30–50 km/hr. The DL throughput results are approximately of 10 to 65 Mbps. The test results varied to a high degree particularly depending on the shadowing conditions from high buildings on the test route and results decreased with increasing distance from the site.

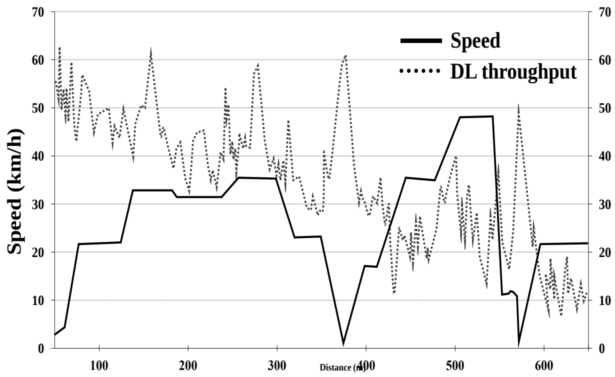
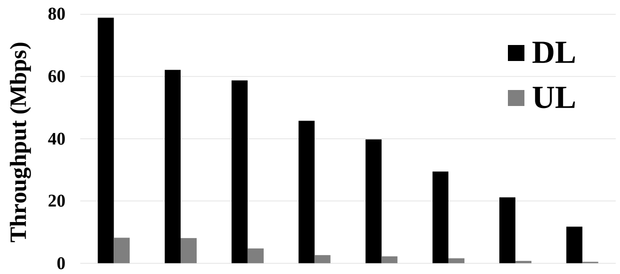


Fig. 2. Downlink throughput (drive test).

Fig. 3 shows the average of DL/UL throughput along the route of drive test. We also measure the signal to interference plus Noise Ratio (SINR) along the route.

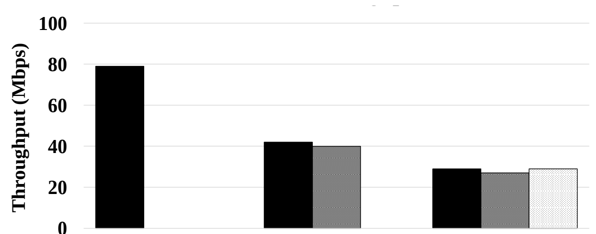


SINR (dB)	29.8	27	22.9	19.2	15.7	12.5	9.1	4.1
DL (Mbps)	78.9	62.14	58.75	45.79	39.81	29.47	21.18	11.76
UL (Mbps)	8.21	8.1	4.79	2.6	2.22	1.62	0.77	0.46
Distance (km)	0.01	0.05	0.15	0.25	0.35	0.45	0.55	0.65

Fig. 3. Average DL/UL throughput respected to distance and SINR.

B. DL Throughput in a Single and Multi-User Environment

To study cell downlink throughput, we measured DL throughput at the test site (eNodeB1) in each user in 3 scenarios (single user, 2 users, and 3 users in a cell). The results show in Fig. 4 which can be proved that the LTE system can manage DL throughput effectively. The measured in this test was about the same as the theoretical LTE standard [5].

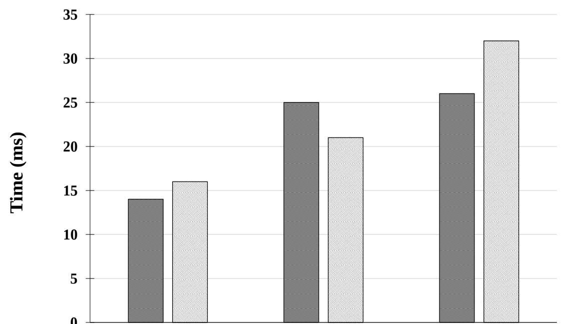


	single user	2 users	3 users
UE1	78.56	44.83	28.95
UE2		41.16	26.37
UE3			29.38

Fig. 4. Cell downlink throughput.

C. The Latency Performance

The latency performance was evaluated by sending repeated data packet in various sizes (32 kbyte, 1000 kbyte and 1500 kbyte) to a FTP server. Fig. 5 shows that the latency results are less than 50 ms (RTT < 50 ms) which is acceptable results under the LTE standard [5].



	32 bytes	1000 bytes	1500 bytes
With no load	14	25	26
With 3TCP sessions	16	21	32

Fig. 5. Latency.

D. Application Operations Environment Test

We tested the application operation environment on the BWA-LTE system by running various types of applications such as video streaming, FTP file transferring, web browsing, VoIP, and online games. We found that applications traditionally used on a fixed network could indeed run on an BWA-LTE system. This is proved that the high-speed, large-capacity, and low-latency features of the BWA-LTE can serve practical applications in the real environment.

IV. Concluding Remark

The field trial described in this paper evaluated an end-to-end BWA-LTE system covering a dense-urban environment in Siam square area, Bangkok, Thailand. The findings were used to assess system performance, from basic characteristics such as latency performance and DL/UL throughput. Results showed that the system has sufficiently high performance even in the field. Also tested in the field trial was the applicability of BWA-LTE system operations. The findings showed that applications traditionally used on a fixed IP network could also operate on an LTE system. In future trials, NBTC will test systems designed for various types of areas such as coverage holes and indoor dead zones and will test solutions to problems faced by telecommunications operators and regulators. The field experience will facilitate the design of infrastructure solutions, as well as network planning and field deployment. This will be advantageous for both the users and the operators.

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