

Chapter 9

Two years of technological progress and innovation

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OVERALL CONTEXT: INTERNET PROTOCOL AND INTEGRATION

The drive towards the globalization of Information and Communication Technologies (ICTs) which involves computer hardware and software, radio and television receivers, broadcasting and telecommunication equipment and networking and multimedia systems, has created new technologies, products and services. The years 1997 and 1998 saw an unprecedented number of such innovations.

This chapter describes those innovations which have a strong impact on the trend toward technological convergence. A complete book on the subject would not be sufficient to present an adequate picture of the whole reality, and many important areas, such as the mainframe segment of computing, RISC processors, parallel computing or questions of security, have not been included. Another constraint is the difficulty in drawing a clear line between hardware and software in technological innovation. Many developments in scientific computing, data base handling and network use which might have been included have been omitted for reasons of limited space. Nevertheless, it is hoped that this survey will help the reader to understand the accelerating pace of innovation in all information and communication technologies, which seems to be driven by the two phenomena of globalization and integration.

Integration is taking place in the form of large numbers of virtual communities. Such communities are identified by specific unifying themes which allow planners to identify a range of products, systems and services to address the needs of the community members. Products resulting from the technological convergence of computer, broadcasting, telecommunication and consumer electronics are examined to determine how services in the immediate future will be shaped by the present product innovations, especially for the generation, transmission and use of content.

A singular technological feature of the two years in question, which is a turning point for ICTs, is the pre-eminence of the Internet Protocol (IP) for communication, around which ICTs are reorienting and growing. This versatile connection-less protocol is a method by which data is sent over the Internet as packets from one computer to another, each having a unique address. Different packets may be delivered through different routes to their destination, where they are re-sequenced by the Transmission Control Protocol (TCP) and put back in the right order.

The Wide Area Networks (WAN) which are identified as Internet (international networks), Intranets (corporate or intra-organizational networks) and Extranets (extra-organizational networks) are all IP-based. IP has left its imprint not only on Metropolitan Area Networks (MAN) and Local Area Networks (LAN), but also on equipment such as the network computer, workstation, work group server, media server, Web server, cable TV networks, wireless 'last mile link' to the customer premises, set-top-box and even a kiosk.

This review will centre on two sub-themes concerning such systems, equipment and devices: the technologies driving the content markets and new products of the past two years which are likely to shape services in the near future. Leading technology brands cited here are to be regarded as representative illustrations of trends from a fleeting market.

COMPUTER HARDWARE

The technologies driving the content market have brought about new developments which have increased the speed, capacity and versatility of computer hardware. Moore's Law has predictably doubled the performance of microprocessors every 18 months and personal computers (PCs) have become increasingly powerful with the introduction of new devices such as cache, more effective architecture and bus interfaces as well as extensive instruction sets. The

introduction of the Slot-1 interface in the second generation of the Intel Pentium family of chips, from the first generation 296-pin Socket-7 interface, made a 242-Contact Slot Access available through a cartridge with a single edge contact. This innovation will ensure a smooth upgrading from one model of the chip to the next without having to change the PC design extensively. The result is a designer's paradise for minimizing user problems, while upgrading the capacity of PCs frequently to accommodate an ever-growing range of content. The low cost medium speed entry-level Covington allows designers to create a plethora of product lines from a single mother board. Mendocino is increasing the 128K of L-2 Cache on the processor chip at processor speeds. The Celeron chip has the capacity to produce further growth in the content market. The three leading chip manufacturers, AMD, Cyrix and IDT, are marketing K6, MXi and C6 chips respectively in competition with Intel, and will strengthen their position by early 1999 with the introduction of K7, Jalapeno and C7. By then, Intel will be expanding its processing capacity with Katmai and Merced Chips with a 64-Bit instruction set for the server and workstation markets.

Hand-held computing is becoming a useful tool for the collection of data in the field. Battery-operated receptacles of wireless information, integrated PDA chips like Intel's Strong Arm-1100 running at 200 MHz consuming only 200 milliwatts to power a hand-held PC, 3Com's Palm-III with an infrared receiver and wired modem for connecting to the Web, and Novatel Minstrel's Wireless Modem, which integrates both data and voice communication, are forerunners in this area. Optical Read Only Memory (OROM), with up to 128 MB of storage and no moving parts, provides extra storage in the hand-held PC. Philips Nino Palm PC which runs pocket versions of Microsoft applications is already available, although the battery power pack at present does not last for more than a few weeks. A close competitor, Windows CE, is gaining momentum.

PERIPHERALS

The main problem in home automation is the communication among various devices and appliances. A possible solution appeared with several technologies using existing home ac wiring for telephone, and computer and appliance control utilizing the X-10 Standard module available for most types of appliances. Consumer electronics and PC industry companies have also agreed upon a new consumer electronics bus standard (LE bus), marketed, for instance, by Home Plug and Play, which is an improvement on the X-10 standard followed previously. Software for controlling modules of either of these standards is available. Ethernet PC network with CE-Bus controllers can be connected to PCs and home entertainment systems.

The desk top Sedona offers a versatile tool for content searching which groups file system, Web browser and e-mail client into a single graphic user interface – a trendsetting concept developed by the Intel Architecture Lab (IAL). Sedona can locate items selectively and find files, e-mail, Web pages or news items of interest without any active input. It can also correlate a message or a document that has been opened with other relevant stored information.

New audio standards have been introduced which allow multimedia to provide real-life, 3-D sound for content developers of titles encoded with Dolby digital. This can add depth to sound, almost to the point of immersion. Multimedia titles can now be encoded with information that creates the illusion of 3-D sound with just headphones or a pair of PC speakers. Direct sound and Direct sound 3-D from Microsoft allows for the mixing of multiple audio streams and programme-surround channels. As multimedia require larger and larger files, the 1.44 MB capacity of the floppy disk is becoming less appealing and is giving way to three typical competing technologies for removable drive: IOMEGA Zip Drive, Sony-Fujifilm HiFd and LS-120, tending towards the

goal of inexpensive 100 MB adequate for multimedia presentation applications, and of course compatible with the existing 3.5 inch floppy disks.

MEMORY

There is a shift from compact disc-read only memory (CD-ROM), towards digital versatile disc read-only memory, version 2 (DVD-ROM-2) drives which can read CD recordable or CD re-writable media. Though better than DVD-ROM-1, at present, they lag behind the fastest CD-ROM drives in overall performance. The sheer enormity of DVD capacity will be useful for storing raw data. It is possible to make feature-length, documentary films using DVD, using high-resolution MPEG-2-standard video compression, immersive Dolby-standard audio compression and extensive 3-D graphics. Everything from high density needs to theatre quality audio and video has become possible. Compared to the 650 MB peak capacity of CD-ROM, contemporary DVD-ROM media can store nearly 5 GB of data per side, and this quantity will soon attain 17 GB. MPEG-2 has now surpassed the quality of laser disks. An interactive geographic Map Atlas, giving a terrain database of the entire surface of the earth at 1 km intervals with MPEG-2 video, has now become a possibility.

COMPUTER SOFTWARE

In 1998, the software industry reached a turning point: the decisions made will determine the direction to be taken by software architectures of the future. This trend is accelerated by the convergence of computer, communication and consumer electronics. The once-dominant operating system, such as Windows 3 booted from DOS, will make an exit. Windows NT is now on the verge of addressing the need to support inexpensive computers and a limited range of device support. Microsoft has begun certain development efforts which will make Windows NT usable as a consumer operating system, thereby making Windows

a more stable platform. A 64-bit architecture, the next paradigm shift in computing, is another new development. To the more than 4 billion bytes of space in a 32-bit address, 4 billion more bytes are being added. Thanks to the memory-mapped file system, programmers will not be required to open, close, read from or write to files any more. The operating system will move the bytes between disk and memory as required to get the data structure from the operating system that contains the data in the file. The new architecture will also allow for the use of integers instead of floating point numbers in many applications, thereby increasing the processing speed and simplifying programming efforts.

USER-FRIENDLINESS AND USER INVOLVEMENT

The year 1998 also saw the beginning of a shift away from professional intermediaries by associating users directly with their software. As a result, users will be required to learn how to express their problems, set up and adapt computations and carry out tasks such as configuration, upgrade, back-up and recovery. To attain this goal, software system designers have had to re-define user-friendliness. As a result, software carriers like the Web, Integrated Office Suites, Interactive Environment and Visual Basic, which create their own environment from locally available resources, have become popular because they allow users to create or modify software to correspond to their needs. The setting up of stand-alone processes that can run unmonitored requires an open-ended set of computations – independent processes in mail filters, automatic cheque payment and Daemons, which are sets of software routines and instructions for automating network management tasks.

In another move to user-friendliness, sparked by the concept of a hyper-linked design of the World Wide Web, the user interface on personal computers has begun to imitate human perception. The Graphic User Interface is inventing software products that

organize information graphically in more and more intuitively appealing ways. Continuous speech recognition programmes from International Business Machines (IBM), Dragon Systems and others, have started a process whereby speech recognition will be added to the existing programmes like the speech-enabled version of Lotus Notes.

DATABASES

The development of Object-Oriented Data-base Management Systems has accelerated to overshadow the traditional Relational Data Base Management (RDBM) software development. Object-Oriented databases allow new data types to be created with traditional attributes found in relational models as well as built-in functions, methods and objects which are convenient for applications requiring video and image content. However, the growing popularity of data mining (the 'mining' of numerical data in repositories such as spreadsheets and databases) and data warehousing (the gathering of data from legacy mainframe and PC server databases into gigantic centralized databases) has made it possible to keep RDBMS in use. The interoperability of the Distributed Component Object Model (D-COM) and of Java running on Common Object Request Broker Architecture (CORBA) made databases capable of mixing and matching data in an unprecedented manner. These two trends have brought about a hybrid technology that patches object capabilities on to traditional RDBMS products.

Data visualization is a new graphics application which displays in a graphical form the trends that the numbers represent. The evolving Extensible Markup Language (XML) and dynamic Hyper Text Markup Language (HTML) are being integrated to give better graphics on the Web, and new graphics software is being developed for data mining to bring out any hidden information. PCs featuring 3-D graphics and exceeding current performance are actively being developed which will increase immersive experience, as if sound and graphics were surrounding the user.

VIRTUAL REALITY

Virtual Reality (VR) is now regarded as a natural extension of interactive multimedia. New immersive interfaces like Vision Dome and Immersive Work Bench allow several workers to co-operate and interact in conducting simulation experiments on virtual prototypes. With high-speed networks and the World Wide Web, work may be carried out from almost any geographical location. Architects and furniture wholesalers have already begun using VR on the Web in 3-D by using Virtual Reality Modeling Language (VRML) to give customers a wide selection of simulated prototypes from which to choose.

During 1997 and 1998, there was a rush to create World Wide Web-enabled Software that could be used over the Internet, Intranets and Extranets for exchanging data, with a web site to run programmes, control experiments remotely or publish documents on a network. A significant software-related development has been a shift towards the Web-centred work environment and the electronic distribution of information. One major deficiency of the Web, namely the limitation of HTML in dealing with mathematics, has been reasonably solved. Instead of the past practice of representing equations as embedded graphics, which proved highly inefficient, an extension of HTML, called MathML, has been developed. Many new developments have encouraged the electronic publication of journals, some of which have replaced the paper versions.

One of the most significant developments of software applications in 1997 and 1998 saw the rise of the Enterprise Resources Planning (ERP) package, offering a completely new opportunity for organizations to plan their resources around growing customer demand and to offer leading-edge solutions, reduced turn-around time, increased efficiency and improved profit margins. ERP integrates the entire enterprise from suppliers-retailers to customers, and covers departments as functionally independent as finance, production and distribution.

NETWORKING FOR VIRTUAL COMMUNITIES

In 1997 and 1998, the concept of network-based virtual communities, which will redefine the relationship between companies and customers, gained ground. The emphasis is shifting away from the retailers and is allowing customers to deal directly with wholesalers for the purchase of products and services by capturing and managing information themselves. This is promising to become a beneficial situation for both customers and wholesalers.

Virtual communities will act as agents for their subscribers who will receive adequate, accurate and timely information on products and services; they can purchase at a lower price and with better quality, while this same medium – so supporters claim – meets the social need for communication. The wholesalers will find the virtual community to be a powerful vehicle for expanding their markets, since the very concept is oriented away from brand images. They will also benefit from the increased propensity of customers to buy, and from reduced marketing costs of customer searching. Wholesalers will also receive a better statistical picture of changing customer tastes and choices and be able to target products to a subset of customers judged more likely to purchase. Above all, the overhead of building retail outlets will be minimized, while an online networked environment will reach a much broader customer base with no geographical limits.

The virtual community requires a technological strategy based on speed and leverage, with the emphasis on modular technology architecture and a focused information infrastructure. The choice of the network platform is between participation in an online service or the Internet. The strength of the Internet lies in its enormous diversity of resources assembled in one networking environment, and the TCP/IP and HTML standards offer more opportunity for growth and innovation than proprietary platforms.

Widespread developments of new technologies are taking place to make the Internet the best choice for the virtual community.

Thousands of millions of dollars invested in conventional networks, with voice-dominant circuit-switched analog networks, are being threatened by the widespread popularity of the IP-based data networks. The IP packet as the natural medium of exchange was adopted so quickly that the growth of data and voice-over-data traffic increased sharply in 1997 and 1998. It is estimated that worldwide data traffic is multiplying by an annual factor of ten or more.

LOCAL AREA NETWORKS

In the local area networks, or LANs, switching technology has resulted in Fast Ethernet in the range of 100 Mb/s and Gigabit Ethernet in the range of 1 Gb/s. Asynchronous Transfer Mode (ATM) has proved useful in full backbone networks as well as in Synchronous Optical Networks (SONETs). According to a worldwide survey conducted by Dell's Oro Group, the market for ATM switches and concentrators increased by 77% from 1996 to 1997, and 60% from 1997 to 1998. ATM is also a leader in the MAN/WAN for inter-building and intra-campus connectivity, and is becoming an important infrastructure for public carrier networks. Such ATM networking is bringing significant synergies to the operation of IP networks, allowing for true integration of multiple traffic types on the same network infrastructure. Wireless LANs have strengthened only in areas where optical fibre networks with high band-width are either absent or deficient. Wireless systems have provided good solutions to the last mile problem in MANs. For this, the Multi-channel, Multi-point Distribution System (MDS) in the two GHz band and as the Local Multi-point Distribution System (LMDS) in the high-frequency band between 26 GHz and 30 GHz have found wide acceptance. With cellular phones, the digitalization process is gaining ground.

DATA TRANSMISSION

Trends in Europe are towards the growth of Integrated Services Digital Networks (ISDN), which is not the case in North America. The speed and reliability of ISDN at a typical data transmission rate of 128 Kb/s has made it attractive for homes and small businesses. A serious competitor for ISDN is Asymmetric Digital Subscriber Line (ADSL) technology, which allows data to flow downstream towards the subscriber at rates of up to 6 Mb/s. Both are suitable for Internet access.

SATELLITE TELECOMMUNICATIONS

Although INMARSAT-A was first launched in 1991 as an alternative to VSATs by offering high transmission speeds from a miniature ground terminal, the latest version called INMARSAT-B Duplex High Speed Data (HSD) service has now become commercially available in all oceanic regions. It supports high-speed file transfer, store and forward video, video conferencing as well as voice, fax and data transmission. A large number of users including government agencies, international organizations, multinational companies and broadcast service providers have found the services useful.

Many of the above-mentioned development, like ATM and SONET, have led to the creation of networked multimedia systems, which offer several advantages for transmitting still and moving images, graphics, texts and sound; a number of content-rich applications are pushing multimedia communications forward.

Motorola's \$3,400 million Iridium venture, with a constellation of 66 satellites and ground links to hand-held phones, was the beginning of a new race among the giants of the satellite business. Competitors such as Loral's 48-satellite Global Star System, the Echostar System and Hughes Electronics Constellation, among others, will probably place ten times the present number 150 commercial satellites into orbit

over the next decade. From the present \$9,000 million annual revenue from satellite services, the year 2000 is expected to see nearly \$30,000 million. Such Low Earth Orbiting (LEO) Satellite systems (they orbit about 1,000 km above the earth) and Medium Earth Orbit (MEO) satellites will bring about a revolution in global voice, paging and fax systems, as well as usher in the next stage of broad-band multi-satellite systems offering fast Internet and video. Compared to the \$30,000 million invested in the cable television industry over the past two decades, the satellite telecommunications industry has invested more than \$20,000 million in the past five years and has lined up \$60,000 million for the next five. One of the keys to making satellites pervasive has been the reduction in the cost and size of user terminals by concentrating power more intensely on smaller geographic areas and by re-using precious frequency spectrums many times over. The growth of the Internet and other distributed networks is making star networks less and less effective. Consequently, in 1997 and 1998, commercial satellites with on-board processing, allowing signals to be switched between spot beams in the satellites, began to appear.

THE WORLD WIDE WEB

The World Wide Web is a window open to the tens of millions of pages available online. In addition to being a provider of video services, the Web is a major market driver for broad-band networking. At the beginning of 1997, an estimated 30 million users worldwide used the Web for work, education and recreation at home. With the increase of multimedia applications, Web content is becoming more and more tailored to fast networks. Web browsers have already become universal Graphical User Interfaces (GUIs) for narrow-band services like e-mail, file transfer, transaction processing, Web surfing, and so on. The technology of the Web browser has been extended to broad-band GUIs.

The strong signalling requirements for networking systems imposed by Web access saw the beginning of a signalling crisis in 1998, because not all network types could comply with the signalling requirements necessary in broad-band systems. One way of solving this problem was to move from pull mode to push mode data. Push mode allows the servers and networks that provide content to make more efficient use of the available bandwidth and processing time. An important application of push mode data is software updates received from Web Servers. In push mode, the service provider can control content and timing, and it is therefore becoming popular with advertisers.

TELEPHONY

Voice-over-data and IP telephony (VOIP) systems grew exponentially in 1997 and 1998 with a perceptible reduction in telephone tariffs, though at the cost of telephone quality. At present, the IP networks, including the Internet, are not ready for voice-over-data traffic on a very large scale. While waiting for the advent of broadband Internet-II to offer long term solutions, users will continue to experience the effect of overloading on voice quality.

IP telephony includes voice-over LANs, Internet, Intranets and Extranets. Both real-time and store-and-forward fax traffic can also be addressed as can unified messaging over the Web. In private networks, voice with IP over Frame Relay (FR) or ATM is being used to accommodate multimedia and sophisticated collaborative computing.

IP - BASED CONSUMER ELECTRONICS

Personal computers and digital TVs are converging into one integrated product. Current PCs are constructed with video receiver cards, whereas televisions, with embedded microprocessors required for electronic programme guide (EPG) and digital de-coding, have already been built on a pilot scale. Only a small

incremental cost is required to add more power and memory to transform a television set into a computer. Services such as Web TV from Microsoft and InterCast are already narrowing the gap between the Web and television. Efforts are under way to establish a consistent link between the Web television so that broadcasters can create a new form of entertainment. High Definition TV (HDTV) is a high-quality digital TV development, delivering data services and multiple channels.

Super-high definition image system (SHD), with a resolution equal to that of a 35-mm film and data capacity four times that of HDTV, has been introduced to make it possible to read stored newspapers even when they are displayed at actual size. This SHD image system may be combined with a Digital Network Library system to provide versatile applications such as a Digital Museum. A seamless video environment can be created by employing ATM-based 150 Mbps HDTV encoding SHD large-screen display technology and tandem HDTV screens with minimal gap between the screens.

In this context, it should be pointed out that data broadcasting standards remain problematic. It may be assumed that Web standards will prevail, but adapting Web standards to a purely broadcasting environment is proving difficult.

Video on demand (VoD) is an emerging service currently under trial. VoD enables consumers to order films, documentaries and educational broadcast/content over a network. As a pull-mode service, no two subscribers are likely to be watching the same film or using the same VCR control such as 'rewind' and 'fast forward'. Separate data flows can therefore be established for each viewer using a band-width allocated to a single consumer. With digital compression as one of the enabling technologies for VoD with MPEG, a film of television broadcasting quality can be stored in 3 GB of memory and then played out at 3 Mb/s. A variation, called near video on demand (nVoD), is also at the pilot stage.

Over the past two years, the set-top-box has gained consumer popularity as a supplement to the television set. The set-top-box is used to provide capacity not present in the TV or VCR by including a slot for 'additional functions', along with a tuner appropriate for the transmission medium. Transmission can be by cable, direct broadcast satellite (DBS), microwave TV, multi-channel, multi-point distribution service (MMDS), cellular TV that uses 28 GHz wireless cable service, or other such devices. Current services made possible by the set-top-box are navigation and interactive programming systems that use on-screen images and cursor-like devices to allow subscribers to select and interact with other services including home shopping, video on demand, electronic games, educational programmes, electronic publishing and telecommunication services like the Internet.

The set-top-box and even television sets have been developed with an embedded network computer (NC). Whereas networked PCs provide each user with local storage and processing with much of the data located within the mainframe, NC goes a step further by distributing data, programmes and computing power across many nodes on the Internet or Intranets. TCP/IP protocol, Inter-programme communication, a mobile code like Java and data representation and retrieval such as HTML and structured query language (SQL) allow for a distributed architecture. NC provides a lower cost alternative to standard PCs for Internet communication. The user needs an appropriate access device to browse the information and call up the functions available on the network.

CONCLUSION

During 1997 and 1998, information and communication technologies underwent a sea change with the emergence of the Internet Protocol (IP) as the de-facto standard for both network systems and digital equipment. The protocol made it possible to integrate digital technologies leading to the convergence of

computer, broadcasting, telecommunication and consumer electronics.

Speed, capacity and versatility of computer hardware doubled in accordance with Moore's Law. The Bus interface in computer architecture ensured smooth upgrading from one model of the chip to the next without having to modify the PC design extensively. Hand-held computing is becoming a useful tool for the collection of data in the field. Home automation saw the introduction of a consumer electronics Bus plug-and-play standard for connecting PCs to home appliances. Peripheral equipment, such as sound recording and reproduction, external storage devices and data compression techniques made similar progress.

In 1998, leading software manufacturers influenced the direction to be taken by the software architecture of the future. Microsoft has set in motion certain development efforts which aim at making Windows NT useful as a consumer operating system. Along with these trends, 64-bit architecture, which is the next development in software, is emerging. Users are being more directly associated with their software. In the same vein, the user interface on PCs, encouraged by the concept of a hyper-linked design of the World Wide Web, moved closer to human perception simulation. Software packages for continuous speech recognition became a consumer item. On the database front, object-oriented data base management systems accelerated to overshadow traditional relational database management software.

The significant software-related development has seen a shift towards a Web-centred work environment, and electronic distribution of information over the World Wide Web.

Network-based virtual communities are changing the relationships between companies and their customers by allowing customers to deal directly for the purchase of products and services. In local area networks, switching technology has led to very high data-transmission capabilities. ATM has proved useful

in full backbone networks as well as with SONETs. The integration of multiple traffic types on the same network infrastructure is progressively taking place and wireless systems have provided good solutions to the last mile problem in medium-area networks (MANs). European trends in ISDN are catching on fast in North America and Asia.

The launching of Motorola's Iridium venture started a new race among the giants of the satellite business, with applications in global voice, paging and fax as well as the next stage of broad-band multi-satellite systems offering fast Internet and video. Commercial satellites with on-board processing, allowing signals to be switched between spot beams in the satellite, were also developed in 1997 and 1998. The Web has become a major market driver for broad-band networking with an estimated 30 million households worldwide using the Web for work at home, education or recreation in 1997. From narrow-band services like e-mail, the technology of the Web browser is being extended to become broad-band Graphical User Interfaces.

Personal computers and digital TVs are converging into one integrated product. Services such as Web TV are already narrowing the gap between the Web and television. Efforts are under way to establish a consistent link between the Web and television for the creation of new forms of entertainment. Video on demand, on computer networks, is an emerging service which is currently under trial. In 1997 and 1998, the set-top-box gained consumer popularity as a supplement to the television set. On the Internet, navigation and interactive programming systems that use on-screen images and cursor-like devices to allow subscribers to select and interact with the system are facilitating the rapid development of services such as home shopping, video on demand, electronic games, educational programmes, electronic publishing and other telecommunication services. Browsing on a television set has become possible with a set-top-box.

In the near future, there will be a further spread

of the ubiquitous Internet Protocol bringing about an accelerated convergence of computer, broadcasting, telecommunication and consumer electronics. This convergence occurs within the context of a strong competitive environment, since all the actors on the scene want to reach the average consumer (and his money) and thus enter into wide-scale marketing at national, regional or international levels. In this context, the Internet has been one of the main driving forces, either directly through improvements of Internet related technologies like Internet telephony, Network Computers or Java, or indirectly, through the development of concurrent technologies such as Video on Demand or the set-top-box. It is very likely that this competition will continue and that a wide range of technological innovations affecting all the components – hardware and software – which are used to produce, record, store, process, transmit and broadcast information in the widest meaning of these words these will appear in the coming years.

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