Paper

Mobile Telecommunication Systems Changed the Electronic Communications and ICT Market

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Abstract—The paper covers development and importance of mobile (cellular) telecommunication services, which developed during last about 20 years and are currently the most important and profitable telecommunication sector. The development of mobile telecommunications becomes essential factor of economic growth in many countries, especially in developing countries. Currently due to the scientific and technological progress as well as the implementation a new standard known as LTE system, cellular telecommunication becomes the basic element of the modern broadband telecommunication infrastructure and internet services. Growing importance of the mobile systems is also connected with great popularity of new mobile terminals – smartphones and tablets. These terminals together with the technology known as cloud computing changed also the ICT market. The paper relates to the situation in many countries, but mainly to Poland.

Keywords—GSM cellular network, market penetration and prospects, mobile communication, services.

1. Introduction

Cellular systems are the main element of the mobile (radio) communications and have started to shape the entire development of electronic communications, including broadband Internet and electronic media.

The first cellular systems, called cellular telephony emerged in the US in the 70's and were designed for personal voice communications (telephony). In the initial stage of their development, analog systems prevailed, both in the signal processing and their transmission in free space. Those systems are called first generation systems and are marked by the symbol 1G.

In Europe in the beginning of 80's the analog system NMT 450 (Nordic Mobile Telephony) gained the widest popularity working in the frequency band 450 MHz. The system was developed in Scandinavia, mainly by the company Ericsson. NMT was accepted in 1992 in Poland and implemented by Telekomunikacja Polska affiliated company Centertel (today Orange).

In Europe in the early 80's, studies were undertaken to develop a more modern, fully digital system known under the name GSM, the acronym standing today for Global System for Mobile Communications (initially Groupe Spécial Mobile from the name of the committee initiated by CEPT in 1982). After the creation of ETSI (European Telecommunications Standards Institute), the institute continued work on GSM, establishing the European standard for this system through the issue of the system specifications in 1991. From then on the European career of GSM system started, followed by the world-wide one, making GSM the dominating standard for mobile (cellular) telecommunications in the world. The GSM system defined by the mentioned ETSI standard is called the second generation system and is marked by the symbol 2G.

In Poland the GSM age was initiated by the Minister of Communications (Post and Telecommunications) issuing in year 1996 two new GSM licenses for companies Polkomtel (market name Plus) and Polska Telefonia Cyfrowa PTC (market name Era, today T-Mobile). Later the GSM licenses were granted to companies Centertel (today Orange) and Play (initially called P4).

The new factor driving the development of cellular systems and their impact on the development of electronic communication systems is the recent emerging, during the past five years, of the new generation of cellular terminals such as smartphones and tablets. The significance of this phenomenon will be discussed later in this study.

This article is organized as follows. After short introduction presented in Section 1 development of GSM's mobile telecommunication systems through the years was described in Section 2. Section 3 presents development of the world market in the last decade by the countries ad regions. Section 4 focuses on services and new terminals and the Section 7 presents mentioned issues in Poland. Section 8 concluded an article.

2. The Development of GSM's Mobile Telecommunication Systems

The GSM system, initially developed for telephony needs, continues to include many additional services, making it the universal digital communication system encompassing in addition to voice many services, ranging from the popular SMS to data transmission, including multimedia. It shall be underlined that the GSM system, developed by the joint effort of the european countries for nearly the whole continent, became the standard worldwide. Although in the US other similar cellular systems gained popularity, the consis-

tent joint policy of the european governments induced the worldwide success of this system.

GSM further developed its technologies to capture new frequency bands and to increase the throughput of transmission, and has remained the foundation of the subsequent system variations enlarging the range of its applications.

The GSM system, initially developed for a 900 MHz band, due to high growth of the mobile service market and the number of subscribers, was implemented in 1800 MHz band, also known as DCS 1800 (Digital Communication System in band 1800 MHz). Due to propagation reasons (shorter ranges) DCS 1800 is offered mostly in urban agglomerations, characterized by high density of population.

Soon after, in the 90's, GPRS technology (General Packet Radio Service) was developed, enabling GSM to transmit mobile data with the theoretical rate of 115 kbit/s (in practice 35 kbit/s in most applications), followed by EGPRS technology (Extended GPRS) known as EDGE (Enhanced Data for Global Evolution). GSM systems utilizing EDGE enable a data transmission rate of theoretically up to 473 kbit/s, however, most often 236.8 kbit/s. Informally GSM with such technology is sometimes called the 2.5G or even 2.75G generation of this system. At the end of the 90's another GSM enhancement called UMTS (Universal Mobile Telecommunications System) was developed, called 3G. By default UMTS allows a transmission data rate of 384 kbit/s. GSM and UMTS networks are compatible and mobile phones work as terminals for both networks.

Jointly all these developed technologies should be seen as a family of cellular systems GSM.

In the year 2000 subsequent expansions of GSM system were created, called HSPA (High Speed Packet Access) and then HSPA+, allowing for a data rate of up to 14 Mbit/s at HSPA and 28 Mbit/s at HSPA+. These are commonly referred to as the 3.5G generation of the system.

In 2008 another standard for mobile telecommunication was proposed under the name LTE (Long Term Evolution) featuring much better transmission parameters than its predecessors, most of all the transmission rate of up to 100 Mbit/s, nearly as high as in fixed line fiber optic networks. Works are in progress on a standard defined as LTE Advanced (LTEA), which is about to feature a transmission rate in the range of 1 Gbit/s. It is expected that this standard shall be accepted in 2013.

In principle the LTE system has already become a worldwide standard. In many countries, including North America (USA and Canada), Brazil, Germany, Scandinavia, Central-Eastern Europe (including Poland), the Russian Federation, India and Australia, LTE was used in commercial networks already in 2012. In China, Western Europe, Mexico and other countries LTE is in preparation for commercialization or in trials.

The international consortium 3GPP (3rd Generation Partnership Project) plays an important role in mobile standard development, gathering six standard partners from North America, Asia and Europe (ETSI). Among other 3GPP has established UMTS (IMT-2000), HSPA+, LTE and LTEA standards.

A certain variant of mobile telecommunications is the Wi-Fi standard (actually few standards of IEEE 802.11 series) designed mainly for internet access in local WLANs (Wireless Local Area Networks), working in unlicensed bands, mainly in 2.4 GHz. This technology is used by individuals for small access networks in apartments and houses, as well as entities providing internet access in public spaces – in cafes, railway stations, hotels, offices. This technique can be as well used for covering larger areas like cities or municipalities. In the US, the FCC is considering a project to build free public Wi-Fi networks practically in all cities, however, with a strong resistance from cellular network operators [1]. As for now the world-wide scale of such undertakings is still small, however, in many countries including Poland, Wi-Fi hot spot type of internet access is practiced. This technology is being further developed, however, complementarily to GSM networks.

3. Development of the World Market of Mobile Telecommunication Systems

The mentioned history of the development of the family of GSM systems clearly points out the huge and comprehensive technological progress in this realm. This progress is characterized by a quick global market growth for mobile telecommunication services along with internet services because (similarly to fixed line telephony) the mobile telephony infrastructure is successfully used to prove internet access service. That was the primary goal of the consecutive GSM system improvements, including the most recent one – LTE.

The percentage penetration of a given service is the measure of the market development of the service, most commonly understood as the number of users of the service for 100 inhabitants. The mobile telecommunication service penetration achieves worldwide impressive values, quite substantially exceeding 100, which means that the number of used terminals (SIM cards) is significantly higher than the number of citizens. The latter is qualified by various reasons, though possibly results simply from users switching from the older registered phone to smartphone.

It is worth emphasizing that the fast development of mobile telecommunications is the privilege of not only rich societies, although the penetration levels exceeding 100 occur just in those countries, but also in developing countries. Mobile telecommunication achieves significant values of service penetration because the available services exceed voice service (internet service and other services in recent development) and constitute a strong catalyst of the economic growth of those societies.

In Fig. 1, taken from statistical resources [2] of ITU (International Telecommunication Union) the history of worldwide growth of the mobile telecommunication sector during the last decade is shown, with an indication of this growth

in developed countries, developing countries, and world average.

For comparison Fig. 2 presents the changes during the last decade in the penetration of the fixed line telephony, referring as previously to developed, undeveloped countries, and a world average.

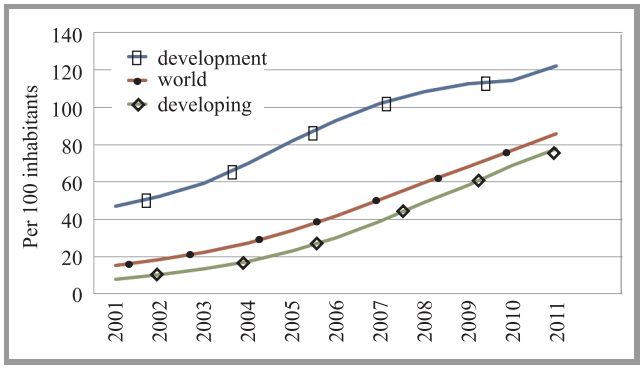

Fig. 1. Worldwide mobile penetration per 100 inhabitants in years 2001–2011.

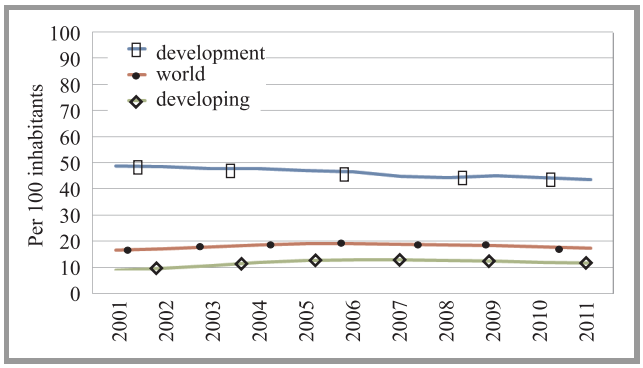

Fig. 2. Worldwide fixed line penetration per 100 inhabitants in years 2001–2011.

Obviously, during these decades the fixed line telephony services served as a foundation for the telecommunication system of the world. The market development for these services was recognized as one of the most important factors defining the economic and social prosperity of the countries having a sufficiently well-developed telecommunication network enabling to provide these services. However, as seen in Fig. 2, during decades of development the fixed line telephony has achieved no spectacular successes in widely spreading the services and developing the market for the majority of world citizens. That applies first of all to developing countries, but also to many European countries. The reasons can be identified as the very weak economic condition of the developing countries and also in many cases as an underestimation of the catalytic properties of telecommunication systems for the development of national economies.

As a result of the emergence of an alternative technology of mobile systems and networks, the situation changed in favor of the development of the new technology, which can be proven by comparing data from Fig. 1 and Fig. 2. Mobile systems turned out to be not only an efficient competition in voice services (telephony), which was the immediate reason of the decline of fixed line telephony worldwide, but also became an important transmission medium for such services as SMS, MMS and internet access.

The worldwide average decline, including developing countries, is not big, see Fig. 2. A stronger decline is observed in developed countries, which is due to a stronger dynamics of the mobile telephony development and increasing internet access through the mobile infrastructure.

These phenomena are shown in Fig. 3 with respect to few highly developed countries, including Poland, Czech Republic and China, which has to be regarded as a developed country [2].

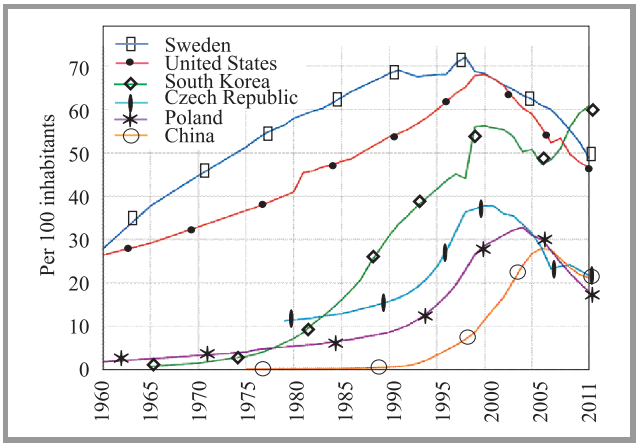

Fig. 3. Fixed line telephony penetration per 100 inhabitants in selected countries, including Poland.

The decrease in popularity of fixed line telephony can be observed nearly everywhere. However, in South Korea there is a significant growth, whereas in Poland and Czech Republic a dramatic penetration decrease can be observed, moreover in Poland it continues to deepen. Figure 3 shows an interesting regularity. The highest penetration has occurred around the turn of the century, caused by the strong growth of mobile telecommunication. In China that height was achieved around 2005, which is attributable to time-shifted economic prosperity of this country in relation to highly developed countries.

In Fig. 4, following ITU data, the mobile market development measured by the penetration ratio in few EU countries (including Poland), Asia and the USA is shown. The same information regarding Easter European countries is presented in Fig. 5. In this development scenario, Europe is particularly privileged, as the most favorable conditions were created here for the development of the common GSM standard elaborated by ETSI. In the USA, where no common standard for mobile systems was adopted, the growth ratio was lower, as shown in Fig. 3, however, at the beginning of the process, the mobile penetration in US was higher.

The position of Poland is high on this chart, showing our success in the development of this realm of electronic communication. That's a result of effective regulatory policy, assuming the competitive model of market develop-

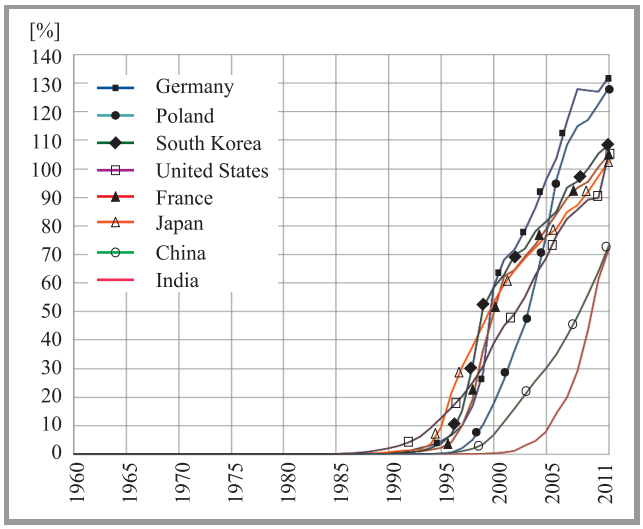

Fig. 4. Mobile telecommunication development in selected countries of EU, Asia and USA, measured by the penetration ratio.

ment from the very beginning of the development of GSM in Poland. Mobile penetration in Poland for the end of 2011 was 131.6% and is approximated at 140% for the end of 2012, taking the growth ratio into account [3]. The successes in developing mobile telecommunication in the world's most populated countries – China and India – are worth deep consideration, as they contributed to spectacular economic and civilization success in these countries.

Although the mobile penetration in both China and India has not neared 100% yet, the achieved results should be recognized as impressive, considering the high population. South Korea deserves particular attention for the consequent adoption of electronic communication systems and networks with use of the latest fixed line (fiber optics) and mobile technologies, making them the leader in utilizing internet for economic and social applications. This purpose has been served for many years by an effective economic policy of the country's government supporting development of electronic communication means and directed towards the development of a knowledge-based economy.

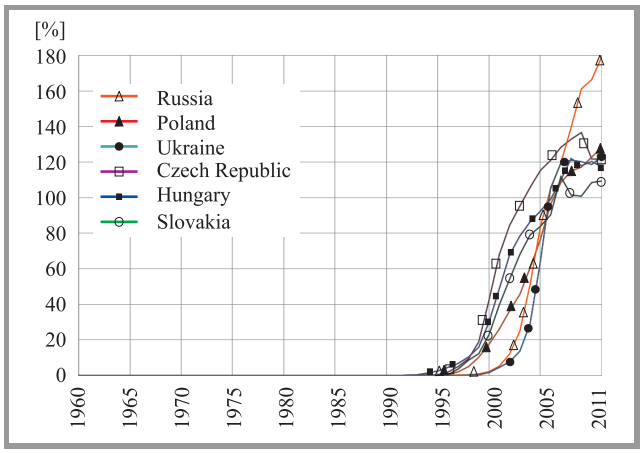

Fig. 5. Penetration of mobile services in selected countries of Central-Eastern Europe and Russia.

With regard to the development of mobile telecommunications, Africa is the weakest developed continent. Measured by penetration, the leading African countries are South Africa with penetration of 128% by the end of 2011, Morocco (112%), Egypt (102%) and Congo (95%). The weakest developed are Eritrea (5%), Ethiopia (17%), Burundi (15%), Djibouti (22%), Central African Republic (25%), and Chad (32%). The countries of the Middle East and Central East and Middle Asia have well developed mobile telecommunications.

As an addendum to the above short description of the world-wide development status of mobile telecommunications, the following analysis of Ericsson [4], Fig. 6 shows the breakdown of mobile penetration by the continents and certain selected regions as well as the global penetration ratio for November 2012. Surprisingly, the highest penetration was observed in Central Eastern Europe. It results from taking into account Russia, achieving an exceptionally high rate of 180% by the end of 2011, which may be due to a certain overreaction to the underdevelopment of fixed line telephony at the time before the transformation. The remaining positions in this chart are rather in-line with the general rating of the national economies of the countries located in the presented regions.

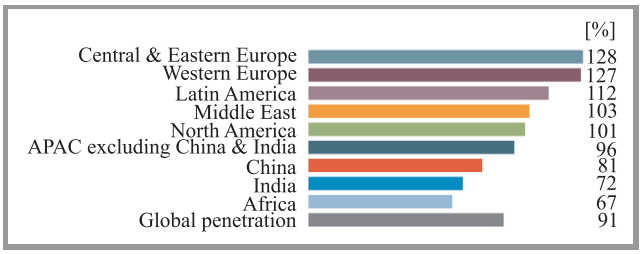

Fig. 6. Mobile penetration according to Ericsson Mobility Report, November 2012 in selected geographical regions (APAC – Asia Pacific).

The worldwide development success of mobile telecommunication takes root in more favorable economic characteristics for infrastructure development, as the cable-based access network is not necessary and the network construction time is much shorter than in the case of fixed line access networks.

However, the other reason of this success is the attractiveness and multitude of the services available through the mobile access networks, particularly in networks utilizing enhanced variants of GSM, such as HSPA and LTE.

4. Mobile Telecommunication Services

As mentioned, mobile communication systems were designed for personal telephone communications. For this reason, the first mobile terminals were simple radiotelephone sets. The term *mobile telephony* narrows down the meaning of this realm (though commonly used), because apart of voice services numerous services were developed based on data transmission and internet access.

Messaging services SMS and later MMS, gained great popularity, particularly SMS and afterwards emerged mobile payments, GPS service, a camera built in the handset, and others.

Still the highest significance has the use of mobile infrastructure for fast and ultrafast internet access, tied to spreading HSPA, HSPA+ and LTE technologies (and soon LTE Advanced). It can be claimed that the mobile infrastructure is becoming fast internet infrastructure, proved by the chart shown in Fig. 7 [4]. Apparently from 2009 the data transmission has prevailed over the voice transmission in the worldwide mobile traffic and this tendency becomes stronger as time goes by. The same source indicates that data transmission traffic may exceed 12 times by year 2018 [4].

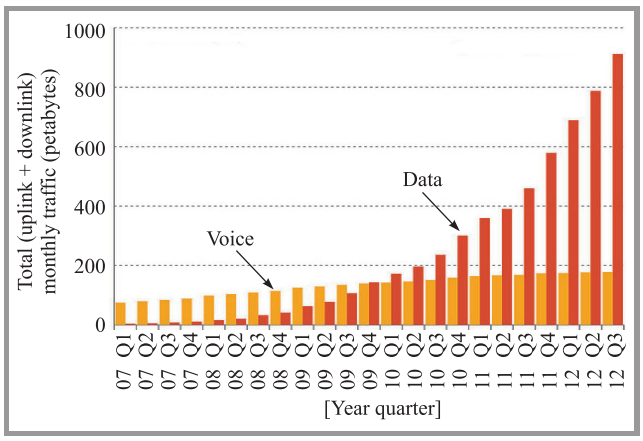

Fig. 7. Global telecommunication traffic in mobile networks.

With a high likelihood it can be assumed that the general trend for the ratio of voice traffic to data traffic is determined by the traffic in highest developed countries. In the developing countries, where the internet network is not yet sufficiently developed, most likely the voice traffic still prevails over the data traffic.

Analysis of the development of data transmission in internet networks, including mobile networks, conducted among others by Ericsson [4] and Cisco [5] indicate that the phenomenon of the high data traffic growth is primarily linked to the transmission of motion pictures (Internet TV, VOD, films download). They require high throughput networks and fast internet, attributable to countries with a rich telecommunication infrastructure. According to Cisco already today 5% of traffic is linked to this phenomenon, and expected to grow to 75% by 2016 [5].

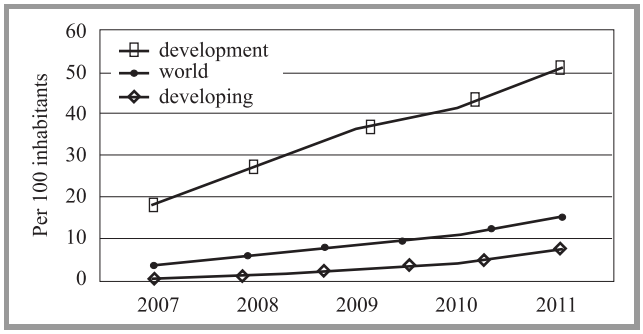

Fig. 8. Broadband mobile internet subscriber penetration worldwide.

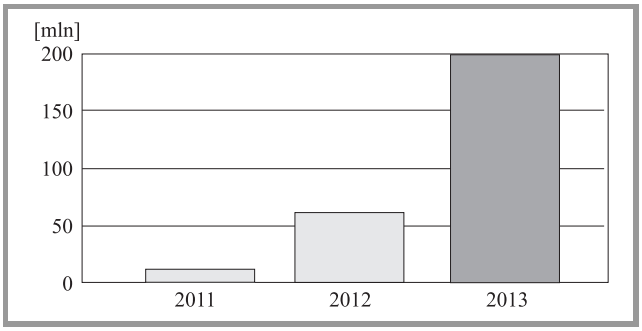

Fig. 9. LTE users worldwide.

Figures 8 and 9 presents both technical and functional development of mobile telecommunications tends towards taking over the role of the main internet transmission medium by the mobile infrastructure [6]. This phenomenon is unavoidable mainly due to lower costs for construction of access networks as well as technical (LTE development towards high data transfer rates).

5. New Terminals for Mobile Networks Step Up the Mobile Telecommunication Sector and Changes ICT Market

The progress in the development of mobile terminals has continued since the implementation of mobile telephony and it has substantially widened the scope of its services. During two decades the market have gone from bulky and heavy telephone sets resembling boxes (i.e., first terminals for NMT 450) to smartphones.

A smartphone with built-in internet access and other services is a small computer with a dedicated operating system (Android, iOS), built-in considerable memory and a large touch screen display replacing the numerical keypad. Some sets have built-in voice recognition, enabling voice-to-text conversion useful for, i.e., dictating SMS using voice. The present and future role of smartphones in daily life is worth reading in [7]. The essence is summarized by stating: "The smartphone of the future will be a constant companion, coach, collaborator, and advisor".

The growing popularity of smartphones caused by their versatility and rapidly increasing number of applications, affects other areas of activity. As a result of experiments conducted by Mayo Clinic in the USA the smartphone was recognized as a fully functional diagnostic device, enabling remote monitoring of the brain, heart activities, or the course of diabetes [8]. Recently the smartphone has been used as a proximity payment device in the NFC (Near Field

Communication) standard, which has a limiting impact on the payment cards market. Similarly, incorporating GPS into smartphones by end of the previous decade resulted in drop of demand and production of independent PND (Portable Navigation Device) [9]. Adding a digital camera to smartphones, initially with an average resolution, but then constantly improved and today comparable with popular compact cameras, has significantly limited the sales volumes of such cameras [10].

The number of smartphones in worldwide use as well as their impact on citizens' activity is growing quickly. According to forecasts by the Deloitte advisory reported in TMT Predictions in 2013 the number of sold smartphones should reach 1 bln, and by 2013 the number of smartphones in use should reach 2 bln [6] . [11] predicts that within next 10 years 5 bln people will have smartphones for both home and professional use.

In Poland the number of smartphones is growing rapidly as shown on Fig. 10 [5]. Probably the number of new mobile terminals was around 10 mln in 2012 and according to the forecast in Fig. 10 around 5 mln were smartphones. Because the total smartphone sales in previous years was around 5 mln sets, it can be estimated that 10 mln such sets operate in Polish mobile networks, i.e., around 25% of the number of active mobile terminals. It can be also presumed that within the next years, maybe by 2015, smartphones will dominate. That will have a fundamental impact on the spreading of internet service.

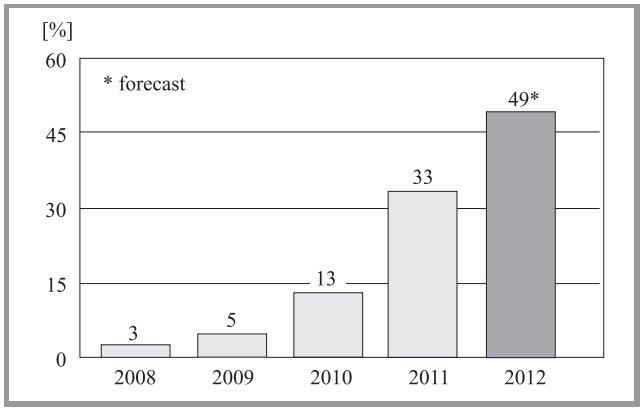

Fig. 10. Smartphones share in total number of mobile terminals.

In 2010 Apple released the first tablet called iPad, which initiated a rapid development of a new generation of personal computers tailored for mobile use. Apple's concept for such a tablet computer was soon found very useful and had many followers like Samsung, Nokia, LG, Microsoft, Google and others. The concept accurately met the needs of companies, whose employees frequently need instant access to company network resources from a remote location. Similarly to smartphones, a tablet has a touch screen display (with size 7–10 inch and HD resolution), most frequently an Google Android operating system and quite high computing power, comparable to middle range computer notebooks. This caused tablets to become a true success for both IT and mobile markets. The tablet became a mobile internet terminal successfully competing with the notebook, basically eliminating small computers called netbooks from the market, due to truly mobile properties like light weight, moderate size with a still significant screen size and a touch screen control.

According to tablet market data from North America during 2012 the notebook sales volumes achieved 64 mln while tablet sales 80 mln. But the global sales forecast for 2015 predicts sales of 276 mln tablets and 270 mln notebooks. During 2011 in Poland 120,000 tablets were sold, in 2012 possibly 0.5 mln [12]. The tablet spread forecast for the five biggest EU countries as a percentage of penetration is given in Table 1 [13]. Some other expert companies [14] forecast that within the next five years as many as 5 bln tablets will find their way to the global market.

Table 1
Tablet user penetration in selected EU countries, by percent of Internet users

Year	2010 [%]	2011 [%]	2012 [%]	2013 [%]	2014 [%]	2015 [%]	2016 [%]
UK	4	9	21	28	35	41	46
Italy	5	10	20	30	37	43	46
Spain	5	10	20	30	37	42	46
France	3	8	18	26	33	39	43
Germany	3	7	17	23	29	35	40
EU-5	3.8	8.5	19	26.8	33.6	39.5	43.8

According to Fig. 11 the large majority of smart connected devices are smartphones and tablets, together making around 70% of world market, which additionally proves their increasing share in the total number of mobile terminals [15].

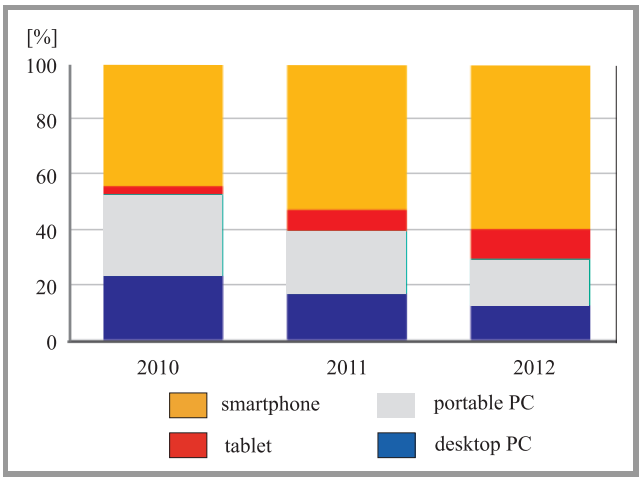

Fig. 11. Worldwide smart connected device market share by product category 2010–2012.

The borderline between a smartphone and a tablet is conventional, as the manufacturers of smartphones aim at increasing the smartphone screen size (i.e., Samsung with their high class sets Galaxy Note), and the manufacturers

of tablets lower their costs by lowering tablet screen size, as in the case of Apple and their new series of size-reduced iPads, at a much lowered price [12].

As can be seen from the listed data, the significance of the emerging new smart terminals within the past five years cannot be underestimated, because it is an important catalyst for the increased importance of mobile telecommunications and mobile access to the internet.

It is highly probable that the great popularity of smartphones and tablets is still a privilege of the developed countries due to the still quite high prices of the devices. According to IDC [15] the average price of tablet becomes below 461 USD and of smartphone below 408 USD and the lowering trend continues. In Poland a high class smartphone Samsung Galaxy S3 LTE is available for around 2100 PLN, and the highest model of the Apple iPad for around 3500 PLN. As in the case of any popular mass product, prices of smartphones and tablets will undoubtedly drop significantly, hence the advantages of using them will be shared by a larger number of users, including those in developing countries. Thus far, the simpler models of mobile terminals, going out of use in the developed world, are still in common use in the developing countries.

6. Mobile Telecommunication in Poland

As previously mentioned, the mobile age began in Poland in 1992 by establishing the company Centertel, affiliated with the national telecom operator Telekomunikacja Polska, however, the true march to success began in 1996 by introducing GSM system with its later system enhancements. Poland was indeed successful in this realm as was already stressed and is proven on Figs. 4 and 5. The measure of this success is also the fact that the value of the mobile market is 60% of the value of the total telecommunication market and amounted to 23,432 bln PLN in 2011 (23,214 bln PLN in 2010).

According to GUS data [16] there were 23 mobile operators on the market in 2011, with the biggest ones Polkomtel, T-Mobile, Orange, Play, all four of them having their own countrywide network infrastructures. The fullest description of the mobile networks infrastructure and area coverage is given in the UKE report [17]. The report was created in accordance with the law [18] of 2010 voted in order to streamline investment processes in telecommunication networks, particularly for increasing the efficiency of utilizing financial means from EU aid programs. The law obliges both the concerned economic entities to report to UKE adequate information about the state of their infrastructure and UKE to publish such information in the respective annual report. The data for the report is prepared by UKE with the help of the National Institute of Telecommunication. The development issues of both mobile and fixed infrastructure, particularly in relation to the development of internet services are represented also in [19].

The analysis of data contained in reports [17] and [19] reveals that mobile service coverage is irregular and it is obvious that the privileged regions are: Central Poland, Lesser Poland, Silesia, Greater Poland and Gdańsk-Pomerania. The coverage maps of three major operators: T-Mobile, Orange and Play are similar, however, Polkomtel's map is unrepresentative due to the operator not supplying the pertinent data. In Fig. 12 sourced from [17] the coverage of map of Centertel (Orange) network is shown. Map of Poland is there colored by dots corresponding to localities within Orange network coverage. It seems that this network coverage is distributed evenly over the country's territory.

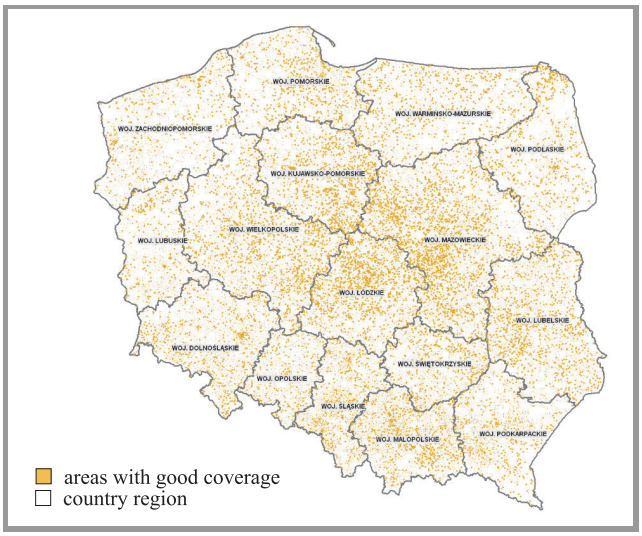

Fig. 12. Mobile operator Centertel (Orange) network coverage.

Considering mobile networks coverage and high penetration ratios (Figs. 4 and 5) one can claim that practically every citizen of Poland has access to mobile telecommunication services. During past two years important events occurred, which can have a significant impact on the mobile telecommunication infrastructure development. Mainly it concerns the LTE system and thus the internet services as well.

The first implementations of LTE in Poland appeared right after the world's first commercial installations of this system in the USA and Scandinavia. In October 2011 Polkomtel was purchased by holding of Mr. Solorz for an unprecedented amount 18.3 bln PLN, motivated mainly by the intention to build a powerful telecom-media company directed towards development of LTE and thus fast internet in Poland. According to information shared by Mrs Scheer of Polkomtel [20], LTE services are probably already being offered to around 20 mln citizens in Poland, in more than 3,300 localities, including 156 cities with more than 20,000 inhabitants.

In this way, Solorz's holding has created a real alternative competition for fixed line broadband internet service suppliers. In Poland, similarly to other countries utilizing radio access, the development of LTE mobile internet is naturally limited by the shortage of an available frequency spectrum. On February 13th, 2013 the result was published of the tender announced in 2012 for the reservation of frequencies

in band 1800 MHz devoted to the development of LTE system and thus of the mobile internet infrastructure in Poland [21]. The winners of the competition were: operator Play with 3 blocks of 5 MHz each (total 15 MHz) and T-Mobile with 2 blocks (10 MHz). As a result of this tender the State Treasury received around a 950 mln PLN income. It indicates a high interest in the LTE development not only Solorz's holding, but also other operators.

Another tender (as an auction) is expected in 2013 for that part of band 800 MHz [22], which is the digital dividend linked with the digital switchover of the terrestrial TV in Poland and was occupied for the military applications until 2012. The spectrum of 2.6 GHz (and higher bands) may also be available, however, the band 800 MHz is mostly attractive due to a relatively lower network investment cost than in the case of higher frequencies. UKE president Mrs. Magdalena Gaj has estimated [22] that due to making this frequency spectrum [21] available to investors, LTE can encompass 90% of the country's territory, and the planned auction for band 800 MHz frequencies will allow to extend LTE services to less developed areas.

7. Conclusions

The progress in science and technology tied first of all to new abilities of reaching high speeds of digital data transmission during the past five years unexpectedly created a new alternative for the development of the broadband telecommunication infrastructure, which utilizes mobile systems.

Until recently, before LTE and LTEA were developed, fiber technology was regarded as perfect and useful for all known systems of electronic communications (FTTH technology – Fiber To The Home). It still remains such, as it is technologically perfect, stable and safe. Radio-based mobile systems have their natural limitations linked to the propagation of electromagnetic waves in free space, such as dependence on weather conditions, dependence of the effective bit rate on the distance from the base station as well as on subscriber-generated traffic and others. However LTE, and particularly LTEA, have numerous advantages in economy and functionality (mobility), and therefore in some circumstances they can compete with fixed line optical fiber access networks. It indicates the necessity of the realization analysis preceding the adoption of the right strategy for broadband infrastructure development.

In Poland the broadband telecommunication infrastructure has to be built practically everywhere, because it is a necessary condition of the social and economic development and it is an important goal of EU strategy known as Digital Agenda for Europe (DAE).

In Poland during past three years, many projects were undertaken with the support of EU funding aiming at the expansion of the broadband telecommunication infrastructure, mainly in the scope of building fixed line (cable) access and backbone (fiber) networks [19]. These projects create opportunities to substantially improve the status of the countrywide telecommunication infrastructure and realizing the goals of DAE. That was expressed by establishing 16 regional programs currently under execution as well as a large program for Eastern Poland, all of them related to building the broadband infrastructure.

Fortunately, besides these projects resulting from the initiative of the interested telecom operators, actions were undertaken aiming at the expansion of broadband mobile infrastructure, linked with wide-scale LTE implementations. The holding of Mr. Solorz companies has directed itself towards the development of LTE network and is already providing broadband LTE services. A new frequency spectrum was made available for building new LTE access networks. In 2013 an auction for the additional spectrum (800 MHz) will be conducted. Jointly it may lead to a substantial acceleration of the development of Polish broadband infrastructure and new opportunities for the entirety of mobile systems. It is estimated that as a result of these actions the chances to achieve the main DAE goal with respect to spreading fast internet access in Poland – ensuring every citizen an access speed of 30 Mbps by 2020 – becomes more realistic than it would appear from the state of our current assets, as was described in [19].

The strong trend for a successive replacement of mobile terminals by the new generation of smart connected devices able to achieve mobile access to many present and future services is a favorable outcome for the above plans.

New mobile terminals are changing not only the electronic communications but also the ICT market, due to first of all the important changes in the PC market, with respect to the growth of the demand for tablets and the downfall of the demand for personal computers, mainly desktops but also notebooks. The recently implemented new technology of so called *cloud computing* is contributing to these important changes of the ICT market.

In this connection taking into account all mentioned circumstances one can state that we are entering step by step into the new era anticipated and named by Steve Jobs (Apple Company) in 2007 as *post-PC computing.*

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