The Cradle of the Cognitive Infocommunications

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Abstract: Information and communication technologies (ICT) and cognitive sciences (CS) are both pursued at the Budapest University of Technology and Economics (BME). The Department of the Telecommunications and Media Informatics (TMIT) is focusing on ICT and its related applications and convergence issues. After deploying the convergence of the telecommunications, information and media technologies based on the evolution and common use of the digital technology, the widening convergence process embraced CS, and resulted in the establishment of cognitive infocommunications as a new scientific discipline at the end of the last decade. Contents involved in the convergence process are expanded, the information value chains are merged and also expanded, and the convergent ICT applications are completed by cognitive features.

Keywords: cognitive sciences; cognitive infocommunications; information and communication technologies; digital convergence; convergent applications

1 Introduction

During the last two decades considerable progress has been achieved in breaking down the barriers among certain scientific disciplines. The integration of voice- (telephony), data- and media communications based on digital communication technology has led to the concept of electronic communications. The convergence of communication, information and media technologies using common digital technology has resulted in the birth of the first real convergent sector, called the infocommunications (infocom), or ICT/IST/TIM (information and communication technology / information society technology / telecommunications, information and media technologies) sector. The process of the convergence is further extended, the synergic combination of the infocommunications and the cognitive science has created cognitive infocommunications (CogInfoCom), and the next step is also outlined by the combination of infocommunications, cognitive science, quantum mechanics, nanotechnology and biotechnology. Convergence is more

than the sum of the component sciences; it brings surplus advantages, generates synergic impacts, and gives rise to new approaches, platforms, products, services and applications. These convergence phenomena are relevant to the realization of the information society, because they are not restricted to the level of technology, but rather they influence wider and wider fields and are becoming a social phenomenon. For the deployment of the synergies the convergence necessitates the reconsideration of the cooperation forms of the companies and the market structure of the concerned sectors, as well as the harmonization of the regulation of the converging areas.

The first papers dedicated to the comprehensive analysis of the convergence of voice, data and media communications were published in the mid-nineties [14, 24, 29, 31, 42]. Communication networks are the point of entry to participation in information societies, which provide both accesses to services and information for participation. The Green paper on the convergence of the telecommunications, information and media sectors was issued by the European Commission in 1997 [7]. The International Telecommunication Union identified the convergence as a main trend in 1999 [21]. The key issue in these and latter documents is the investigation of the impact of the technological trend on the market structure and the regulation of the telephone-based telecommunication, datacommunication and broadcasting sectors; the main challenge is how to capitalize on the transformed and upgraded electronic communication networks and services, and to find the best regulatory regime to deploy this process [19, 20, 25, 37]. Electronic communications provide the bearing digital infrastructure for the digitalized content services and applications, whereby the convergence process has been naturally expanded to all information processing and content management functions; and the integration of telecommunications with information technology and electronic media has been realized, the infocommunication sector was born. (In a wider sense, in general, the integration of these sectors is frequently called the ICT, IST or TIM sector) [7, 23, 38]. Here content traditionally involves voice, data and visual information only, however content space cannot be limited to these inputs. All other senses, including touching, smelling, as well as emotions, sensory information, 3D gestures, and any other cognitive information can be also processed, transmitted and displayed. Cognitive infocommunications by definition aims to manage this expanding content space, and to provide opportunities for creating enhanced, richer applications [5].

This paper outlines the whole convergence process, focusing on the cognitive phase, the technological reasons, the changes in the value chains, the layer structure of the integrated sector, the regulatory impacts, as well as the emerging applications derived by widening the scope of the convergence process, and refers to some achievements reached at the Department of Telecommunications and Media Informatics of the Budapest University of Technology and Economics in the convergence issues.

2 Phases and Models of Digital Convergence

Recently the most comprehensive phenomenon and pervasive trend in the world of telecommunications, information technology and electronic media (hereafter: media) is the convergence of these sectors, which is manifested in the unification of their technologies, in the integration of their markets and in the harmonization of their regulation. The convergence process is triggered by the huge scale development of digital technology, and hence it is generally called *digital convergence*. Specific costs of the fundamental functions, such as the transmission, storage and processing of information have been continuously halved per 18…..24 months for 40 years. This uniform technology base has given rise not only to the effectiveness of the economies of scale and the efficient increase of the complexity of the products and services, but has also provided additional synergic opportunities for the combination of the sector's functions. The convergence of technologies provides technical opportunities; the real exploitation of the digital convergence depends on the business benefits, on the added value and the cost-effectiveness of the integrated solutions. Therefore the history and the steps of the convergence process are well presented by the evolution of the value chains. The information value chains represent the consequent value-generating functions from information sources to the usage at the destination. To emphasize the evolutionary phases, we use here a simple value chain model only [20]. Recently, we can identify four main overlapping phases of the digital convergence.

Phase 1 - Traditional separation, internal digitization. Traditionally, the various contents, such as voice, data and text, and audio-visual (AV) programs, are associated with separated services, networks and user terminals, and the markets and their regulation are separately managed. Separated sectors are defined with own value chain (Figure 1). Voice is managed by telephony (voice communications), data and text by datacommunications, AV programs by radio & television broadcasting and distribution (mediacommunications). These sectors have their own specific technology, however the sector specific technologies are more and more characterized by the intensive use of the digital technology for the various functions. The digitization of telephony started with the introduction of digital transmission and then the digital control and switching, which laid the foundation for the transition to an integrated digital network [21, 31-33]. Modern mobile telephony (GSM) is already fully based on digital technology. Fixed and mobile telephony convergence (FMC) can be considered a specific case in the frame of the voice's value chain. Digital solutions have also penetrated into mediacommunications.

Phase 2 - Electronic communications, unified telecommunications. Digital technology – the basic technology of computers – transformed communication technology first and then gradually penetrated into media technology. The merger of the separated value chains has begun. Computer networks became capable of voice communications, using the PC as a voice terminal (VoIP). Downloading

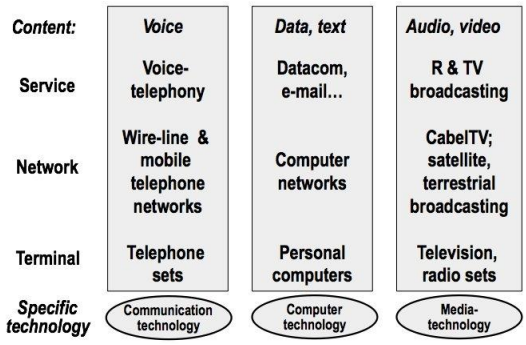

Figure 1
Separate value chains and digitalization

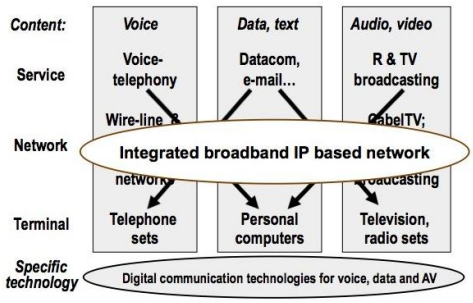

Figure 2a
Convergence of networks

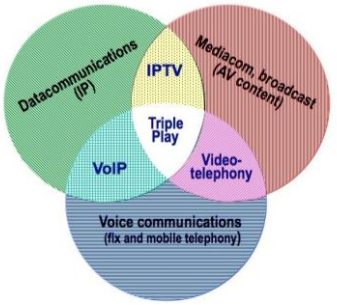

Figure 2b
Convergence of services

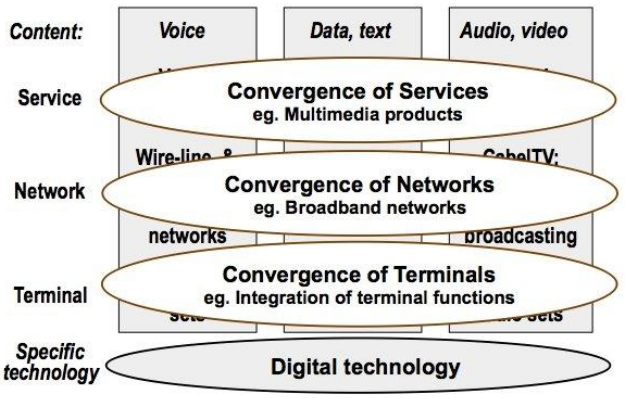

Figure 2c
Horizontal convergences: unified electronic communications

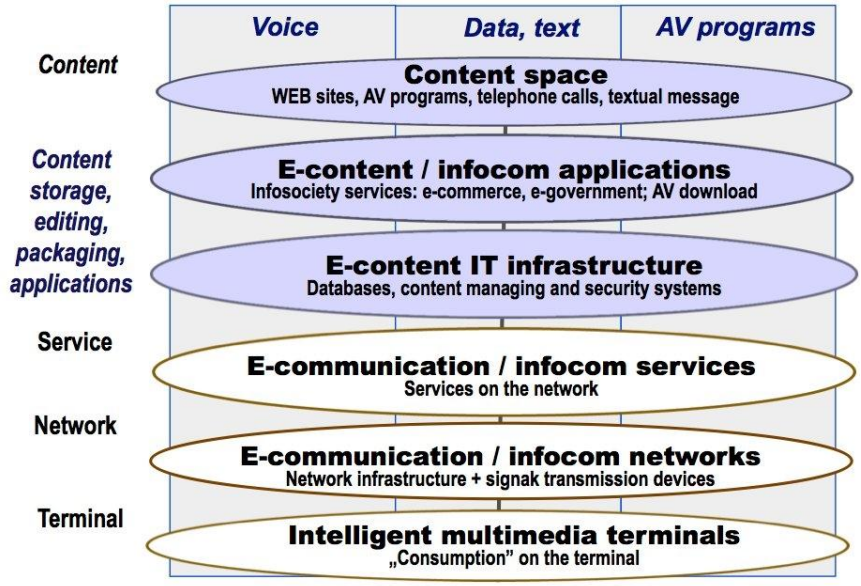

Figure 3

Digital convergence of the communications, information technology and content management

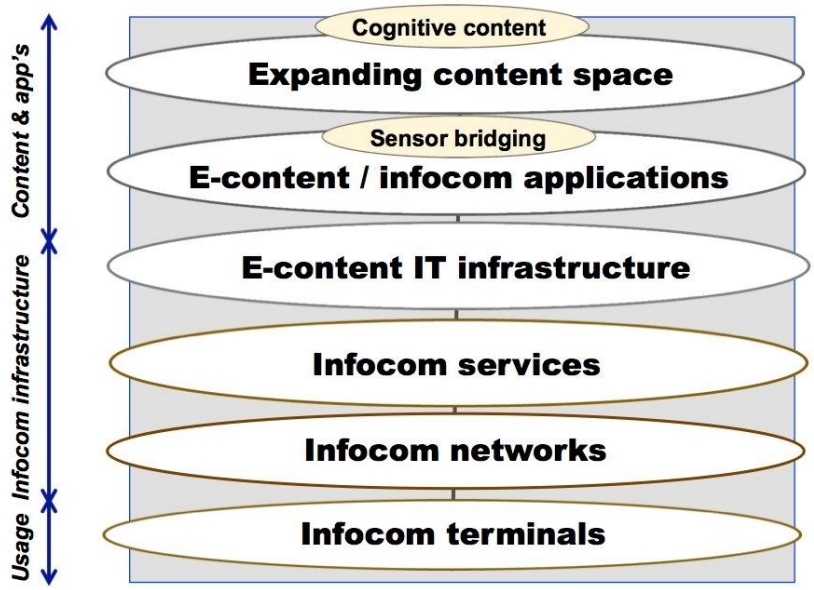

Figure 4

Expanding content space: cognitive infocommunications

media streams to PC-s, they can operate as audiovisual terminals. The SMS type data transmission has been developed for mobile phones. By digitization any kind of information content can be transmitted in the same way through different networks and therefore the integrated realization of these networks has become reasonable. A broadband IP-based network as an integrated network is equally able to transmit voice, data, text, audiovisual programs, multimedia, etc. (Figure 2a). The combination of contents and voice, data and AV services provides new IP-based multimedia service opportunities (Figure 2b). At the users, various integrative terminals appeared. The value chains of the voice-, data and mediacommunications have been intertwined; horizontal convergence and some integration of the services, networks and terminals can be identified, and instead of the separated "vertical" value chains single value chain with horizontal layers can be formed (Figure 2c) [20, 21, 31, 37, 38]. A unified telecommunication sector has emerged, which is formally called electronic communications. Deploying these horizontal convergences there is a uniform regulation for electronic communications in the European Union [11].

Phase 3 - Infocommunications, TIM convergence. Computer science and IT have been applied in telecommunications generally; more and more computers are connected through networks. The electronic media and content producing industries have also entered the convergence process to utilize the opportunities provided by telecommunications and computer networks which is demonstrated by the overwhelming spread of the Internet. Digital technology transformed and brought closer telecommunications, IT and content management, making the viable combination of the previously separated operational modes possible. Electronic content services and applications based on web technologies and delivered by electronic communication networks and services are emerged, from simple e-content services as information on traffic conditions, video on demand, etc. up to e-commerce, e-health, e-learning, e-government, on-line administrations, voting, population census or games, etc. In general they are called e-content or infocommunication applications (the terms content services, e-services, and information society's services are also used) [3, 7, 19, 20, 23, 38]. More sophisticated Future Internet applications have also been conceived and developed for managing a smart home or office, an intelligent transportation or energy system, or intelligent digital cities. The three convergent sectors are really merged, as an infocommunication sector (the terms of TIM, ICT and IST are also used). This infocommunication or TIM convergence pervades our everyday life; the convergent TIM technology is a relevant pillar of the future networked knowledge society. The value chain of the infocommunications shown in Figure 3 is also a layer model, containing three additional layers: the layer of the jointly managed content space, the layer of the specific infocommunication applications and the layer of the common IT infrastructure for the applications, including common databases, content management (editing, packaging, searching, etc.) and security systems etc. These three layers were separated during the evolution of the

Phase 3 from an initial application layer. The three layers below the application layer (IT infrastructure, e-communication services and networks) can be considered the infocommunication infrastructure.

Phase 4 – Cognitive infocommunications, expanding content space. The TIM convergence relating to the managed traditional content, such as telephone calls, text messages, AV programs, as well as web sites transforms the business and banking spheres, public administration and health, transport, education, knowledge systems, and it has societal implications. The business model and the social acceptance are becoming significant for the success of new solutions. Technological innovation is increasingly supported by research results on user attitudes, and human-oriented solutions can be developed by taking them into account. Recently, the sensory information managed has been limited to sight and hearing, but the content space can be expanded to all senses, including touching, smelling or any other modality, in general the human emotions and feeling, and gestures in 3D space. The sensory information obtained or experienced can not only be transferred to the destination, but also transformed to an appropriate sensory modality in a way that the user can process it effectively [9]. For example the sensory information reallocated and transformed from vision to hearing in the case of reverse radar, which helps the driver to sense obstacles when reversing the car with a beeping sound which becomes more frequent when an object is close to the car [2, 16]. Cognitive infocommunications (CogInfoCom) combines infocommunications and cognitive science and expands the content space with cognitive and sensory contents. The goal of the convergent cognitive applications is to extend the capabilities of the human brain through infocommunication devices, irrespective of geographical distance, including any combination of artificial and biological cognitive systems [5]. Thereby in the value chain the content layer is also expanded and the applications layer involves the bridging of the sensory information to an appropriate, manageable one, if necessary (Figure 4). The concept of CogInfoCom was born in the last decade; its deployment will further enhance the business and societal implications of the digital convergence process and prepare the further expansion of the content space.

3 The Labor Room and Some Examples on Convergent Applications

The Department of Telecommunications and Media Informatics (TMIT) of the Budapest University of Technology and Economics (BME) was established in 1949 as the Department of Wire-bound Telecommunications, and renamed into present form in 2003. Professor László Kozma, the founder of the department, dealt with the combination of telephony and computer technology. Later, Professor Géza Gordos was a pioneer in datacommunications and speech processing, recognition and synthesis [17, 28], and Professor Tamás Henk and

others established and deployed a high-speed network modeling, planning and management school in the department [6, 8, 12, 18, 39]. The author of this paper was the visioner and a leading planner of the digitalization of the Hungarian telecommunications network [32-36], and focused the attention of the department on the infocommunications convergence and media informatics, including technological and regulatory issues [3, 22-23, 37-40]. At the end of the last decade a natural extension of the infocommunication convergence, the synergic combination of the infocommunications and the cognitive sciences, the concept and scientific discipline of cognitive infocommunications was born by Professor Péter Baranyi [4, 5, 9, 15]. Since then the concept has been developed by a widening community, and the convergent infocommunication applications are completed by cognitive features [1, 2].

Henceforth some particular examples are shown from our practice for the infocommunication convergence and its extension with cognitive features.

The Medicine Line (MLN) automatic telephone information system was developed and put into operation in Hungary in 2006. The MLN system speaks and understands Hungarian. The MLN system reads (using a specialized text-to-speech converter) the textual information about the drug, having access to the content of the Patient Information Leaflets (PIL), and it contains a specialized speech recognizer for drug names and PIL chapter titles, etc. The dialogue between the system and the caller can be controlled by voice, or by pressing the phone's buttons. The MLN system is a perfect example of the integration of telecommunications (voice), information processing (speech synthesis and recognition) and content (PIL). The MLN system can help physicians, chemists, and hospital patients, in particular visually impaired and elderly people to get drug information by voice. (The drug information is also accessible in written form on the Web.) [26, 28]

The MLN and similar text-to-speech systems controlled by voice can be extended with the detection of the caller's intonation and feeling in order to control the style of the synthetized speech [13, 27, 43, 44]. For text-to-speech applications controlled by written text, special text mining procedures have been developed to recognize the caller's emotion and identify the speech style from the written text (dialects, slang, bad or good humor, …), then the style of the response is based on the recognized speech style or emotion [41].

An important area for sensor bridging cognitive infocommunications is the *autonomous vehicle driving systems* (AVDS), which recognize potential dangers, pedestrians on the road, driving limitations and possibilities. One of the key examples for a successful AVDS is to identify appropriate traffic rules valid on a certain road sector or at a junction. Such visual recognition helps navigation assisting systems to be safer, because the most car accidents occur due to the lack of concentration and failures to notice important traffic signs. Pedestrian recognition is also a key aspect of safe intelligent transport systems. A driver

support system has been developed which combines raw sensory with extracted visual data to provide extended information about the visual scene around the car [2, 16].

Three Dimensional (3D) Internet radically expands the environment of communications, and provides wide opportunities for cognitive infocommunications [4, 15]. 3D is natural for people, and 3D communications can embrace our cognitive systems, including not only hearing and vision, but gestures, somatic sensation (touch), smell (olfaction), etc. [9, 30]. Recently, a lot of applications running in different-sized touchscreens as user interfaces are now decisive in shaping the customer experience. Users more intensively use smart phones, laptops and tablet screens, and the smart TV interface has also become part of the screen portfolio; thus some gestures detected by simple or sophisticated touches within the display area are involved and the navigation practice is significantly changing. By Internet of Things (IoT) virtual walking and navigation in a shop, e.g. a drug-store can be done, and goods, such as drugs in box can be seen and virtually smelled and moved. Games are already excellent application area to test different cognitive input solutions. The 3D visualization techniques may promote multi-dimensional evaluation and comparison of different goods or shops or companies. Much more efficient warnings can be conceived for critical situations by combining visual and voice signals and vibration feedback, which are already widespread in gaming [5].

And finally we can refer to the additional emerging opportunities provided by the *Future Internet*, including dynamically adaptive Future Internet applications, e.g. in e-health area, interactive virtual media experiences [10]. In general, by enhancing the intelligence of things, in particularly their artificial cognitive components, sensory capabilities, proper CogInfoCom systems are created and Internet of Cognitive Things is approached.

Conclusions

The evolution of digital technology has had a pervasive impact on communication, information and media technologies and resulted in a convergent sector, called the infocommunications, or ICT/IST/TIM sector, which has become the pillar of the future networked knowledge society, and led to the birth of cognitive infocommunications. This paper identifies four phases of the evolution of the digital world: (1) the digitization of the separate communication sectors, (2) the digital convergence of the different communication forms, (3) the digital convergence of communications, information technology and content management, and (4) the expansion of the managed content space toward cognitive contents and beyond. The information value chain in each phase is radically different; the separated vertical value chains are merged and transformed into a single value chain with more and more horizontal layers. The paper also outlines some examples of cognitive infocommunications applications developed in the CogInfoCom's cradle. Several other examples for applying cognitive

content and combining biological and artificial cognitive systems are presented in the literature [1, 2].

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