Teleworking through Optical Networks, Wireless Links, and PBX Technologies

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Abstract: - The development of teleworking relies heavily on telecommunications infrastructure. In particular, fiber optic networks for high speed networking and various wireless standards (IEEE 802.1x) lead to extensions of fixed networks. Moreover, Private Branch Exchanges (PBXs) with the introduction of IP technology are being transformed to universal access platforms for corporations and organizations. In this paper, an overview of these emerging telecommunication technologies and their deployment in Greece is presented. Emphasis is given to the implementation plans for the island of Crete, like the Metropolitan Area Networks (MANs) exploiting fiber optics and wireless communications, or the wireless hotspots for the tourism sector. These implementations' implications on teleworking development in Crete, is examined along with other issues, such as regional development, prevention of out-migration from rural areas, and provision of telematic services.

Keywords: - Teleworking, Networks, Networking, Private Branch Exchanges, Wireless links, Optical networks, Multimedia services, Telematic services, Communication engineering.

1 Introduction

In general, teleworking involves an enormous variety of different types of activities, carried out in varying locations under diverse contractual arrangements. Exploitation of teleworking opens up the concept of the office (or the bank, the shop, the university, the hospital). An organization is no longer geographically confined into a building, as it is defined as a network of relationships. From the teleworkers' point of view, telecooperation methods provide enhanced communication with colleagues, as well as the ability to connect with professional and other networks of people, regardless of their home location.

Although, various types of teleworking (home-based teleworking, mobile teleworking, teleworking on remote sites controlled by the employer, teleworking from telecottages or telecentres, etc.) exist, the common element in all of them is the use of information-processing technologies along with the transmission of voice and data through telecom networks. In particular, modern information and communication technologies (ICT) facilitate tele-cooperation (through computer data and application sharing, video conferencing, etc.) by the use of teleworkers of different ICT infrastructures at a reasonable cost. However, in order the effect of ICT technologies and new network technologies to be catalytic, the existence of high capacity and performance digital infrastructure providing secure and uninterrupted communications is required. In this way, the so called broadband communications will have a significant impact on the social models of organization, and specifically on teleworking.

Broadband communications are characterized by the ability to transfer large volumes of data between systems and users, with the emphasis on "always ON" connectivity and seamless transfer of rich multimedia content, including the transmission over the local loop. Particularly in the case of Greece, analysis of the available data demonstrates that the combination of the intrinsic characteristics of the local market and the lack of any real competition in telecommunications (with the notable exception of mobile telephony), have allowed for only the slowest development of broadband access compared with that in EU and the OECD. The Greek telecom market for broadband communications depends heavily on the core fiber optics networks, as well as on xDSL and LMDS implementations of the dominant provider (OTE). New entrants have also installed broadband infrastructures in selected areas of the prefectures of the capital Athens and Thessaloniki, mainly fiber optics and LMDS

systems. The dependence from OTE, however, increases significantly the risk of new entrants since they are obliged to sign interconnection agreements, to use the unbundled local loop for xDSL, and to negotiate collocation agreements. In general, mainly due to local market characteristics and telecom regulations environment, broadband access in Greece is ranked very low (OECD data, 2001).

Development of broadband access for the Greek public sector (which has begun in 2001 and is still under implementation) promotes tele-cooperation and leads to effective provision of services to the citizen and governmental efficiency. Over 1,800 public administrative entities will be integrated into the SYZEFXIS network. In addition to wide area networking, further take-up of broadband services may be provided on a limited geographical scale. For example, interconnection of networks in a city into a larger network leads to Metropolitan Area Networks (MANs), enhancing the way ICT applications and services are conducted. The implementation of MANs requires collaboration among local authorities and entities and strengthens the regional information society development.

The main purpose of this paper is to study the close relation of advanced telecom infrastructure to teleworking development. In particular, Section 2 deals with both well established and forthcoming communication technologies, with emphasis on metropolitan area networking. In Section 3, issues related to teleworking activities in various economic sectors for Crete are presented. Finally, in Section 4, the plans for ICT infrastructure in Greece through the 3rd EU Community Support Framework as well as their implications to teleworking development, are presented.

2 Communication Technologies

If teleworking fulfills its promises, organizations must exploit the available broadband access technologies and extend their voice (namely, their PBX platform) and LAN infrastructure to remote employees, in an inexpensive and easy to deploy and manage way. In particular, the wide adoption of the suite of Internet Protocols (IP) for data communications has become the cornerstone of new, converged networks that offer combined data and voice services over various broadband communication links. It is envisaged that the Voice-over-IP (VoIP) technology will finally provide a reliable and flexible transport mechanism for voice traffic by encapsulating voice into IP packets. In

such a way, communication over an IP packet switched network provides various paths between locations and supports the data and voice requirements of the distributed workforce, as opposed to the traditional point-to-point connection between any two locations provided by a circuit switched network approach.

Aside to broadband access (such as DSL connections) over the Public Switched Telephone Network (PSTN), third generation cellular networks supporting mobile teleworking or even digital audio broadcasting systems [1], alternative broadband ICT infrastructures are available to implement teleworking solutions. The ICT infrastructures to be examined in this paper, may support telecooperation activities to geographically confined areas (IEEE 802.11x suite of protocols), metropolitan areas (wireless and optical MANs) as well as to provide wide area networking (PBX technology).

2.1 Wireless LAN Neworking
The first wireless LAN technologies were low-speed (1-2 Mbps) proprietary solutions using either infrared light (IR) or radio frequencies (RF). Despite the low bandwidth provided by early WLANs, the wireless freedom and flexibility allowed these early products to find a place in vertical markets such as retail and warehousing (where mobile workers use hand-held devices for inventory management and data collection), or hospitals (for delivery of patient information). However, improvements in security, performance, interoperability and manageability of former WLANs' implementations, led to the current viable choices of IEEE 802.11b, IEEE 802.11a and IEEE 802.11g WLANs (all based on the initial IEEE 802.11 standard of 1997). In particular, IEEE 802.11b WLANs (also known as Wi-Fi) use the 2.4 GHz frequency band, the only portion of the RF spectrum reserved for unlicensed devices. While LOS communications is not strictly required, it is desirable in order to achieve a physical layer 11 Mbps data rate within a maximum range of 100 m. IEEE 802.11a (5 GHz) and IEEE 802.11g (2.4 GHz) are more appropriately suited for high bandwidth applications (both offering 54 Mbps physical layer data rate at a maximum range of 80 m and 150 m).

As with other radio-based technologies, WLANs' efficiency is being affected by: a) the range to be covered by the WLAN, b) the power to be used by the IEEE 802.11x devices, c) the real maximum offered throughput, and d) the presence of an interference-free environment. For example, the use of omni-directional antennas (for access points and

WLAN's clients) does not require positioning, but repeaters or external amplifiers are needed to work well over long distances. On the other hand, the use of directional antennas requires careful positioning, which when combined with amplification, extends the WLAN's range to distances up to several kilometers in case of LOS communications. This is of primary importance for a multi-site organization, as networks located in buildings far away from each other can be integrated into a single LAN. In such a way, WLANs become internal adjuncts to the organization's network and can facilitate tele-cooperation activities (like voice over WLANs and wireless videoconferencing).

In addition to in-building and building-to-building communications, WLAN technologies can also serve the mobile teleworker. In particular, connectivity for workforce "on the move" is covered by public hotspots, through the use of laptops and other mobile devices. Such WLAN hotspots are being deployed in public locations (like airports, hotels, and convention centers) and provide flexible communications even in case they are administered by different Internet Service Providers (ISPs) through roaming agreements. Thus, mobile teleworkers depending upon the internet and their corporate network, can sustain improved workgroup collaboration and immediate response to customers.

2.2 Wireless MAN Neworking

Broadband wireless access over longer-range coverage than WLANs (which is typically used as a hotspot technology) through fixed wireless links, is based on Local Multipoint Distribute Services (LMDS), Multichannel Multipoint Distribution Services (MMDS) systems or other proprietary approaches. LMDS systems use the 25 GHz and higher spectrum range (depending on licensing) to deliver voice, data, internet and video services. They exploit a cellular-like architecture (though services provided are fixed, not mobile) in a point-to-point or point-to-multipoint configuration. In order LMDS systems to be a cost-effective option, as LOS communication is required, the customer premises need to be within distance of 8 Km assuming good weather conditions, and within 1 – 2 Km in regions where precipitation is heavy. These short distances make LMDS suitable for deployment in densely covered metropolitan areas, but not for widely dispersed rural locations. Furthermore, performance suffers because the nodes connected to each cell are sharing its total bandwidth [2]. On the other hand, MMDS systems are characterized by the limited

spectrum allocated for use between 2.5 GHz and 2.7 GHz, while their typical setup is that of one-way point-to-point transmissions. Although MMDS systems can reach further than LMDS systems (up to 45 Km away), they exhibit high transmission latencies, service quality fluctuations and cannot support large numbers of users.

An effort to overcome the aforementioned limitations is that of the WiMAX Forum, a non-profit trade organization founded in 2002 by leading vendors of wireless access equipment and telecom components. Its mission is to lay the groundwork for an industry-wide acceptance and implementation of the IEEE 802.16 and ETSI HiperMAN standards covering the 2-11 GHz band for wireless MANs. The core components of a WiMAX system are the subscriber station (Customer Premises Equipment) and the base station, forming a cell for point-to-point communications. WiMAX provides up to 50 Km of service area range, allows users to get broadband connectivity without needing direct LOS with the base station, supports adaptive antenna systems for enhanced link budget, offers quality of service (QoS) support, and provides up to 280 Mbps data rates per base station. WiMAX for teleworking (while certified solutions are expected on market):

- ensures broadband access in isolated rural areas,
- provides alternative access for home-based teleworkers in areas with no xDSL unbundling,
- supports mobile teleworkers, while the IEEE 802.16e sub-committee is working on extending the standard for portability, and
- provides connectivity to a multisite organization in a MAN area.

2.3 Optical MANs

Fiber-optic technology has met the unprecedented demand for bandwidth required at long-haul optical networks, due to the phenomenal expansion of the internet traffic in 1990s. In particular, Wavelength Division Multiplexing (WDM) increased the capacity and lowered the cost per bit for these networks. Unfortunately, the MAN network environment has lagged behind in the availability of low-cost fast service provisioning using WDM. Recently WDM technology (and the optical transparency it allows) as well as new metro-area equipment, have matured enough and become sufficiently cost effective [3]. In such a way, optical access MANs interface the end high bandwith users and the backbone long-haul network. From a functional point of view, the optical access MANs consist of the Distribution Network and the Feeder Network. The distribution network directly

interfaces with the customer premises and is responsible for delivering and collecting traffic. The feeder network aggregates traffic, delivers traffic to an appropriate egress point, and transfers traffic between portions of the distribution network. However, services are also driving the network infrastructure of optical MANs. This way and related to teleworking services, optical access MANs should provide:

- huge bandwidth with low latency, as applications (i.e. video distribution, video conferencing, remote medicine) stress network's capabilities,
- rapid provision of new connections, as organizations may request connection on-demand (thus, the optical access MAN must be agile enough to dynamically and efficiently provide the required resources),
- provision of virtual LAN connectivity within the network (thus, it is desirable to create a virtual LAN environment between the two locales so that servers, databases, and peripherals can be easily shared),
- transparency in order to provide connectivity regardless of the protocol and the data rate (the network must directly interoperate with IP, ATM, or Gigabit Ethernet traffic types and E1/T1 or standard SONET/SDH connection rates),
- interoperability with already deployed SONET/SDH access rings in metropolitan areas (in such a way, aggregation of traffic from customers with relatively low data rates and gain access via SONET/SDH add/drop multiplexers will also be carried out, thus, enhancing tele-cooperation activities of all entities connected to the optical access MAN),
- ability to connect additional entities to the network, leading to improved return of investment and to multiplicative effects concerning services' uptake [i.e. first deploying the feeder fiber with many strands of fiber in the sheath, and next installing when needed the distribution fiber (first for large customers, because once distribution fiber is in place, smaller customer entities near the distribution route could be easily added to the network)].

2.4 PBX Technology

Most organizations have private telephone networks designed around PBXs and key telephone systems (a lower priced, reduced functionality version of the headquarters' PBX) for their voice communication needs. PBX's job is to circuit-switch calls over local internal connections, allowing users to share a certain number of external phone lines. Exploitation of traditional PBX technology, however, presents some major drawbacks for teleworking:

- use of proprietary and vendor-specific protocols, leading to high cost and difficult to manage

implementation on a large scale,
- difficulty in integrating other traffic types, such as data and video for various business applications.

However, PBX systems are: a) migrating from a purely proprietary software/hardware architecture to an open server platform, b) incorporating VoIP technology, and c) exploiting the growing ubiquity of broadband access. All these lead to an IP-PBX open server platform, which extends organizations' voice and LAN infrastructure to remote locations. Such IP-PBX implementations provide "unified communications" for teleworking purposes, in order to improve desktop-worker productivity, facilitate co-workers' interactions, reduce telecom expenses, and optimize real-time management operations. The aforementioned benefits are achieved by:

- permitting teleworkers to easily apply customized features of their voice extensions on their voice communication profiles to their home or office phone as they move between multiple locations, including voicemail as well as unified messaging with integration of email clients,
- leveraging teleworkers as virtual call center agents with a broad range of call center applications,
- incorporating instant messaging management software, that allows users to transmit/receive in real time voice/data/text information,
- incorporating call routing features, that provide long-distance cost savings through toll bypass.

3 Teleworking in Crete Island

Development of teleworking is not dependent only upon the existence of broadband access infrastructure (exploiting the technologies examined in Section 2), but is highly related to socioeconomic issues as well as to the penetration of ICT technologies. The island of Crete, in particular, is characterized by its geographical isolation from the mainland and the deficit of broadband access in major parts of the island. The latter is due to the geographical distribution of population (only 42% in urban areas) and that most of the economic activities take place in northern Crete. Furthermore, we should mention the dominant role of the services' sector occupying 56% of Crete's GNP and 8.5% of Crete's active population (about twice of the Greek average). Moreover, the penetration of ICT technologies, in terms of using information technology and Internet, is below the Greek average.

Early efforts on teleworking application areas in Crete island focused on the tourism sector. In the

framework of the EU-funded TEMeTeN project in late 90s, the deployment of teleworking business centers in hotels with use of ICT was examined. In a market survey conducted during this project, 68% of the respondents would regard Crete as a more attractive destination for holidays if teleworking facilities were available, while 63% of them would prolong their stay in such a case. In another project funded by public local authorities in the area of Messara (Heraklion, Crete), the IEEE 802.11b WLAN technology was exploited to interconnect the premises of the local authorities. The endpoints of the network were about 40 Km apart, LOS and non-LOS wireless links were established, while the coverage survey and study was conducted by T.E.I..

T.E.I. of Crete has been also involved in projects that promote tele-consulting and tele-cooperation in the healthcare and education areas. Application of ICT technologies to health care in Crete is stimulated by the need of people living in rural and remote areas to access special medical care.

Incorporation of teleworking in the education area involves the following issues: equity of access through cost-effective broadband interconnection of the students to the educational material, use of standardized information technology tools, necessity for continual and up-to-date training in fields where lifelong learning is imperative, efficient exploitation of human and educational resources through tele-cooperation of students and tutors. All the aforementioned issues were taken into account to the design and implementation of pilot projects run by T.E.I.. Access to the educational resources is feasible either via wires through the hub device of T.E.I.'s LAN (for students within T.E.I.), via IEEE 802.11b wireless communication links providing a network throughput of 1.6 Mbps (for students close to T.E.I. premises and under LOS conditions), or via Integrated Services Digital Network (ISDN) connections (for students located far away from T.E.I.). Tele-cooperation of students and tutors is accomplished either by real-time communication (i.e. videoconferencing) or by non real-time communication tools (i.e. e-mail). Evaluation of this project indicates that interactive educational resources and real-time communications with tutors are most appealing to students, especially in periods where no examinations took place and during the examination period, respectively.

The main limitation of the above tele-learning and tele-cooperation platform was that it could not distribute efficiently high quality audiovisual content to more than two students at a time, when streaming delivery method was utilized. To overcome such a limitation and enable broadband access to educational resources, the Terrestrial Digital Video Broadcasting standard (DVB-T) was exploited [4]. Until recently, DVB-T was used mainly as a medium for broadcasting "bouquets" of digital TV programs to a large number of viewers scattered over large geographical areas. The intrinsic, however, characteristic of DVB-T is the combination of heterogeneous traffic (MPEG-2 TV programs and IP services) into a single transport stream, enabled for its usage as the "last mile" technology in networking infrastructures for the provision of IP services. Experimentation proved that when a 23 Mbps total available bit rate of the DVB-T downlink was utilized, it may serve efficiently up to 15 simultaneous students (requesting video files under the stream delivery). Also, the overall system's performance attracted a greater number of students for participation in tele-learning and tele-cooperation activities.

4 Network Infrastructure Plans

In 2002, the Seville European Council endorsed the e-Europe 2005 Action Plan that sets out a strategy to make broadband infrastructure widely available to businesses and citizens throughout Europe at affordable prices. This plan also outlines the need to develop adequate content and services, with particular emphasis on public administration (e-government), dynamic business environment (e-business), health services (e-health) and education (e-learning). Furthermore, European Commission in its guidelines for the 2000-2006 programs, identified Information Society as a key priority for structural funds interventions with a strong emphasis on demand for services and applications. Actually, Community action through the structural funds has among its main objectives to promote the development and structural adjustment of regions lagging behind or regions under economic and social restructuring. However, although Information Society has considerable potential for strengthening economic and social cohesion, the success of regional development strategies will depend on the regions' ability to integrate ICT technologies as well as on several approaches boosting demand, such as:
- encouraging of demand aggregation for broadband services in the public sector,
- stimulating of demand in the private sector (for types or clusters of SMEs),

- developing content and services with local and regional interest,
- equipping the population with the necessary skills to use broadband connections.

For Greece, the Operational Program for the Information Society under the 3rd Community Support Framework, provides for both public and private sector funding of actions related to development of broadband infrastructures and services. With a total budget of 248,000,000 euro, implementation of projects which promote the development of broadband services at regional level giving priority to the public administration, education and health, will be carried out. These projects aim, also, at reinforcing the supply and demand for broadband services both from the public administration and from SMEs. As ERDF's support should not a priori favour any particular technology nor limit the technology choice of the regions, selection criteria for the projected investments must adhere to the principle of "technology neutrality" and the choice must be clearly justified on the basis of a cost-benefit analysis. Therefore, technologies examined in Section 2 will be taken into account as possible alternatives for the provision of services, including the newly established satellite communication infrastructures in Greece (Hellas-Sat) to provide satellite services to remote areas. In particular, according to the targets set by the Operational Program from the Information Society, implementation of optical MANs in all cities with over 10,000 inhabitants and their subsequent interconnection to at least 10 regional level fiber optics networks, is envisaged. Such metropolitan and regional networks will meet the needs of public entities in broadband services, will promote competition, and will confirm in practice the anticipated –low compared to benefits– implementation and operation costs.

5   Conclusions

Teleworking increasingly involves the use of advanced communications infrastructure and teleworkers are a major user group for the broadband access technologies examined in this paper. Furthermore, the development of appropriate broadband infrastructures accessible by all citizens at affordable prices, can efficiently overcome the risk of the digital divide among citizens or regions and will provide equal opportunities and possibilities for the development of local societies.

Actually, broadband access through wired, wireless and optical communications is becoming a prerequisite in terms of maintaining and improving the existing economic, social and administrative processes and strengthening social cohesion, development and competitiveness.

Our involvement to network planning of optical MANs in three less developed and remote areas of Crete served as a field study. We also had the opportunity to assess the role of broadband teleworking in reversing the trend of out-migration from rural areas, as well as to act as a pole of attraction for business activities. However, in order to brand broadband teleworking as one of the most important contributors of sustainable development, public funds should be provided and synergies among various entities (municipalities, prefectures, telecom organizations, hospitals, health centers, educational institutions, etc.) should be established.

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