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The ICT sector hand-in-hand with other sectors for a sustainable future

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Abstract. The ICT sector gets its true power and real meaning only when it offers information and communication solutions to other sectors and together with them prepares novel infrastructures, services and applications for the connected home, connected enterprises, connected public institutions and communities, and also a connected society. In this way it provides each of them with a more sustainable future.

Keywords: ICT (information and communication technologies), connected society, sustainable future

1 WHAT WILL THE FUTURE BE LIKE?

Our future and that of our children will largely depend on the balance of, and the ability to harmonize, the technological, environmental and, above all, economic and social maturity levels of all stakeholders in an increasingly globalized world.

The value and importance of the ICT (Information and Communication Technologies) sector will grow substantially, thanks to the advanced and ecologically friendly networks and elements used in them, rich services and applications, as well as advanced business models. The synergy effects of multidisciplinary use beyond the sector borders will contribute to the progress of the technological and environmental maturity of the other sectors. Based on its computing capacities, enriching data in terms of meaning and transforming it into information, a variety of presentation options and simple use, as well as its openness for the digital and social inclusion of as many users as possible while providing adequate security and privacy policies, the ICT sector will help increase the economic and social maturity level of the whole of society, thus making its contribution to a more sustainable future.

The world is going increasingly digital, and the internet has the key role in the development of the information society. Some claim that the internet is mankind's sixth sense, so its connection with other senses is of utmost importance. The proper technological support for mobility, fast and ultra-fast internet, along with advanced services and general inclusion, will bring an amazing progress after the key obstacles in the development of the information society have been overcome.

In May 2010 the European Council adopted a Digital Agenda [1], which is part of the Europe of 2020 strategy to overcome the economic crisis and ensure a stable future for Europe. In addition, they laid down seven priority areas of action: a new Single Market to deliver the benefits of the digital era; improvement of the ICT standard-setting and interoperability; increasing the trust in the internet and reinforcement of the internet security; significant increasing in the speed of internet access; increasing investments in research and development; enhancing digital literacy, skills and inclusion; and using the information and communication technologies to respond to the challenges facing society like climate changes and the ageing population. The Digital Agenda lays down 100 actions for the indicated areas, of which 31 are legislative measures that will promote the sustainability growth and general inclusion.

2 DIRECTIONS OF THE ICT DEVELOPMENT

The diverse telecommunications networks and the internet have undergone diametrically opposed transformations. The basic concept of the internet was to interconnect two smart devices in a relatively simple manner, while telecommunications networks connected simple devices in ever more complex ways.

The appearance of more or less intelligent devices and things (smart mobile phones, tablet computers, smart TV and smart objects) that connect to the telecommunications networks using different technologies, replacement of circuit-switching with packet switching, unification of fixed, wireless, mobile and cable networks at the IP level (All-IP networks), and introduction of the Carrier Ethernet services, bring these networks closer to the internet, both in terms of the architecture and the characteristics. On the other hand, the internet is increasingly becoming a service and business platform.

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The entrance of OTT (Over-the-Top) service providers, emergence of social networks, spread of video services (VoD, YouTube) and multimedia content (xHDTV – High-Definition Television, IPTV – IP Television) either used interactively or with a time delay, personalization, use of other rich services and a variety of applications, including those in the area of information technologies – all contribute to an enormous increase in traffic across the networks. There is a natural need, in particular with business users, for uniform access to, and the co-existence of, communications and also information services and business applications. Since this environment is the largest marketplace in the world, the security and privacy policy are of special importance.

Owing to the growing need for mobility and nomadic services, and based on the increase in the number of intelligent mobile devices and things as well as the associated services, an increasing focus is being placed on the mobile [2] and/or heterogeneous networks [3]. The heterogeneous networks support different wireline, wireless and mobile-access technologies and backhaul networks, which interconnect the access networks with either mobile or fixed core networks. The re-integration of the fixed and mobile operators along with the predominance of the broadband mobile access and mobile core networks is a trend perceptible worldwide. At the same time, there is a trend for the functional stratification of operators into providers of the network infrastructure and associated services, service infrastructure providers, providers of services and applications, and providers of the content, similar to the OSI stack structure.

The new architectures of the mobile and fixed networks include elements that introduce intelligence into those parts of the networks and in ways that enable the dynamic implementation of resources and traffic-management policies with regard to the services used and in accordance with the agreed business models. The technologies support new business models in the network in such a way as to make it possible for all the providers to get a share of income that they are entitled to. Likewise, the new technologies have built-in support for the end-to-end quality of service at different levels for all types of services, from network to video and multimedia services. For that reason, providers enter into Service Level Agreements, with one another and with end-users, thus providing the end-user with the agreed-upon user experience.

Interconnecting people, people and things, and one thing with another (the IoT – Internet of Things paradigm) dramatically increases the number of smart objects that form sensor, attenuator or even ad-hoc networks; one such an example being the communication between vehicles using on-board units (OBUs). Because of the increased volume of traffic generated by the devices and things themselves or at their interface with humans it is particularly important to think about the optimal path and the flow of the control and data traffic in the network. The growth of the number of devices results in an increased demand for network resources. An IP address is an essential source in IP networks. The IPv4 address space has been exhausted, so a transition to IPv6 is crucial. We are already facing problems caused by the co-existence or replacement of the IPv4 with the IPv6 protocol due to the eliminated IPv6 backward compatibility.

Because of the tremendous importance of information, not only information technologies, it would be logical to interpret the ICT acronym, which denotes information and communication technologies, as information, communications and technologies. The collection, transmission and governance of information for such diverse purposes as information transfer to knowledge, media advertising, marketing rules and work with customers along with control in the global space represent a completely new dimension in the development of the ICT sector.

We must not overlook the fact that the ICT sector shall, at the technological level, ensure an adequate network and data-security policy, and create solutions that will evoke a high degree of trust with the users. Access to digital content and the entertainment-industry content also involves copyright and licensing policy.

3 STRATEGIC TECHNOLOGIES

At a conference held in October 2011, the Gartner, Inc. analytics house presented strategic technologies and trends for 2012 [4] with the potential for a significant impact on the enterprise in the next three years. These include: media tablets and other intelligent mobile devices, mobile-centric applications and interfaces, contextual and social user experience, the internet of things, application stores and marketplaces, big data, next-generation analytics, extreme low-energy servers, in-memory computing, and cloud computing.

3.1 Mobile and heterogeneous networks

Media tablets and other intelligent devices for the mobile and wireless access that provide the user with multimedia content in addition to conventional services, change the meaning of mobile networks while introducing heterogeneous networks. Media devices are still expected to run in different environments, form factors and platforms.

There is a growing demand for radio capacity in the next-generation mobile networks, so pico base-stations (pBSs) and femto base-stations (Home eNodeB – HeNbs) are being introduced.

The use of broadband services requires higher transmission rates. In 4G networks this has resulted in higher transmission rates for the current access technologies, i.e., non-3GPP wireless technologies such as mobile WiMAX [5] (Worldwide Interoperability for Microwave Access) and wi-fi. At the same time, a new radio technology, LTE-Advanced [6] (3GPP, version 10), is being introduced in 4G networks. Along with the 2G/3G technologies there are also fixed-access

technologies, like xDSL over copper, different types of optical and electrical access, and cable access.

We are facing a major challenge on the global scale with regard to how to efficiently control, and over what core networks to connect the above mentioned access technologies, mobile (2G/3G/4G), wireless (wi-fi or WLAN access points, mesh wi-fi), and fixed access networks to ensure the services continuity, while devices move between different types of access networks. In the 4G mobile network, the Evolved Packet Core (EPC) architecture [7] is a promising solution for the core network. This is a flat, "All-IP" architecture similar to the IMS (IP Multimedia System) architecture, i.e., the separation of the control and data plane. In the new architecture, IMS is just one of the services, which connects, among others, the fixed part of the network to the mobile core network.

Mobile (2G/3G/4G, femto) and wireless (wi-fi, wi-fi mesh) radio technologies can also be connected over fixed-access networks and backhaul networks using the Ethernet and IP/xMPLS transport technology (aggregation layer), either to a fixed or a mobile core network. A mobile or a wireless backhaul network also comprises support for the data offload [8] of 3G/4G networks over wi-fi or WLAN access points, and integrates femto (HeNb) and pico base-stations (pBSs) in fixed transport networks. Similarly, residential gateways (RGs) support new forms of radio access networks (femto base-stations – HeNbs), while offering full support to IMS/RCS services.

Cable networks that are based on the DOCSIS (Data over Cable Service Interface Specification) standard and support IPv6 are used extensively to access broadband services.

Particular attention is paid to the network intelligence for the needs of a variety of Policy and Charging Enforcement Functions (PCEFs), as defined by the Policy and Charging Rules Function (PCRF). The aim of introducing this function was, among other things, to support innovative business models at the entry of new players, among them the OTT service providers, and handle business relations among them.

Because of the demand for an excellent user experience and for moving devices among various access networks, support for the dynamic end-to-end Quality of Service (QoS) and service continuity is built in the network architecture for all types of services, while devices move between different access networks.

In the 4G networks, great efforts have been made to ensure the quality of the oldest, i.e. voice service in the new media environment: Voice over LTE (VoLTE), and Voice Over WiFi (VoWiFi). As a result, operators often decide to provide a voice service over the existing 3G networks, while providing data, video and multimedia services via 4G networks.

In the heterogeneous networks, special care is given to their standardization. 3 GPP has standardized the LTE-Advanced and EPC architecture as a 4G-network architecture, whereas WiMAX Forum has provided for the coordination of the network architecture standardization within the IEEE organization (802.16e). The IEEE, in turn, has defined the latest wi-fi standard (802.11n). The standardization organization ITU-T has defined the technologies and architectures of future networks in its Y.3001 standard. ITU-T also standardized DOCSIS.

3.2 Open Platforms and Applications with Excellent User Experience

Applications and user interfaces for mobile devices have experienced the largest growth and the most radical changes over recent years.

Until recently, the Short Message Service (SMS) was the key service in mobile telephony. The advent of social networks, such as Twitter and Facebook, the use of mobile devices as a replacement for play consoles, and the exceptional variety of video and multimedia content for these devices have resulted in totally new approaches to the design of graphical interfaces and the handling of these devices. Thus, the two major manufacturers, Apple and Samsung, have developed new-technology solutions for displays (Amuled), touch-screens and voice interaction with devices, which replace the textual information input. Increasingly, client applications are substituted by more advanced applications designed by using Web technologies (HTML5). According to Gartner, Inc., by 2015 half of the conventional applications will have been produced using the new mobile Web technologies.

The incredible expansion of applications for mobile and other devices was made possible by introducing the concept of Open Service Platforms, Apps Stores and the Marketplace offered by manufacturers such as Apple, Google, Amazon, and Samsung, EURO-5 operators and others. The manufacturers offered the basic services and related application programming interfaces, which allowed new applications to be developed by both individuals as well as small and medium-sized enterprises. Apart from the entertainment and educational content services primarily offered by Apple and Google, rich communication services not based on voice, but multimedia, connections and connections to social networks are important as well. These services are provided by operators. The Rich Communications Suite (RCS) standard anticipates the development of applications with a very similar user experience for different devices (the mobile phone and the computer). The RCS and RCS-e standards are being developed by the GSMA, the mobile operators' association. The important fact is that devices, for example, mobile phones, are originally provided with the entire support and have all the required services and applications installed, including those required for access to social networks. There is also the MMTel standard (Multi-Media Telephony), drawn up by 3GPP and ETSI/TISPAN as the only global standard that defines an evolved telephony service for real-time multimedia

communications on fixed broadband and narrowband access, and mobile access in the IMS environment.

The contextual and social user experience in social networks is an additional motivator for the use of applications. Apart from the quality of service in the networks, the quality of the content personalization and the way it is presented has an impact on the user experience. This fact is widely used in contextual advertising.

3.3 The Internet of Things

By connecting things to the internet, the internet of things (IoT) introduces completely new dimensions into the existing networks: new architectures, technologies and protocols. The number of smart objects that interconnect to exchange data is increasing enormously. According to Ericsson [9], the number of connected and linked things will reach 50 billion by 2020, while GSMA [10] has estimated the number of cellular phones will be 24 billion by 2020. Things comprise different sensors and actuators, objects equipped with the RFID (Radio-Frequency Identification) tag, and also WEB services. Most often, sensors connect to wireless-sensor and actuator networks (WSANs) over standard protocols, like ZigBee1, MiWi2, WirelessHART3, 6LoWPAN4 and others, but they all rely on the IEEE 802.15.4 standard at the physical layer and the Media Access Control (MAC) layer [11]. Near Field Communication (NFC) technology, the Bluetooth5 standard variants and the WiFi6 are often encountered in sensor and actuator networks. At the application layer, the http is replaced by CoAP, which is more optimal in terms of resource usage in the device and communication.

The M2M (machine-to-machine) [12] connection is an IoT area of particular interest. Here, the advanced methods of connecting the means of transport to one another, e.g., interconnecting vehicles and things in vehicles using the on-board unit, are particularly important. The fields of application extend to body-sensor networks, environmental measurements, smart networks, company and transport logistics, and home-automation networks.

The ETSI, IETF and IEEE work actively on M2M standardisation, while the IPSO (IP for Smart Objects) alliance endeavours to define how smart objects will access the network and connect over IP.

3.4 Cloud Computing

Cloud computing is a business model in the first place, and to a lesser extent a technology. It is in the initial phases of development, although the big players in the industry, such as Oracle, SAP, Microsoft and IBM, have long been making efforts to prepare their solutions and services available in a public cloud.

Cloud computing is a lever for the new convergence of communication and information services, particularly with business users.

Service providers in a cloud, the industry and the public sector all see the infrastructure as a service (IaaS) in the first place. IaaS includes network resources and access to shared computer resources, servers and the processing power, disk space and other resources. More advanced users utilize the platform as a service (PaaS). The PaaS consists of an operating system, a database, middleware and other standardised software parts and applications offered to others for use via open interfaces. Some providers associate a part of the PaaS (particularly open service platforms) with software as a service (SaaS), while others offer in the SaaS, as well as parts of software, also applications (CRM, office applications and similar), etc.

All services are connected to one another communication-wise, but at the same time communications can be offered as a service (CaaS – Communications as a Service). The mechanisms in networks and protocols, as well as the architectural concepts, support the mobility of these resources and their virtualization, are provided with appropriate security and encryption mechanisms, and ensure the quality of service on communication paths.

The need for broadband access, as well as open communication and information services and infrastructure platforms, is increasing. Application programming interfaces are mainly an opportunity for small and medium-sized enterprises to develop new services and applications. They make it possible for operators to simplify the management of these networks and the provision of services for end users, thus reducing operating expenses.

In addition to the quality of service, it is necessary to ensure the organizational excellence and closer cooperation between the development and operative technical departments (IT departments). The DevOps technology has been developed for this purpose.

The security, privacy and trust policy will have a strong impact on a decision about where the services will be available: in public clouds, private clouds, hybrid clouds, or even community clouds [13].

3.5 Big Data and Next-Generation Analytics

Users and things exchange and store large amount of simple text data in addition to complex multimedia and web data. They exchange this data either locally or in a cloud, and in particular, in real time.

New technologies, new forms of storing and accessing data, and the ability to retrieve information from different data sources are under development (data federation). Relational databases are replaced by object-relational, object, EAV (Entity-Attribute-Value) and semi-structured databases. Data servers that due to a need for fast data handling, store the data in memory and, if necessary, save it on external memory units, have been gaining ground.

The analysis of large amounts of data in real time requires new techniques. In doing this, statistics, semantic techniques, machine learning and logical

reasoning methods are required for the semantic enrichment of data to employ. Based on data streams, texts and web, and by analyzing social networks, new information and knowledge that can be used in different fields and for different purposes are acquired. Correlating the current data with its history, and predicting future events and circumstances based on existing information are of utmost importance. To more easily understand the circumstances and interpret information, a clear visualization of complex data is necessary.

3.6 Efficient Use of Resources

During the recession and the unfavourable economic situation, the cost aspect of the growing demand for network and device resources is very important; it is a challenge for all ICT stakeholders and solution providers. Hardware with low power-consumption components is available. In addition, the consolidation of servers and the virtualization of resources are in progress. During operation, resources are only used when really necessary. Batteries and low-energy processors for all types of end-user devices are a big challenge.

3.7 Support to Operative and Business Processes

The goal of network and service providers is to automate the operating processes as much as possible, and to allow end users to manage their services on their own. These providers also connect business processes such as Customer Relationship Management (CRM) with billing systems. When managing a large number of elements, they even developed special network models such as self-organised networks (SONs) with automatic radio-spectrum planning and the automatic optimisation and configuration of base-stations. Of exceptional importance is the end-to-end management and monitoring of Quality of Service, and the provision of user experience in accordance with SLAs.

4 BUSINESS MODELS AND NEW PLAYERS

Innovative business models introduced by the **Telco 2.0™ Initiative** [14] include telcos, the media and the technology sectors, and run in both directions. The Telco 2.0 strategy lays down six opportunities for the operators: core services, vertical industry solutions, infrastructure services, embedded communications, third-party enablers, and own-brand OTT services. The users of these services include not only residential and business users, but also devices.

These models are innovative in that operators integrate developers, retailers, governments, media, devices, healthcare, industry, and other telcos in a business relationship. Other initiatives connected with the business models are Telco 2.0, M-Commerce2.0, Cloud2.0, M2M2.0, Digital Entertainment2.0 and MobileApps2.0.

One should not overlook the role of the OTT service providers [15] such as Google, Apple and Amazon, and social network providers such as Twitter and Facebook, which are increasingly becoming part of the telecommunications sector. Despite the fact that these operators and incumbent telcos are competitors at present, they will have to recognize that only mutual cooperation can result in an organic growth for both. Telcos will overcome fears of becoming a "dumb pipe" and turn into a "happy intelligent pipe", and OTT providers will not be forced to build parallel networks, install additional servers for the local storage of content at the operator, and cache servers (for example, the Google Cache Server). One should not neglect the fact that this is the beginning of a new type of network, a content-based network (CBN), which – because of the large traffic volume – compels telcos to establish "peering" connections.

The infrastructure services, such as cloud computing, which reduce users' initial investments in ICT, and cut ICT expenses by paying per use, have an impact on the new business models. The flexibility of the charging and billing systems is becoming a competitive advantage for the providers of all categories, including communication-service and infrastructure providers, service-enabler providers and service and application providers.

Apart from the innovative business models, the innovative marketing approaches and measures taken by regulators also have an effect on the operation of the providers.

5 THE ICT SECTOR HAND-IN-HAND WITH OTHER SECTORS

The following scopes of use are outstanding in terms of their general social and economic importance: the energy industry, biomedicine with telemedicine as its essential part, transport and mobility, integral support to conducting business, development and operative processes, the environment and life habitats on the Earth, the space habitat, and learning.

The significance of the ICT sector for the energy industry [16, 17] and biomedicine [18] is briefly described below.

The ICT sector will make a major contribution to transforming electricity systems to active distribution networks (smart grids). The following areas are crucial: the inclusion of renewable sources in virtual power-plants and energy holders, reservoirs, an advanced metering infrastructure (AMI) for smart electricity meters with two-way communication links between the key actors and devices (wireline, wireless and mobile networks vs. powerline communications, PLC), real-time data exchange (IEEE P 1901, IEC 61334 and ITU-T g.hn. standards), support to sensor networks for intelligent devices in home area networks (HANs), open service platforms, and operation and business support systems (management and monitoring systems, and

charging and billing systems). The fact is that the electricity network, although very stable and reliable, will not be used for AMI very soon, so over the short term an ICT network will be built parallel to this network. Based on rich data, information and analytics, the ICT sector also helps reduce energy consumption and increase energy efficiency.

In healthcare information systems, the ICT sector supports primary healthcare processes, secures access to a standard electronic health record (EHR), and implements biomedicine and telemedicine services for the medical staff, patients and all other medical insurance policy holders.

Europe has set itself the objective of a general implementation of telemedicine services by 2020. The application of ICT in monitoring the most vulnerable members of society will make it possible for these members to be actively included in society on an equal footing. It will also provide a more efficient system for knowledge transfer from biomedicine research to practice. For example, ICT will make the transfer of the results of biomedicine research in lunar habitats to primary healthcare easier.

6 CONNECTED IN DIFFERENT ENVIRONMENTS

We are connected in different environments: at home, in the office, in public institutions and local communities, and in society. An individual's private, business and public life is becoming ever more intertwined so we are connected to one another in different environments at the same time.

By the end of 2013, all European households should have a broadband access in their homes. The home environment with an increasing number of large-screen TV sets, associated video cameras and remote controls and any kind of telephone terminal provides a variety of entertainment, information, multimedia, video and voice services over a fixed or mobile network. It connects us to a private social network, provides an insight into the status and activities of the absent family members or friends, and allows us to exchange messages and photographs. The TV screen and other devices are a window on the digital world.

The Connected Home solutions [19] are open and suitable to connect not only family members and friends who use multimedia services, but also things. The innovative ideas of applications in home automation, energy industry, e-health (telemedicine being its important part) and other fields will bring about, after making the required improvements, a new quality of living at home and outside it.

Local community members are linked through social and information services that are closely connected with the life of the community. The services include local TV, a video library, local news and the exchange of other information, educational content and chat rooms, and local social networks with enabled telecommunications services. Local communities can offer these services [20] via a community cloud.

E-government utilizes integral ICT solutions for the internal organization of the government institutions, and communication between them and externally, thus considerably increasing its efficiency. With e-Administration, e-Health and other services provided by the government its citizens save time and money and, what is more important, these services are within reach at all times.

Based on the concept of smart transport and logistics, smart buildings and infrastructure, smart electricity consumption, smart habitats and various contextual information, education and new forms of socializing, smart cities and smart countries will introduce new sociological dimensions and overall inclusion in addition to a more efficient use of resources.

In companies, unified communications [21] among the employees, the possibility of teleworking and advanced relationships with customers and suppliers are of extreme importance. Rich services, such as shared desktop, presence and geolocation status, shared collaboration in preparing documents, and the remote use of office and other tools increase the efficiency of the employees. Cloud computing services facilitate hardware and software development and testing. Interconnecting things simplifies the logistics and other processes. In the digital world, e-commerce, media advertising and marketing have acquired a totally new character and meaning. Open service platforms and programming interfaces will contribute to the prosperity of small and medium-sized enterprises.

7 CONCLUSION

The ICT sector with its advanced, innovative technological solutions and principles remains as a very important independent sector. Its importance for sustainable development, general advancement and inclusion becomes even greater when connected with other sectors. The future internet will be represented by heterogeneous networks dominated by the mobile internet. These networks will be penetrated by multimedia services and content, and will be the next step on the way to a digital world. The future internet will be in the first place a new service and business platform that will offer a variety of services with an identical user experience on diverse devices. Things, too, will connect to form specific ecosystems. By offering rich data and analytics they will provide completely new information and approaches in different areas of application.

All the above-mentioned have one thing in common: built-in intelligence, which means a new quantitative leap in the perception of the digital world. Ease of use in addition to advanced services and applications will help each member of society get the content and information important for them.

New business models and new technologies will allow innovative players to take an active part in the new era of electronic communications.

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