

FTTA Fiber-To-The-Antenna – Technology Change in Mobile Communications

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Introduction

Mobile communication is a regular part of our daily lives. Children use mobile handhelds with the same easiness as business people, however, we are currently only at the beginning of a true mobile communication world. The current status of mobile communication is comparable to that of the conventional telephony and the internet in the early nineties. Call rates are high, subscribers are not permanently “online” but have to dial onto the internet, and the available data rates are low. With the emerge of next third-generation mobile communication systems (3G), flat rates (i.e. customers only pay a basic rate irrespective of the number of talk minutes) and higher data rates are already a reality in some European countries. The alternative mobile communication system WiMax promises data rates of up to 72 Mb/s and is thus comparable to fast, cable-based internet connections. This means that mobile network operators for the first time represent serious competition for conventional cable network operators. In Japanese and U.S. cities, WiMax is already being established and subscribers can remain permanently online to read emails and daily newspapers, watch TV programs, surf the internet, make online purchases, as well as using a range of new services. Subscriptions for cellular phone networks will change radically and, as a result, only online rates will be payable, and there will be no data limitations or call charges. The next generation mobile communication systems enable a real world of mobile communication for the first time, with the fiber optic links to cell-site antennas playing a central role in the process.

Trends in mobile communication

At the beginning of the nineties, the first digital mobile communication system GSM (Global System for Mobile Communications) was introduced and proved to be a global success story. GSM is also called the second generation of mobile communication systems (2G), as it succeeded the first analog mobile communication system. GSM was developed primarily for voice telephony, but GPRS also permitted packet-switching data transmission for the first time. The subsequent introduction of EDGE in 2003 enabled higher data rates of up to 250 Kb/s due to new modulation techniques. GSM is now the most widespread and most widely installed mobile communication system.

Based on the success of GSM, the leading manufacturers of mobile communication systems Ericsson, Nokia, Alcatel and Siemens developed the third-generation cellular network UMTS (Universal Mobile Telecommunication System) in the late nineties and it was heralded on the market before the millennium. However, due to the telecom crisis after the year 2000, its introduction to the market was considerably delayed, and the first UMTS systems were not installed in Europe until 2003. What was originally the “universal” cellular phone standard split into three regional standards as the result of differing national and corporate objectives (see Fig. 1). The European W-CDMA system (now also often known as UMTS) established itself worldwide. However, the CDMA2000 system (also abbreviated to CDMA) has a dominant position in the U.S. The systems operating on the basis of the Chinese TD-SCDMA standard are being installed as a matter of urgency to ensure that network coverage is fully established before the Olympic Games in Peking in the summer of 2008. As opposed to GSM, third-generation (3G) cell phone systems are optimized on the basis of packet-switching data transmission. For example, HSPA (High-Speed Packet Access) is a further development of UMTS (see Fig. 1), which enables data rates of up to 28 Mb/s. In the middle of the current year, there were approximately 200 million registered 3G users, which accounted for only 6.7% compared with 3 billion GSM mobile phone users. Leading countries with complete 3G coverage are Japan and South Korea, with Italy, Austria and England taking leading positions in Europe.

Companies such as Ericsson or Nortel are already working on the fourth generation (4G), which is scheduled to come onto the market in 2009/2010 under the name LTE (Long-Term Evolution). With data rates of up to 150 Mb/s, we will enter a real mobile communication world for the first time.

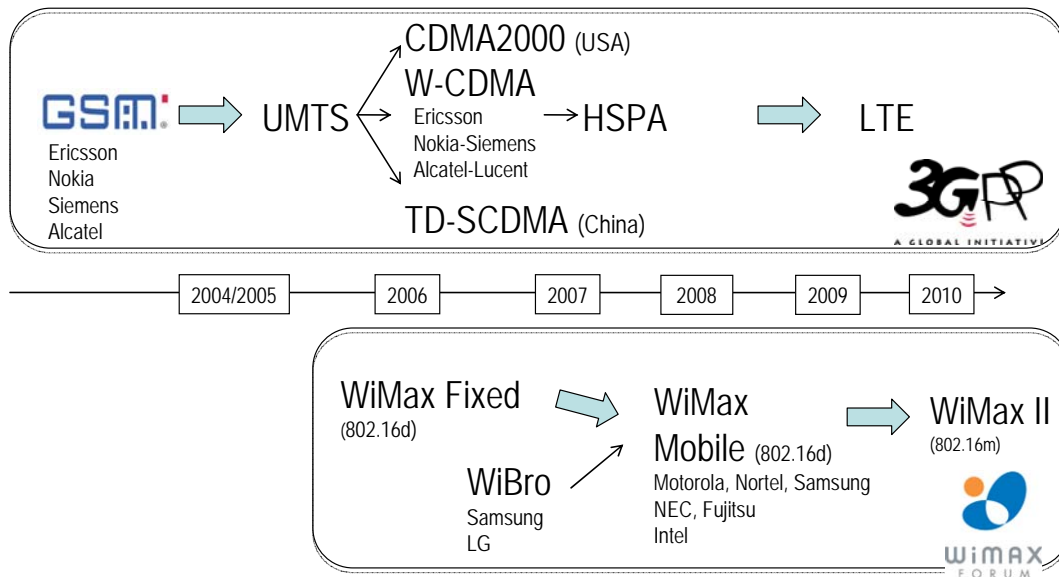


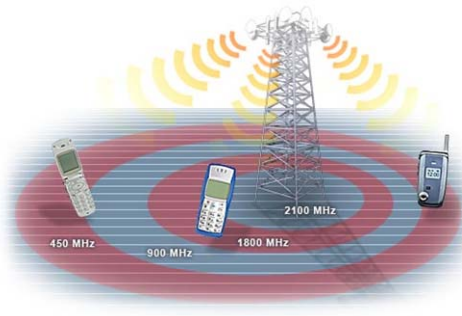
Figure 1: Technology race between 3GPP and WiMax

The so-called WiMax Forum was newly developed alongside the 3GPP (3rd Generation Partnership Project) standardization and corporate initiative, whose primary aim is to disseminate GSM and 3G systems. Here, the aim of previous niche mobile communication systems providers such as Motorola, Samsung, LG, Fujitsu, and also Intel, is to gain greater market shares with their own competing technology (see Fig. 1). Whereas the 3GPP systems of mobile voice technologies (with low data rates) developed in the direction of mobile high-speed data systems, WiMax comes from the opposite direction. The mobile WiMax Standard 803.16d promises data rates of up to 72Mb/s and has its origin in localized, non-mobile hotspot data systems (such as the Korean WiBro Wireless Broadband System). A technology race is currently underway between 3GPP and WiMax. Whereas GSM and 3G systems have a dominant market position, WiMax is the first commercially available cell phone system with data rates in the double-digit Mb/s range. Japan and the leading U.S. network providers Sprint Nextel and Clearwire are establishing area-wide WiMax systems in cities for the first time.

FTTA – Fiber to the Antenna

The radio cell sizes of modern mobile communication systems are becoming increasingly smaller due to increasing data rates, higher transmission frequencies and the increased volume of data. Figure 2 shows a comparison of system parameters of the various cell phone systems. Whereas GSM works predominantly in lower frequency bands around 900 MHz, the new systems use the higher available frequency bands at 2.1 GHz, 2.5 GHz and 3.5 GHz. However, the propagation losses increase with the square of the frequency, which means that the new systems require smaller radio cells in order to be able to guarantee equivalent network coverage. The number of antennas and base stations thus increases as a consequence. The radio cell size is also dependent on system-related parameters, which means that, according to estimates, WiMax systems require four times as many antennas as HSPA systems. Another non-system-related factor is the increasing number of cell phone subscribers and the constantly increasing volume of data due to new services. Network operators are therefore forced to establish increasingly dense networks in order to guarantee a cellular phone service of consistent quality. To recapitulate, the various market and technological developments mean that the number of new antennas to be installed will increase sharply.

Conventional cellular network architectures with copper-wire links between the base station and the cell-site antenna can no longer support this trend in a cost-efficient way and are also no longer competitive. The most modern mobile communication systems now use fiber optics for the link from the base station to the antenna (FTTA = fiber to the antenna).



System	Transmission band	Cell size	Number of antennas
GSM	850/900 MHz 1800/1900 MHz	Large	Low
3G (W-CDMA / HSPA, TD-SCDMA)	2.1 GHz	Medium	Medium
Wimax	2.5 / 3.5 GHz	Small	4x HSPA
4G (LTE, Wimax II)	2.5 / 3.5 GHz	Small	Large (100Mbps)

Figure 2: Comparison of mobile communication systems

Base stations of conventional mobile communication systems modulate the data into the allocated frequency band and subsequently power-amplify the high-frequency signals. These output signals are transmitted via coaxial cables to the antenna which emits the signals into the radio cell (see Fig. 3). The transmission distance via coaxial cables is limited to less than fifty meters, as the coaxial cables are very prone to losses, which have a negative impact on the radio cell coverage and the data throughput. With larger distances, low-loss but expensive coaxial cables are used, which are also time-consuming to install due to their large external diameter. Generally, a base station supplies 3 to 6 antennas, which cover 120° or 60° sectors in the radio cell.

With FTTH mobile communication systems, the entire high-frequency and power electronics are taken from the base station and located at a remote-radio head close to the antenna (see Fig. 3). This remote-radio head (RRH) is linked to the base station by fiber optic cables. The entire base station control and base band signal processing continue to take place in the base station, where the last unit, an SFP transceiver, carries out electro-optical data conversion. The optical signal is transmitted at typical data rates of one Gigabit per second to the radio head-end, which converts the optical signal back into an electrical signal by means of a second SFP module, prior to high-frequency modulation and final power amplification. The radio-frequency signal is transmitted to the antenna via short coaxial cables, so-called jumpers, before being emitted from the antenna. FTTH systems increase transmission distances between base station and remote-radio heads, allow more innovative network architectures (e.g. chaining of RRHs), and have considerable cost benefits in terms of both installation and operation.

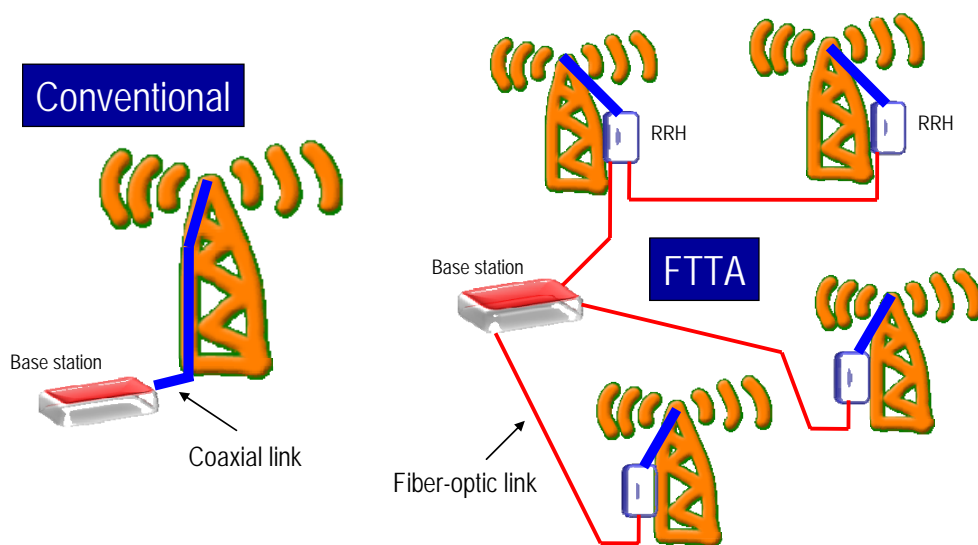


Figure 3: Comparison of conventional mobile communication systems with FTTH systems.

Advantages of FTTA

In a typical, conventional 3-sector base station, three thick coaxial cables run up the mast to the antenna. On the one hand, the cable losses impair the transmission power, but, on the other hand, they also reduce the reception signal quality due to increased signal noise. In typical 7/8" coaxial cables with a length of 30m, approximately 35% of the signal power is lost. The base station has to compensate for these cable losses with expensive and usually inefficient power amplifiers, simultaneously driving up both purchasing and operating costs of the base station. In contrast, power amplifiers in the radio head-ends do not have to be able to compensate for any cable losses, increasing the power efficiency of FTTA systems considerably and reducing the costs of power supply. Compared with rigid coaxial cables, flexible fiber optic cables with typical external diameters of 5.5 mm are cheaper to purchase and simpler to install.

Rental and licensing costs for base stations and antenna sites, e.g. on roofs, in buildings or on masts belonging to other operators, represent cost-driving factors for cellular network operators. The FTTA concept allows base stations, which usually have a large footprint, to be installed at great distances from the actual remote radio heads. The radio heads are designed in such a way that they can be installed simply and easily due to their low weight and size. This simplifies the acquisition of new antenna sites, and the cellular network operator has more freedom to optimize network coverage and eliminate possible inter-cell interference. It is also possible to make use of pre-installed fiber optics infrastructure in buildings or in city networks for the link between the base station and the remote radio head. With singlemode glass fibers, distances are limited to 15 to 20km (due to maximum permissible signal delays in the cellular network).

From the point of view of network operators, the advantages of FTTA can be summarized as follows. Compared with traditional cellular systems, FTTA systems reduce investment costs (CAPEX) on the basis of the following:

- lower or no additional space requirement
- lesser power provision and lower power amplifier requirements
- lower acquisition costs
- simpler system installation

Operating costs (OPEX) are reduced due to

- up to 40% lower power consumption of the overall system
- lower rental costs of telecoms facilities and antenna sites.



Figure 4: Examples of remote-radio heads with fiber optic links.

The technology change from conventional to FTTA systems is currently taking place. Approximately a year ago, the first FTTA networks with W-CDMA systems manufactured by Siemens and Ericsson

were installed. All new developments of 3G systems incorporate fiber optic links between the base station and the remote-radio head, including the new Chinese TD-SCDMA systems which came onto the market a few months ago. All large WiMax manufacturers are also focusing on FTTH. Only GSM systems continue to be installed in conventional networks, although some leading system manufacturers have also announced a change to FTTH.

Fiber optic link and leading solutions in the FTTH market

The FTTH fiber optic link consists of two channels for the so-called uplink and downlink, which is implemented with singlemode or multimode fibers. The current FTTH distances range from a few meters to a few hundred meters. The optical requirements for these comparatively short fiber optics transmission links are very low, as the SPF transceiver modules have large transmission margins of over 20dB and are relatively unsusceptible to optical back reflection.

The real challenge is presented by fiber optic link itself and by installation in a harsh outdoor environment. The remote-radio head is subject to high outdoor temperature fluctuations ranging from -40°C to +60°C and can internally heat up to 85°C since there is no active cooling system in place. A key point is the feed through of the glass fibers from an IP68 protected environment inside the radio head to an unprotected harsh outdoor environment (see Fig. 5). In the field, this is accomplished with robust waterproof fiber optic connectors or pre-chambers with cable insertion. However, this latter solution proves to be difficult and costly during installation. The connector solution has the advantage of efficient and safe installation, which can also be carried out by even less qualified installation teams. The connectors must be highly corrosion-resistant when used in industrial cities and coastal areas.

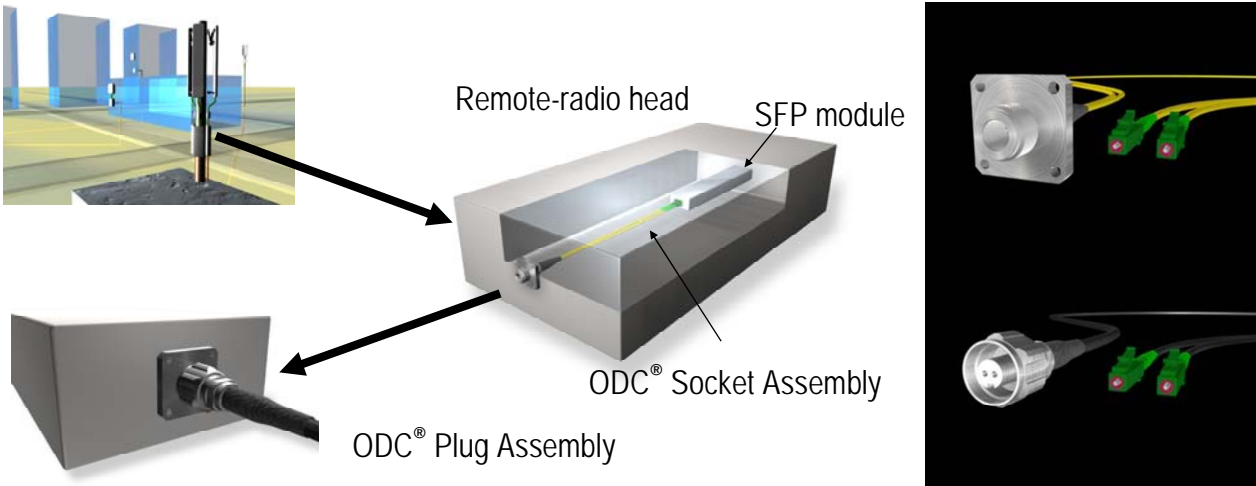


Figure 5: The ODC fiber optic link is now the standard industrial solution for FTTH and cell phone systems.

Simultaneously with the technology change to FTTH, a new generation of fiber optic connectors has established itself as the standard solution for mobile communication systems. The so-called ODC[®] (Outdoor Connector) has been adopted by all leading OEMs for mobile communication systems and has already proved itself to be a reliable, robust and installation-friendly interface in tens of thousands of system installations. The ODC solution was developed by HUBER + SUHNER and is manufactured under license worldwide by two additional leading telecom equipment manufacturers.

Prospects / Outlook

FTTA heralds a new generation of mobile communication systems which provide optimum support for the high-speed systems of the third and fourth generation. From today's standpoint, conventional systems without FTTA will certainly continue to be used and installed for a number of years but will definitely be superseded in the long term. GSM is still the most frequently sold mobile communication technology. However, according to forecasts, by 2010 at the latest, more 3G systems than GSM systems will be marketed. Due to the huge installed basis of GSM and W-CDMA systems, which can subsequently be upgraded to fourth-generation LTE systems, experts are certain that the fourth cell phone generation will be a success. The competing WiMax technology is starting from zero and must first secure a share in the market. Co-existence of both systems in a mutually complementary fashion is a probable scenario.