IMT-Advanced - Objective and Challenges

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Abstract—This paper describes drivers and objectives for IMT-Advanced mobile broadband system defined by ITU-R as well as technical challenges.

Keywords-component; IMT-Advanced; LTE; IEEE802.16; WiMAX

I. INTRODUCTION

The life with “internet” have evolved from simple eMail and file transfer, web surfing to enriched web-based communities and hosted services, such as social-networking sites, video sharing sites, wikis, blogs, and folksonomies. It can be said that most of these services are “user centric” and “user driven” and gradually changing the way we communicate and the business model.

LTE and WiMAX started with solving clear technical objectives: improve radio spectrum efficiency and provide economical Mobile Broadband Wireless network. We should also consider how this evolution will enable new service to be created and how it may create new business models similar to what has been happening with Web 2.0.

Obvious advantage LTE and WiMAX will offer is high speed transport. Higher bandwidth availability means less time to download (or transfer) given amount of data. This will significantly increase variety of information download/push services because minimizing the time to wait for information is one critical issue when assessing the usability of any service.

In addition to the higher radio transport capability, introduction of all IP network architecture and various Open Interfaces will allow more flexibility in developing and deploying new services. Like evolution commonly know as Web 2.0 in the fixed internet world, user driven, user centric development of new services will likely to take place and will bring about new business models.

To meet the ever increasing demand for wireless broadband communication (e.g. increased number of users, higher data rates, video or gaming services which require increased quality of service, etc.), IMT-Advanced is currently under discussion in ITU-R, 3GPP, and IEEE802.16.

II. TWO APPROACHES TOWARD IMT-ADVANCED; WiMAX AND LTE

Although current WiMAX and LTE may seem similar, it is different in many ways. The difference in the current specification is mainly due to the intended deployment scenario and the timing of specification definition. IEEE 802 LAN/MAN Standards Committee has developed IEEE802.16 which defines WirelessMAN™ air interface specification for wireless metropolitan area networks (MANs). Since the initial issue in October 2001, it has evolved from fixed broadband access system to mobile broadband access system. LTE standards have been developed by 3GPP as evolution of Third Generation Mobile System to support growing needs for high speed data traffic. Although LTE can support VoIP, it is assumed to coexist with existing mobile system (2G and/or 3G) for some time.

Both WiMAX and LTE advanced are currently candidate technology of IMT-Advanced. In order for these technologies to be chosen as technology for IMT-Advanced, it must satisfy common requirements and support services specified by ITU-R [1][2].

Figure 1. Evolution of Wireless Broadband Access technologies

A. Spectrum efficiency

Spectrum efficiency (Cell spectral efficiency, Peak spectral efficiency, Cell edge user spectral efficiency) and scalable bandwidth up to and including 40 MHz are required to support...
various broadband services. These requirements are essential to meet the growing need for higher speed by efficiently utilizing the limited frequency resources available.

The following frequency bands have been identified by ITU-R [3] for IMT and/or IMT-2000 by WARC-92, WRC-2000 and WRC-07:

- 450-470 MHz
- 698-960 MHz
- 1 710-2 025 MHz
- 2 110-2 200 MHz
- 2 300-2 400 MHz
- 2 500-2 690 MHz
- 3 400-3 600 MHz

ITU-R has developed frequency arrangements for the bands identified by WARC-92 and WRC-2000, which are described in Recommendation ITU-R M.1036-3. For the frequency bands that were identified at WRC-07, work on the frequency arrangements is ongoing in ITU-R.

Although lower spectrum is preferable considering the indoor penetration loss, the difficulty is anticipated to obtain bandwidth up to and including 40 MHz. Aggregation of spectrum in different frequency bands that may be required to support minimum service requirements and traffic coverage.

Femto cell deployment is another approach to effectively improve spectrum efficiency. By reducing the size of radio cell and increase the reusability of the same frequency bands, it is an attractive solution for indoor application. (e.g., home, small to medium enterprises, enclosed public areas, etc.)

B. Migration issues

IMT-Advanced system will most likely be deployed along side of or as an over-lay to the existing wireless mobile network. For some combination, seamless handover to/from other technology will be required. In certain deployment scenario, concurrent operation in different network technology may be required.

When deploying IMT-Advanced network in a region where voice telephony traffic is predominant and small data user is expected, it may be more efficient, from network resource perspective, to use earlier generation mobile system (e.g., GSM) for voice and use IMT-Advanced network for data services. In this scenario, end devices most likely must support concurrent operation in both network environments. If IMT Advanced network is deployed only in selected areas initially and if VoIP based telephony service is offered, it will be mandatory requirement to support seamless handover from IMT Advanced to earlier generation mobile network which has much better radio coverage. The handover will be required for both voice and data traffic.

For the Basestations, the migration requirement is slightly different. In short, smooth evolution scenario is often a requirement to reduce capital investment by up-grade or re-use the equipment as much as possible. Due to the similarity in key technology adopted by LTE, WiMAX, IMT-Advanced up-grade for some deployment can be done by simple software upgrade.

III. KEY TECHNOLOGIES

A. Spectrum issues

It is well know that both OFDMA and MIMO are two key technologies providing the throughput and spectrum efficiency for WiMAX, LTE, and IMT-Advanced system.

Due to the practical limitations such as portability requirements of end devices (i.e., size and power consumption limitations) and the mobility requirements, we are reaching the practical limit of achieving spectrum efficiency using these technologies.
IV. Technical Challenges

A. Power Efficiency

Reduction of BaseStation power consumption is a requirement both from reducing OPEX as well as reducing the size of equipment for easy installation and less conspicuous installation. For a high power output amplifier, power efficiency is especially important to reduce the size of the equipment. From the manufacturer’s perspective, low cost of production is also essential.

![Output Power vs Efficiency](image)

**Figure 3. Output Power vs Efficiency**

For WiMAX (802.16e based system) and LTE, LDMOS (Laterally Diffused Metal Oxide Semiconductor) or Gallium nitride (GaN) amplifier with Digital Pre-distortion technique can achieve better than 30% power efficiency and meet all RF requirements specified by IEEE802.16 or 3GPP specifications. For future application, HEMT (High Electron Mobility Transistor) devices are promising but commercially available devices are currently limited to an application for certain frequency spectrum.

NEC has developed transmitter amplifiers for mobile base stations, a 2.1GHz model that produces 45W of output power per 100W of power consumption by adopting high performance and highly reliable RF transistor technologies, in addition to independently optimizing Doherty RF circuitry with harmonic tuning.

B. RF Filter

Any equipment which radiate radio signal must conform to spurious emission requirement specified. Although some attempts are made to define uniform specifications in certain frequency bands, it is often different in each country/regions. Depending on the system using the adjacent spectrum, spurious emission requirement may even be different within the same spectrum band. If the entire spectrum intended for the system is available initially, band pass filter providing the sufficient elimination of spurious emission can be provided.

The traditional filter approach is inconvenient for a scenario where desired spectrum bandwidth is not initially available. The Basestation must initially conform to the spurious emission requirement of the allocated narrow channel. When adjacent spectrum become available, it is preferred to be used as one contiguous wider channel but it will have different

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spurious emission requirement and filter cut off frequency will be different from the initial configuration. In some cases, it may be more economical to replace the amplifier and filter section of the Basestation. The Remote RF Head configuration where RF Unit is physically separated from the base band processing portion of the Basestation will allow such replacement with ease. For situations where physical replacement of RF Unit is not an economical solution, tunable filter or easily replaceable filter will be necessary.

C. Smart Antenna Technology

As mentioned previously, Mobile device has disadvantage due to power consumption and physical size limitation. The up-link performance characteristics often become the limiting factor of coverage. In MIMO configuration, Maximum ratio combining (MRC) is used at the receiving end to improve performance.

MRC is a simple processing technique that uses pilot or control channel signals to estimate channel characteristics for multiple antennas and then apply weights to each antenna to maximize signal to noise ratio for the summed signal. MRC captures diversity and combining gains but does not involve active interference mitigation or spatial multiplexing in any way. MMSE, or minimum mean squared error, is another variation on this receive-processing approach.

Adaptive antenna systems (AAS) take the basic concept of MRC a few steps further — by building a richer model of the channel using training data embedded in the traffic channel that enables focusing more closely on users of interest and defocusing on interferers in both transmit and receive. AAS captures diversity, combining, and interference rejection gains.

V. Evaluation of radio interface technologies for IMT-Advanced

ITU-R has issued a guidelines [4] for both the procedure and the criteria (technical, spectrum and service) to be used in evaluating the proposed IMT-Advanced radio interface technologies (RITs) or Sets of RITs (SRITs) for a number of test environments and deployment scenarios for evaluation.

The evaluation criteria specified are: Cell spectral efficiency, Peak spectral efficiency, Bandwidth, Cell edge user spectral efficiency, Control plane latency, User plane latency, Mobility, Intra- and inter-frequency handover interruption time, Inter-system handover, VoIP capacity, Deployment possible in at least one of the identified IMT bands, Channel bandwidth scalability, Support for a wide range of services.

VI. Conclusion

This paper described drivers and objectives for IMT-Advanced mobile broadband system defined by ITU-R. With considerations of some realistic deployment scenarios, technical challenges and some solutions are proposed to realize economical solutions to realize IMT-Advanced system to provide Mobile Broadband environment.

REFERENCES


![Distribution of Communication Quality](Result of UL Simulation analysis)

![Figure 4. Uplink simulation analysis of MRC and Adaptive Interference Cancelation](image)