Key Trends in the Information and Communication Technologies

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Abstract: *The paper describes the key trends in Information and Communications Technologies. It begins with the current status of ICT market and continues with the trends discussion of semiconductor, Information storage, telecommunications and Software technologies. The attention is paid on driving forces of ICT evolution and on some of existing limiting factors.*

Key words: *Information and Communications Technologies Trends, Computer Systems, Information Storage, Telecommunications, Networking.*

INTRODUCTION

In the last year the Information and Communications Technologies (ICT) continue their evolution after 2003 slowdown. There is no excessive optimism or pessimism but the typical crisis-rebirth pattern could be recognized and a long lasting growth period is expected. According to the most of experts the recent ICT crisis should be viewed as the beginning of a new innovation wave. The key trends of this innovation wave are the object of this work.

The current distribution of world ICT market by regions is shown on Figure 1. Europe has a good starting position in the new growth period because of its strong ICT sector. But the future European ICT market share depends mostly on the quality of the economical environment.

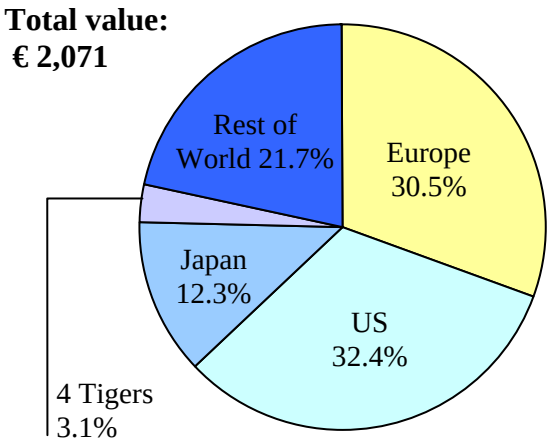

Figure1: World ICT market by regions

The relatively low current levels of Eastern European ICT spending are shown on Table 1. These low levels are a problem now but they also represent good possibilities for fast returning ICT investments in the near future. It could be expected that Eastern Europe will have a substantial contribution for dynamism of European ICT sector in the next years.

Figure 2 represents the structure of European ICT market. The advantage of communication industry over the rest of the ICT industries is obvious and could be used as a basis for the strong evolution of E-economy (the economy based on pervasive use of Internet). Despite of relatively slow recovery in the European ICT market, the indicators of E-economy shows an increasing number of Web-users, Web-buyers and increasing adoption of Internet in the everyday life.

In order to view entire ICT evolution the trends in the semiconductor technology, storage technology, telecommunications and software platforms are discussed below.

Table 1: Information Technology spending in Eastern Europe

	IT spending in € million	*Share in %*	*IT/GDP in %*	*Per capita IT spending in €*
Bulgaria	312	2.7	1.8	40
Czech Republic	2,620	22.7	3.3	254
Estonia	216	1.9	3.1	150
Hungary	1,956	16.9	3.5	193
Latvia	220	1.9	2.5	92
Lithuania	257	2.2	1.7	73
Poland	3,992	34.5	2.0	104
Romania	719	6.2	1.5	32
Slovakia	757	6.5	2.4	141
Slovenia	507	4.4	2.1	255
Total CEE	**11,555**	**100.0**	**2.3**	**111**
Total Western Europe	**286,740**	**100.0**	**3.1**	**735**

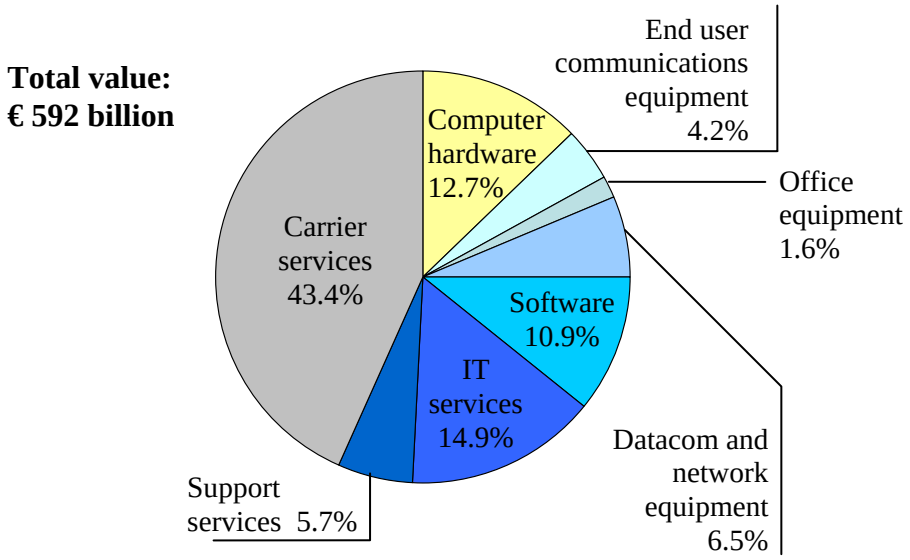

Figure 2: Europe ICT market structure in 2003

SEMICONDUCTOR TECHNOLOGY TRENDS

According to the Moore's law the number of transistors on a chip has doubled approximately every 12 to 18 months for the past 30 years. The exponential growth has been regular since the mid-'70s and so the Moore's Law has become the basis for planning in the semiconductor industry.

Ray Kurzweil suggests that this trend is not limited only to the semiconductors in the last few decades but that the calculations per second per dollar have been also increasing exponentially since electromechanical calculators were introduced in the early 1900s. On Table 2 the growth of computer performance is illustrated from the introduction of the first commercially important computer IBM 1401 in 1960.

Moore's law driving factors that are the proven source of increasing computing capacity and decreasing hardware price could be summarized as follows:

- The growth of chip's area;
- The size reduction of the elementary components of integrated circuits;
- The improvements in circuit design.

These technical drivers but represent the potential limits to the sustainability of the exponential growth.

Table 2: Moore's Law and performance

Year	*Model of CPU*	*Performance (MIPS)*
1960	IBM 1401	0,00057
1969	IBM 360/85	2,53
1973	IBM 370/195	5,72
1983	CDC Cyber 170	19,79
1993	Silicon Graphics Challenge/XL x32	1 979,00
1994	Cray CS6400	4 794,00
2002	NEC Earth Simulator	28 293 540,00

Technological Limits. The further increases of chip area have been limited by the cost per area unit of integrated circuits.

The continuous size reduction of MOS (Metal Oxide Semiconductors) transistors is now threatened by two technical factors:

- The growth of internal delays due to increasing of residual capacity and serial resistances and
- The growth of thermal dissipation due to increasing the influence of the parasite stand-by currents.

Economical Limits. The economic version of Moore's Law states that the investments for development of a new microelectronic technology grow exponentially with the time. Microelectronics companies currently invest about 13% of their revenue in research and development (R&D) and this percentage will grow with the following significant consequences:

- Decreasing number of companies can afford required R&D investments;
- Growing investment risks;
- A growing number of joint ventures with R&D objectives.

The results are high consolidation of the semiconductor industry and very small chances for success of new entrants.

For the further support of the exponential growth stated by the Moore's law the very important question is to have applications demanding it and this way justifying the huge research and development investments. The continuous expansion of CPU's capacity is the main enabling factor for the introduction of new applications. There is an agreement that current production technology will give some confidence about exponential growth in the next 12-14 years. In this period the *Nanoscale devices* with structural features in the range of 1 to 100 nanometers will be introduced. Potential applications of nanoscale electronics in the future 10–15 years include:

- Microprocessor devices with great capacity, lower energy use and cost per gate;
- Communications systems with higher transmission frequencies and more efficient use of the optical spectrum to provide at least 10 times more bandwidth;
- Small mass storage devices with capacities at multi-terabit levels;
- Integrated nanosensor systems those are capable of collecting, processing, and communicating massive amounts of data with minimal size, weight, and power consumption.

The possible alternatives of current semiconductor technology are molecular electronics and quantum computing.

INFORMATION STORAGE TECHNOLOGY TRENDS

Disk drives and other forms of information storage reflect similar improvements in cost and performance like semiconductors. As a consequence, the amount of information in digital form has expanded greatly. Information on disk drives now constitutes the majority of digital information and increasingly, much of this information is available on-line. The annual production of new information and its distribution on different types of magnetic media shows the obvious prevalence of hard disk drives. On Table 3 is shown the evolution of hard disk drive units shipped and total storage capacity of since 1992.

Table 3: The annual production of hard disks

Year Disks	*Sold (Thousands)*	*Storage Capacity (Petabytes)*
1992	42,000	
1995	89,054	104.8
1996	105,686	183.9
1997	129,281	343.63
1998	143,649	724.36
1999	165,857	1394.60
2000	200,000	4,630.5
2001	196,000	7,279.14
2002	213,000	10,849.56
2003	235,000	15,892.24
TOTAL	**1,519,527**	**41,402.73**

Exponential cost reduction of hard disk drives is shown on Figure 3 - since February 2003, the cost of disk-drive capacity has dropped below US$1 per gigabyte.

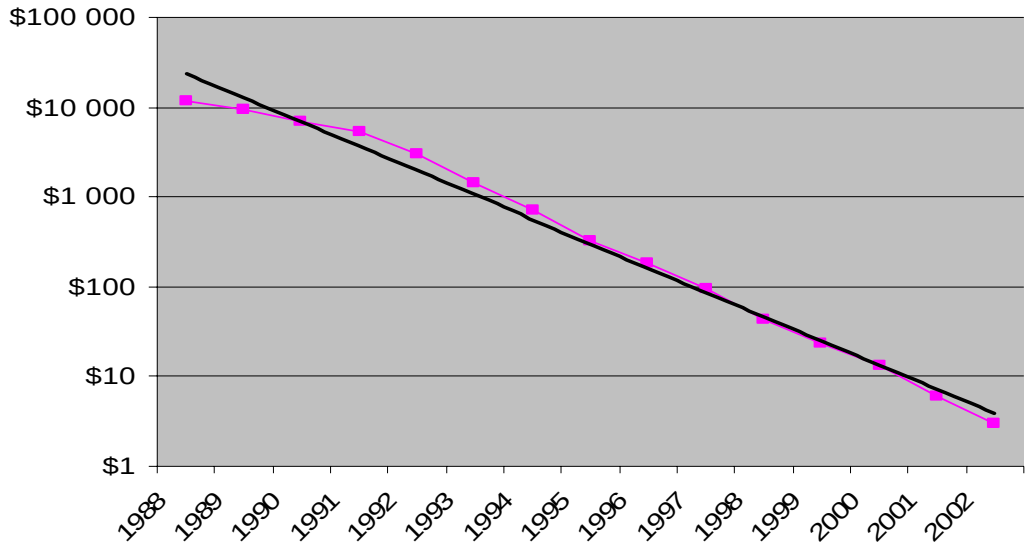

Figure 3: Cost of 1 Gigabyte Information Capacity of Hard Disk Drives

TELECOMMUNICATIONS AND NETWORKING TRENDS

The Metcalf's low states that the value of a network grows in proportion to the square of the users' number. As a network grows, its value increases to each individual user, and the total value of the network increases much faster than the number of users. This is also referred to as "network effects." Metcalfe's Law explains why the adoption of a technology often increases rapidly once a critical mass of users is reached and the technology becomes increasingly valuable. The Internet evolution shown on Figure 4 has been the most dramatic demonstration of Metcalfe's Law. Many Internet-related services also exhibit

network effects and many companies have heavily discounted their services in hopes of later being able to capitalize on the value of the network they have created.

The markets with strong network effects may tend toward monopoly. It is more difficult for new entrants to become established in similar markets.

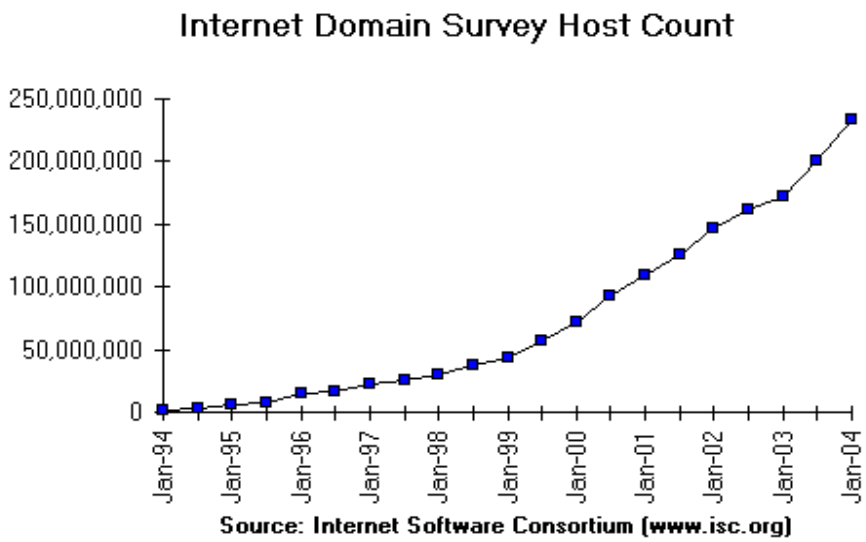

Figure 4: The growing of Internet

The Internet users in Western Europe countries for 2003 compared with the expected users for 2007 are shown on Figure 5.

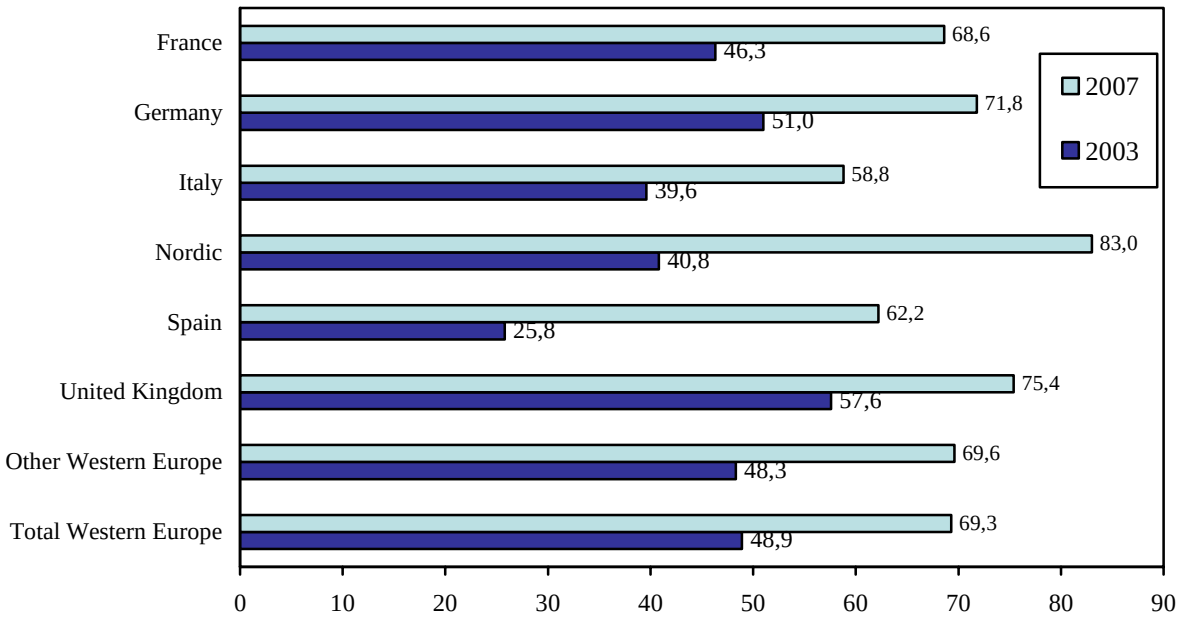

Figure 5: Internet users in Europe for 2003 vs. 2007

The Internet penetration in Bulgaria is represented on Figure 6.

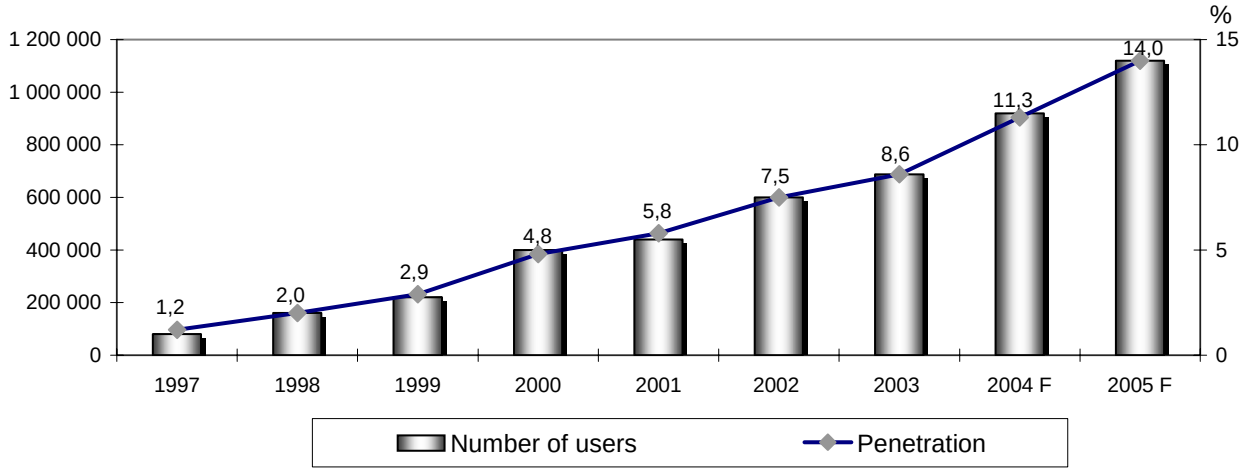

Figure 6: Internet Penetration in Bulgaria

The expected Internet evolution in the near future could be summarized as follows:

- For the increasing amount of real-time traffic the possibility for users' negotiation of QoS (Quality of Services) parameters becomes very important.
- IPv6 Internet protocol will become more widely distributed because of future shortage of Internet address space.
- The migration from IPv4 to IPv6 is not simple and will be performed slowly.

The evolution of broadband access networks is very important for the Internet future.

Currently the *Wired broadband access* in Europe is based mainly on ADSL (Asymmetric Digital Subscriber Loop) technology. The main characteristics of ADSL technology are:

- The existent standard telephone line is used with the downlink capacity from 1.5 to 8 Mbit/s.
- The distance from provider is limited because of high bandwidth requirements and for the same reason the quality of legacy equipment is critical.

The future evolution of ADSL is toward the longer reach by providing better modems or signal regenerators along the loop.

The more expensive but and more perspective alternative of ADSL are the optical fibre access networks that are referred as FTTH (Fibre To The Home). FTTH is usually provided over passive network by using ATM (Asynchronous Transfer Mode) technology. The advantage of ATM is a high level of QoS possibilities. The other characteristics of FTTH technology are:

- Much more capacity – 10 Gbit/s is now widely deployed.
- Need for new cabling.
- All services (Telephone, Internet and Cable TV) can be offered with a single network.

The *Wireless broadband access* currently is deployed mainly by the Wi-Fi (Wireless Fidelity) local area networks that are characterized by the:

- Low cost because of unlicensed frequency band usage;
- The shared bandwidth among users in the 5GHz band is up to 50 Mbit/s;
- The reach is limited

One other wireless network is a Bluetooth radio interface personal area network which mainly is used to create connections among different electronic devices. The overall

transmission capacity of that network is 1 Mbit/s, the reach is more limited than Wi-Fi networks and is about 10 meters.

In the near future the deployment is expected of a third-generation (3G) mobile packet-based broadband network with UMTS (Universal Mobile Telecommunications Service) standard. UMTS is capable to transport text, digitized voice, video, and multimedia at data rates up to 2 Mbit/s. The main services are: Telephony, Videotelephony, Data traffic. The full mobility of users is enabled. The main disadvantage is that UMTS is complex and expensive for operators and vendors and requires massive investments. The expectations are that UMTS will boost mass mobile Internet usage.

Fourth-generation networks include a wide variety of communication technologies. The most distinguished features of these future networks are expected to be:

- Ultra-wideband radio technology – data rates greater than 100 Mbit/s
- Dynamic and automatic construction of networks (ad-hoc networking).

SOFTWARE PLATFORMS

Application development is now under constrains of the existent hardware and network capacity. There are a number of applications that are expecting the future high capacity computing platforms as is shown on Figure 7.

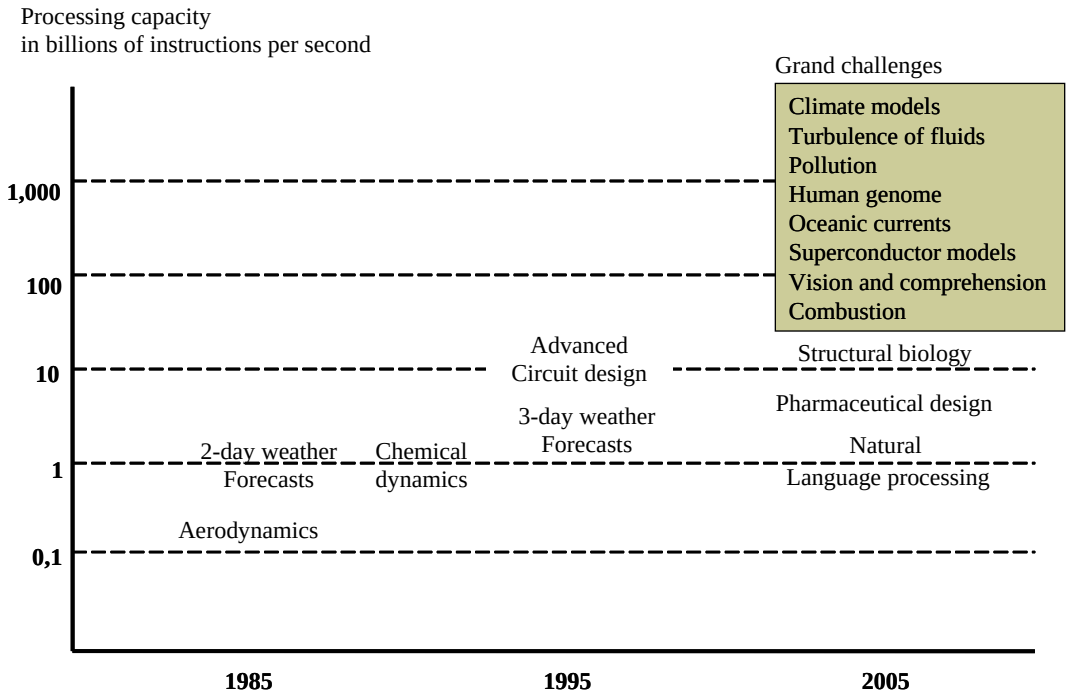

Figure 7: Evolution of application requirements

In the real world the integration of new functionality (i.e. new application deployment) in existing information systems is considerably slower process than capacity growth. The most of the companies are solving now the problems with internal integration of their information systems and have just started inter-organizational integration process. The typical representatives of commercial software platforms that are evolving to support both integration processes are:

- Enterprise Resource Planning (ERP) platforms;
- Customer Relationship Management (CRM) platforms;
- Enterprise Application Integration (EAI) platforms.

The future of inter-organizational integration is closely connected with the development of the E-business platforms and with the emerging languages and standards for Web-service design.

THE RESUME OF THE KEY TRENDS IN THE ICT

The Internet and its Web-enabled infrastructure will continue to grow and expand; Internet technologies will be used in organizations as the primary application service mechanism.

Service and information will be the primary focus for users; the perception of an organization will be measured on their ability to deliver service.

Mobile computing will accelerate dramatically through the use of integrated computing devices; Web technology will be the primary delivery mechanism for mobile devices.

The costs of computing resources will continue to decline; human resources will continue to increase in cost.

The shift from legacy client/server model to network-centric computing environment will allow the organizations to be more customer-focused rather than IT focused.

Network bandwidths will continue to increase, thus allowing Internet-based services and information to be provided in a timelier manner.

The results of the inquiry of IEEE fellows about the center of new technology research and development in 2014 rank the United States on first place (60%), followed by China (18%), Southeast Asia (7%), European Union (6%) and India (5%).

Despite that it could be expected that ICT evolution in the next years will be into its more matured phase, without dramatic changes. Into this evolution phase the role of the ICT applications deployment will be essential and so advantages for the huge and matured economy of the European Union will be more distinguished.

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