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Public Telecommunications Networks

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Contents

1 Introduction

The high demand for advanced telecommunications services by business and residential subscribers, has driven the industry to a race to meet their requirements. Telecommunications business is now one of the most rapidly developing industry sectors, attracting the interest and the investment of many companies, as the opportunities for revenue are very high. However, there is a high risk factor, as the wide range of emerging technologies and their inherent complexity could mislead managers and investors, especially newcomers in the sector.

Today, the focus of all the relevant businesses is on the customer. Subscriber-side values as Quality of Service (QoS), transparency, flexibility, simplicity, security, and, of course, pricing, are key to the success of a network and/or service provider. Therefore, more weight will be given to these merits in the following assessments of the candidate technologies and services.

Following a commentary on the problem and some necessary assumptions, an analysis of the available options, is provided. Each solution is evaluated technically and financially, and its relative merits and weaknesses are presented. Then, some opportunities for newcomers in the area are investigated for each segment. Finally, a conclusive paragraph summarises and comments on the analysis results. An index to the several abbreviations used, pointing to the pages where they are expanded, is also provided.

2 Objective and Assumptions

The problem to be addressed herein requires the investigation of the potential for success of a company in four specific telecommunications segments: data networks, local access, intelligent networks and internet services. Key points of the definition of the problem are:

- the company is not a telecommunications incumbent,
- the company will target *one* of the above segments, and
- the venture will be operating and generating revenue within five years from the date of the investment.

Some assumptions have to be made in relation to the type of the investor. It is desired, for example, that the company maintains or creates a telecommunications engineering and a Research and Development (R&D) department, staffed with qualified and experienced personnel. Information Technology (IT) and Management departments would be deeply involved in the venture, and should have the required staff and equipment, as well. Complementary studies and consultancy could be provided by external specialists. The investment capital should be adequate to cover such indirect costs, as well as marketing and R&D costs. Of course, it will be assumed that the company is based at an economically developed or developing location, offering its services in a competitive marketplace.

3 Data Networks

The data networks segment is growing to one of the most significant and profitable for the telecommunications industry. Most of the public data networks subscribers are corporate and business. All the legacy Public Telecommunications Operators (PTOs) provide their data network, separate from the Public Switched Telephone Network (PSTN). Their solutions are challenged today by a rapidly growing number of competent companies from different business sectors.

3.1 The Technologies

Historically, public data networks services were introduced by legacy PTOs in the 1970s, using the so called X.25 protocol. This technology offers data transfer over unreliable physical media, using large overhead information and extensive error checking and correcting. The effect of this is low utilisation of bandwidth and low transmission speeds. X.25 provides circuit switched Permanent and Switched Virtual Circuits (PVCs and SVCs), uses in-band signalling, and was widely used for corporate networks.

Evolution to transmission media, and introduction of optical fibre in the core network, improved dramatically the transmission error rates and made X.25 obsolete. The bottlenecks in performance moved from the network to the computer terminals. Frame Relay and Switched Multi-megabit Data Service (SMDS) were designed to meet these new requirements. Increasing demand for bandwidth, QoS, and emergence of multimedia were the drivers for the Asynchronous Transfer Mode (ATM) design. The big success of the World Wide Web, has made Internet Protocol (IP) a competitor to all the above. These technologies are examined in detail in the following paragraphs.

3.1.1 Frame Relay

Frame relay is the most popular and highly available worldwide public data network technology today. It provides a bare-bones connection-oriented way to move bits from source to destination at reasonable speed and low cost [1]. The technology provides a minimal transmission protocol, with customer-defined packets up to 1600 bytes long and error detection. There are no acknowledgements or flow control. It is up to the user to take action if a transmission error occurs, as the protocol simply discards the bad packets.

Today frame relay carriers provide PVCs of E1/T1 rates, with some carriers offering T3 speeds; see Table 1. The customers rent a minimum guaranteed capacity, termed as the Committed Information Rate (CIR); see Figure 1. The CIR is usually in the range of 0 to 1 Mbps. It is possible to transmit at a much higher bursty rate, dependent on the network load. There are no data loss

European/ITU-T		American	
E1	2	DS1 or T1	1.5
E2	8	DS2 or T2	6
E3	34	DS3 or T3	45

Table 1: Approximate network access rates in Mbps.

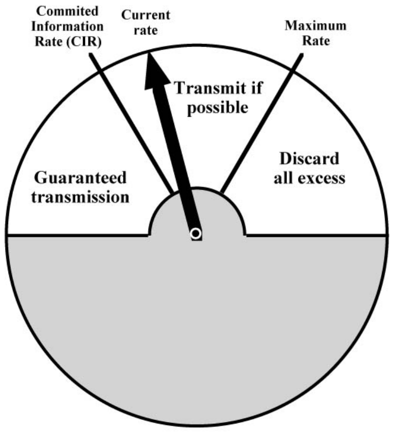

Figure 1: Frame relay CIR (source: [2]).

or delay guarantees, as these are conflicting with the offered availability and average data rate guarantees. Therefore, QoS awareness is definitely not a merit of frame relay.

Frame relay offers a backward compatibility X.25 emulation mode, and forward ATM interworking will be provided in the next months. Internal competition between frame relay providers forces them to consider offering SVCs. This provision is covered in the frame relay specifications, but was largely ignored in the past. SVCs provide to the customer scaling flexibility, lower unit costs, better support of distributed applications.

Competition from ATM and IP has forced network operators to enhance the technology. Enhancements are announced by the Frame Relay Forum, a standardisation body which is backed by telecommunications operators and equipment manufacturers. Such include enhancement of the transparency of the network with read-only Customer Network Management (CNM). Other specifications enhance voice support with the use of the latest compression algorithms as G.729A, use of fixed size voice frames to reduce latency, and priority queueing of them within the Frame Relay Assembler-Disassembler (FRAD).

3.1.2 SMDS

Switched Multi-megabit Data Service was designed exclusively for Local Area Networks (LANs) interconnection. It is a simple, highly reliable, connectionless packet delivery service. It can transparently carry LAN packets such as Ethernet or Token Ring, even IP packets in its payload. SMDS does not provide error correction, as it was designed for reliable links. Due to the bursty nature of the traffic it carries, the SMDS core should be adequately fast. It is thus considered a broadband service; actually, it was the first such service.

SMDS was firstly deployed in the early 1990s. The customer taps all his LANs into the carrier-owned SMDS cloud through leased transmission lines. Access speeds are in the range E1/T1-E3/T3. The subscriber buys a guaranteed average data delivery rate, termed as the Class of Service (CoS). Typical CoS rates are 0.5-25 Mbps. SMDS should be capable to handle data bursts at much higher rates than the CoS.

Due to the advent of ATM, and the competition at the low-end by frame relay and IP, it is very

European/ITU-T (SDH)	American (SONET)	Data Rate (Mbps)
N/A	STS-1 or OC-1	52
STM-1	STS-3 or OC-3	155
STM-3	STS-12 or OC-12	622
STM-16	STS-48 or OC-48	2,500

Table 2: Approximate multiplex rates.

unlikely that SMDS will expand to other geographical locations than those it is already installed: USA, UK and Germany. It will definitely increase its customer base, as it has proven adequate for today's requirements and prices will fall in order to protect the investment of the incumbent operators.

3.1.3 ATM

Asynchronous Transfer Mode is the proposed solution for Broadband Integrated Services Digital Networks (B-ISDN). ATM is often referred to as fast *cell* switching, where cells are packets having a fixed length of 53 bytes. It is connection-oriented, and guarantees only cell sequence integrity, not cell delivery. ATM defines four Categories of Service to suit a wide range of applications:

- Constant Bit Rate (CBR);
- Variable Bit Rate (VBR), Real Time and Non Real Time;
- Available Bit Rate (ABR);
- Undefined Bit Rate (UBR).

ATM switches are complex computers, which deliver the data in a way to maximise the QoS for every Category of Service. ATM is unique in that it is QoS aware and is the only candidate technology for delivering both isochronous and asynchronous traffic efficiently. It also provides interworking with the other data networks technologies through backward compatibility emulation modes.

ATM is the technology that provides today the fastest data transfer rates going well beyond the E3/T3 limit. Current available services reach STM-1/OC-3 and STM-3/OC-12 data rates, and availability for STM-16/OC-48 rates will increase in the near future; see Table 2. For some customers needing such high transfer rates, there is no alternative technology.

3.1.4 IP

The Internet Protocol is currently challenging all the other data networks technologies. Its main advantage is, of course, the World Wide Web. The latter, has rapidly developed as the 'killer' software application of the decade. World Wide Web applications are subject to massive investment, due to the ease of use and their wide user base. The range of these applications is extending from multimedia databases to corporate intranets and Virtual Private Networks (VPNs).

	Frame Relay	T1 ATM	10 Mbps Native LAN	T1 Priv. Line	10 Mbps ATM	N by T1 Priv. Line	T3 Priv. Line
Local Access	$277	$277	N/A	$277	$3487	$1662	$3487
Service Costs	$2668	$3578	$5500	$4425	$16,202	$26,550	$39,843
Router Interface	$33	$33	$33	$80	$278	$278	$667
CSU/DSU	$42	$119	N/A	$100	$389	N/A	$400
Inverse Muxes	N/A	N/A	N/A	N/A	N/A	$667	N/A
Management	$833	$833	N/A	$833	$833	$833	$833
Total Monthly Cost	$3853	$4840	$5533	$5715	$21,189	$29,990	$45,230

Table 3: WAN services cost comparison (source: [4])

IP is a connectionless packet delivery service, which is usually run over one of the aforementioned data network technologies, but, it is a network layer protocol itself, according to the Open Systems Interconnection (OSI) model. Therefore, it can be used directly over data link and physical layers protocols such as Synchronous Digital Hierarchy (SDH) or Synchronous Optical NETwork (SONET), bypassing intermediate protocols. Some Internet Service Providers (ISPs) have launched IP Wide Area Network (WAN) services over SONET in the US [3].

Many internet related businesses are claiming that customers will be more satisfied if buying their internet and data services at one-stop shops. They claim that using the same underlying network technology, namely IP, will enhance the customers' communications equipment integrity, and will cut down costs dramatically.

3.2 The Price

Although ATM seems to be the clear winner among the data networks technologies presented in the previous section, there are a lot of factors to consider, apart from the technology issues. One of them, is customer pricing issues. A sample cost comparison of WAN services, is given in Table 3. A rough study of this table, suggests that the lowest cost WAN service of these listed is frame relay. ATM service costs are relatively high, though lower than the respective bandwidth leased lines rental.

3.3 The Opportunities

It is straightforward that data networks services are not addressed to residential customers. The problem is to interconnect a number of remotely sited LANs of a corporation to a MAN or WAN. Assuming that the LAN protocols used are the same, for example Ethernet, the objective is to provide an attractive and reasonably priced transparent solution.

3.3.1 Network and Service Provision

Since the company has not been involved in telecommunications in the past, it is very unlikely that it will start building its own network infrastructure from scratch. Equally low are the chances that it will lease the vast capacity required and equipment from a carrier, and offer end-to-end service.

The regulatory framework does not inhibit any of the incumbents in telecommunications to offer public data networks, and does not provide benefits for newcomers in the area. Direct competition with the legacy carriers would drive the venture to a disaster, no matter how innovative the service provided is.

A totally innovative network from scratch is the one announced by some joint ventures with participants from telecommunications, computing, entertainment, and aerospace industries. They are promising broadband services from the space, using Low Earth Orbit (LEO) satellites. The investment required is huge, but the service will be end-to-end, allowing for high revenue expectations. The schemes proposed would only be justifiable for low population density areas, or for corporate points of presence in countries which do not have a developed telecommunications infrastructure.

3.3.2 Service Provision

The company could form a middle tier between the customer and the network operator, by offering services, such as masking the underlying network technology from the customer. Such services are Native LAN services [4], in which, the customer sees the remote hosts as connected to his own LAN with a LAN protocol as Ethernet, Token Ring or FDDI. Native LANs can be run over network technologies as ATM, and offer the advantage of not having to climb the steep learning curve of such technologies, and avoiding the investment required by migrating all the equipment to the WAN technology.

The company will have to invest in buying access equipment as CSU/DSUs in order to offer the service. It will have to take all the actions necessary to lease the capacity from a network carrier on behalf of its customer. And it will have to ensure that the LANs are interconnected seamlessly. After the provision of service, revenue can be generated by providing support and management to the network, for example by monitoring performance and identifying bottlenecks, or by satisfying arising customer requirements, as new LAN connections or connection upgrades.

The above service was mentioned as a guideline only for possible opportunities. Success is not guaranteed, as nothing inhibits the network carrier to provide such services. On the other hand, all the network providers are today pushing migration to ATM, as it is easier for them to manage and provide, and do not usually take into account the customer's requirements for simplicity. There might be a niche here for newcomers in telecommunications.

4 Local Access

The local access segment is currently providing ubiquitous telephone service, using mostly copper twisted pair local loops. The existing infrastructure has been proven inadequate to satisfy the increasing needs of subscribers for bandwidth. The success of the internet has boosted competition in the segment, as more emergent physical layer technologies are rivalling to offer more bandwidth everywhere.

4.1 The Technologies

The telephone system was designed for carrying analogue voice traffic. Digital enhancements to the system enabled more services, but, only until the local exchange, due to the huge investment needed to upgrade the local loop. Today, the need for digital data transfer is covered by modems over the analogue network, and the fully digital ISDN and leased lines.

Modems have reached speeds up to 56 Kbps over conventional telephone lines, using high-end digital signal processing techniques. Basic rate ISDN offers up to 128 Kbps, but is not yet priced for the masses; see Table 5 in page 9. Private leased lines are usually offered at E1/T1 speeds, and are addressed to business users, as stated in the previous section.

The above technologies are widely available, and there is little margin for competition with the legacy operators. The technologies that challenge the above are of interest to a newcomer to the local access segment. Such include Digital Subscriber Line (DSL), coaxial cable, fibre, and radio local loop technologies. These will be described in the following paragraphs.

4.1.1 DSL

Digital Subscriber Line or 'last mile' technologies require two digital modems, one at the customer premises and one at the local exchange. Provided that the distance between the two modems is below some limits, the modems can exchange data over copper twisted pair at far higher rates than possible with conventional techniques, retaining an analogue 4kHz band for Plain Old Telephone Service (POTS). DSL technologies are very cost-effective for PTOs as they do not require massive investment and they are installed on demand only. The major DSL variants are shown in Table 4.

Of these variants, ADSL has received the most investment, as it fulfils the requirements for transmitting downstream video to the customer. The ADSL configuration is depicted in Figure 2. However, ADSL has not yet been offered widely, because there is still confusion on the standard. There are two rival modulation technologies: Discrete MultiTone (DMT), and Carrierless Amplitude/Phase (CAP), which are incompatible. DMT is adopted by the European Telecommunications Standards Institute (ETSI) and the American National Standards Institute (ANSI), while CAP has a larger installed user base, as it appeared earlier. Convergence is desirable, as it will lead to reduced access equipment costs and vendor interoperability.

The ADSL Forum claims that ADSL is the great opportunity for the incumbent telecommuni-

Technology	Downstream rate	Upstream rate	Distance (feet)
IDSL (ISDN DSL)	128 Kbps	128 Kbps	18,000
HDSL (High-bit-rate DSL)	768 Kbps	768 Kbps	12,000
ADSL (Asymmetric DSL)	1.5-6 Mbps	0.64-1 Mbps	12,000-18,000
SDSL (Symmetric DSL)	1.5, 2 Mbps	1.5, 2 Mbps	10,000
RADSL (Rate Adaptive DSL)	7 Mbps	1 Mbps	12,000
VDSL (Very-high-rate DSL)	13-52 Mbps	1.5-2.3 Mbps	1000-4500

Table 4: *x*DSL technologies comparison (source: TeleChoice, from [5])

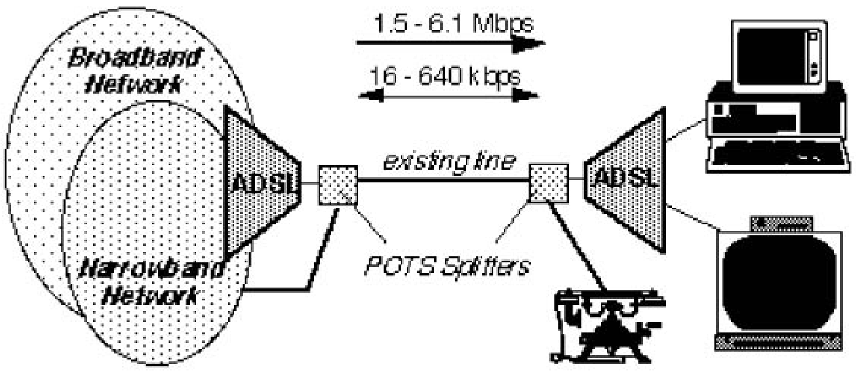

Figure 2: ADSL System Architecture. (source: *ADSL Forum*)

cation companies to protect their vast investment in twisted copper pairs, especially now with the growing competition from cable companies. European PTOs, on the other hand, are experiencing very high growth in their ISDN Basic Rate service and do not feel an immediate need to rush to another high speed service [6].

4.1.2 Cable and Fibre

Cable television (CATV) analogue coaxial star network has had a good penetration to the residential market. The network was designed for unidirectional downstream data flow, and did not have the required reliability to host telecommunications services. Hybrid Fibre Coax (HFC) was the technology enhancement which was adopted in order to make the network capable of providing digital broadband services. Digital data is interleaved with analogue video using Frequency Division Multiplexing (FDM), and is extracted using a cable modem. HFC deployment requires a huge investment, though.

Even if the data services are deployed, the inverse tree topology of the network makes the effective bandwidth for each user a fraction of the cable bandwidth, as capacity is shared between the neighbours using the data service simultaneously. Therefore, the very success of the service might eventually prove its downfall [5]. However, this is the case for ADSL as well, as from a point and over its bandwidth is shared, not dedicated. There are also problems with standardisation, as there has not been defined a upstream Medium Access Control (MAC) layer yet. There are also security issues, as there has not been an agreement on the encryption to be used.

HFC is a Fibre to the Curb (FTTC) variant. There are other variants using copper twisted pair or even radio for the final drop. The Fibre to the Building (FTTB) and Fibre to the Home (FTTH), that extend fibre reach closer to the customer premises, are technologies that require huge investment, and are not yet justifiable by demand.

4.1.3 LMDS

Local Multipoint Distribution Service is the most attractive technology of the Wireless Local Loop (WLL) variants. It has been assigned a 1300 MHz bandwidth in the 28 GHz band. Due to the extremely high frequency, LMDS is strictly a line-of-sight system, and the transmitted signal is

	ADSL	Cable	DirecPC	LMDS	ISDN-BT	ISDN-Deutsche Telekom
Equipment	\$800-\$1000	\$500	\$300	N/A	\$250	\$250
Connection costs	Free	\$100-\$175	\$50	\$225	\$140	\$55
Monthly costs	\$50-\$150	\$30-\$50	\$130	\$80	\$30	\$25

Table 5: Local access technologies cost comparison (sources: Bell Atlantic-ADSL, @Home-Cable, BT and Deutsche Telecom-ISDN, [5]).

limited to a radius of about 25 square miles. This allows for frequency reuse, which combined with cell-resplitting, makes the capacity of the network virtually infinite.

Installed configurations allow downstream rates of about 500 Kbps, with upstream traffic handled by a conventional dial-in modem [5]. The greatest advantages of LMDS are the very rapid service roll-out, and the relatively low investment per customer required, compared to the deployment of a respective wireline network.

4.1.4 DBS and Power

Digital Broadcast to the home by Satellite is now providing television services in some countries, and can be enhanced to provide switched broadband services. The regulatory environment is now being set for such digital data services in the UK [7]. However, in the US and the UK such services have already been deployed using proprietary technology, as seen in the next section.

Broadband access services using the power distribution network are a novel alternative to traditional data delivery services. Research has given positive results; Energis, UK, announced that is will provide end-to-end networks based on this technology, but it could be applied to the local access segment, as well.

4.2 The Price

A rough price comparison of the rival local loop technologies is depicted in Table 5. DirecPC is a DBS service, provided by Hughes Telecommunications. This internet access technology delivers 400 Kbps downstream from the satellite to the antenna dish, and uses a conventional dial-in modem for upstream traffic. The cable solution delivers 1.5-3 Mbps and the LMDS solution 500 Kbps with a modem for upstream traffic. Basic rate ISDN costs are also provided for comparison.

4.3 The Opportunities

In the short term, broadband access services seem to be only justifiable by corporate users, or corporate network access from the home. However, the internet's unforeseen success is an example of a service which was very profitable to the ventures that were ready to provide it immediately; and telephone or cable companies were not.

A newcomer in the local access segment has to compete with both the PTOs and the cable operators, if it wants to hit the broadband network provision market. This is very difficult, provided the vast amounts invested by both operators in their local access segments. On the other hand, it could closely cooperate with them, providing services, support or equipment for one of the technologies mentioned above. Both options are considered in the following paragraphs.

4.3.1 Network and Service Provision

A newcomer in local access networks might look firstly at WLL technologies, such as LMDS, as they offer a rapid service roll-out, the lowest civil costs, more than adequate capacity, flexibility, and large market penetration potential, especially if seamless interworking with the wireline networks could be provided. LMDS is the opportunity for small-scale network investors, taking into account that small scales in network provision require usually much higher investment than large scales in service provision.

WLL is a novel alternative to traditional access schemes, and could have a good appeal to customers, with the suitable marketing strategy and aggressive competitive pricing policy, at least during the first years. Despite the difference of the target markets, useful guidelines can be derived from the success of mobile telephony schemes as PCN, although they had been pushed from regulation. In WLL regulation lags, and this could prove a source of delays and interoperability setbacks. The success of such a novel network provision is highly dependent on the timing of its deployment, which should be well before the respective PTO and cable operators broadband services launch date.

4.3.2 Service Provision

Local access service provision to incumbent network operators involves less risk than network provision, as competition would not be as tough. However, risk levels are still high, as the venture has to select one of the rivalling technologies. All xDSL and cable or fibre based broadband are deployable now, but the investment required is different for each of them. In addition, there is the major issue of standards and regulation for some of the technologies, as mentioned in the previous paragraphs.

The company could invest on ADSL access equipment and provide ADSL service either to the PTOs, or directly to the customers, possibly involving in the ISP business, as well. To accomplish this, it should be able to test the customers' copper connection to their local exchange, and, in cooperation with the PTO, to improve it, if not in the distance limits. It could also charge the customers for the service, according to the maximum bandwidth they achieve. Furthermore, it could provide Customer Premises Equipment (CPE) to split the bandwidth to several terminals.

Cable or HFC service provisions could be handled the same way as ADSL provisions. Charging cannot be flat-rate, as the effective bandwidth is dependent on the network load, so off-peak usage should be stimulated. There might be an opportunity for a middle-tier company between the customers and the cable operator, providing traffic management and manipulating the upstream data from the customer terminals.

5 Intelligent Networks

The introduction of computer-controlled telephone centres in the Private Branch eXchanges (PBXs) provided many advanced services within the range of the corporate network. The incorporation of such services to the core PSTN was considered as an opportunity for PTOs to make their service provision packages more attractive, especially for domestic customers. It is this task that the Intelligent Network (IN) concept claims to accomplish.

5.1 The Technology

As mentioned above, intelligence in the network is meant as its capability to provide some advanced services to its users. The introduction of Stored Program Control (SPC) in the telephone network enabled only some primary services to be provided, more useful to the network operator than to the customer. Advanced services, such as Freephone, could be implemented through major, error-prone, and time-consuming upgrades to the switches' software. Therefore, only very popular advanced services were deployed, and they were mostly proprietary, equipment dependent implementations.

Bearing in mind these problems, Bellcore was the first who outlined an extended call control architecture, which was named IN. It is a modular platform, allowing rapid creation and deployment of novel services. It is also an open architecture, allowing multi-vendor service provision, according to the Open Network Provision (ONP) directives.

5.1.1 Architecture

IN's main enabler is the definition of an advanced out-of-band signalling architecture, based on CCITT Signalling System No 7 (SS7). The layers added to the SS7 architecture to support IN and other advanced applications were: Signalling Connection Control Part (SCCP), Transactions Capabilities Application Part (TCAP), and Intelligent Network Application Part (INAP). The resulting packet switched signalling network provides the backbone connecting the following basic IN elements:

- Service Control Points (SCPs), which are the processors in which the 'intelligence', namely the services software implementation, resides and is executed;
- Signalling Transfer Points (STPs), which are essentially the message packet routers of the signalling network;
- Service Switching Points (SSPs), which are the IN gateways to the POTS, recognising the calls requiring advanced services and forwarding their requests to the SCP.

Key to the network operators and service providers IN components are also the following:

- Service Creation Environments (SCEs), for the development and testing of new services, and for the modification of existing ones.
- Intelligent Peripherals (IPs), for providing user interaction functions, such as voice guidance or digit collection [8].

- Service Data Points (SDPs), which are databases holding the customer and service related records and other essential data.
- Service Management Systems (SMSs), which administer the service provision, by updating and synchronising the data used by SCPs and taking fault and overload management actions.

5.1.2 Standards

One of the major issues in IN is standards. There are divergencies between the US and international standards organisations. In the US, from the original IN-1 the standard evolved to the Advanced IN (AIN) specifications, with AIN 0.2 being the latest version. In Europe and the rest of the world, the International Telecommunications Union (ITU) specifications are adopted. In these, sets of services that have to be supported by IN architectures are defined, called Capability Sets (CS). The initially specified CS was called CS-1, however, some bodies as ETSI revised it to the more compact CS-1R. The CS-2 will be a superset of CS-1, but its release has been delayed.

These standards do not specify the exact structure or implementation of IN services, but give general and, sometimes, multiple descriptions of them. The services are constructed out of service features, which were introduced to facilitate the reuse of common tasks between services. One major problem with the current IN standards is that they do not address effectively the issue of feature interaction between services, and the possible conflicts that may arise.

Cellular mobile telephone networks architectures already provide IN services, as they were relatively recently developed. There are two main proposals for the upgrade of the existing signalling architecture to a more advanced configuration, Wireless IN (WIN) and Customised Applications for Mobile Enhanced Logic (CAMEL). They are both separating the service plane from the network plane, allowing roaming customers to use the advanced services they are subscribed to, to the visitor network, even if the latter does not provide them.

5.1.3 Services

IN services are implemented by using software engineering techniques. There are companies providing user-friendly creation tools for service providers. Such tools provide usually Service Independent Blocks (SIBs), which can be considered as the foundation classes for the services' development. Before the development, testing and deployment stages, a marketing analysis on the potential for success of a service should be conducted. After the deployment, service maintenance and enhancements should be provided, according to the customers' requirements.

The most popular IN services to-date can be roughly categorised as follows:

- *Charge* centric, for example, Freephone, Account and Credit Card Calling, Premium Rate Calling, Split Charging.
- *Route* centric, for example, Call Forwarding, Conference Calls, Time-of-day or Day-of-week routing, Nearest Point Routing, Televoting.
- *User* centric, for example, Follow-me, Personal Number, Number Portability, VPN, Call Waiting, Call Back on Busy, Call Screening.

Of course, the above classification categories are not mutually exclusive, neither exhaustive.

5.2 The Opportunities

Differentiation of services is the cornerstone of success of a telecommunications operator. Customers buy services, and they will select the carrier who offers those that suit them better. For a new competitor, services as those mentioned in the previous section are only a start point, and more customer-tailored services have to be provided. Competition is not only external, but could also be internal, as the IN architecture allows multiple service providers for each carrier network.

Assuming that the operator has already installed IN-aware equipment and has adopted the SS7 signalling network, the company could establish an agreement with it to provide a suite of services. The company should invest in service creation software from intelligent networks products providers as Nortel, USA, or GPT, UK, and in essential computer hardware for the development of the services. Training of the engineers, developers and managers to the environment is considered as part of the investment, as well.

A possible service life cycle is depicted in Figure 3. For novel IN services, a marketing survey of the target customer groups that are likely to subscribe to the IN services should be conducted initially. These groups include fixed and cellular network subscribers. The survey could include polling a sample of customers on the services that are most interesting to them. Several customers profiles would then be built, each assigned a specific bundle of services.

Next comes the service design phase. It is up to the company to ensure that there are no conflicting feature interactions within the services in each bundle. The probability of integrity breaches due to possible ambiguous use by the customers should be kept very low, by an extensive and exhaustive testing procedure before and during service deployment. Once a service is installed, arising demand for enhancements, additions and modifications to the service bundles could be satisfied by the company, making it a long term contractor.

The revenue generating solutions are the ones that have a strong appeal to customers. Such include services that give the users privileges and full control, whether they are domestic and business customers or network operators. Therefore, the company should balance the demand for

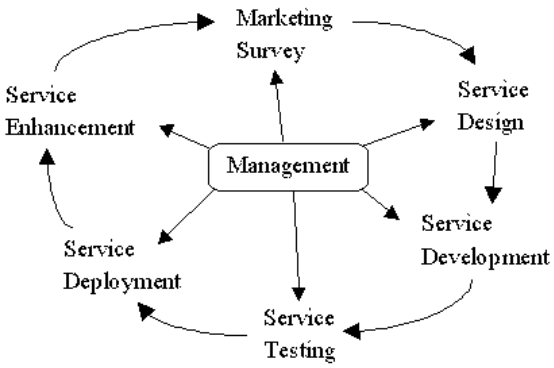

Figure 3: A proposed service life cycle.

such services, and the requirements for service integrity and reliability.

6 Internet

The internet business has grown to one of the most profitable with its continually expanding user base. The majority of its users access it through PSTN connections to the ISPs. Due to its success, legacy PTOs are involving in the ISP business, either by forming alliances with ISPs, or by providing end-to-end internet service.

6.1 The Technologies

The internet in the start of the decade was an extended network interconnecting computer networks sited in academic, industrial research, governmental and commercial organisations. Much of the network traffic was text-based, and the most remarkable application was electronic mail (e-mail). A computer could be connected to the internet, if except than the transmission path, it had a unique IP address, and it was using the Transfer Control Protocol/Internet Protocol (TCP/IP) for transmitting and receiving data [1].

The advent of the World Wide Web brought the big explosion in the number of computers and users of the network. Due to the danger of exhaustion of available IP addresses technologies as Point to Point Protocol (PPP) with dynamic IP addressing are used to provide dial-up access to the masses of residential customers. Newer developments as IPv6 are solving the addressing problem. Other enhancements as IP multicasting improvements, CoS-based routing via IPv6, SecureIP, and Resource Reservation Protocol (RSVP), were announced by the Internet Engineering Task Force (IETF). The ultimate goal is IP dialtone, an ubiquitous network that will deliver multimedia data everywhere.

However, the internet has grown today to scales which were unexpected for the industry. The increased proportion of multimedia in the delivered data, pushes for increased bandwidth and QoS in the local access, which is not currently widely available. There are also pricing issues, as today's subscription scheme with separate fees to the PTO and the ISP is not efficient. There are also content related issues, as user freedom and privacy are conflicting with malicious use of the network. Usage-based pricing is also an unresolved issue to-date.

6.2 The Opportunities

The objective of a newcomer in the internet provision segment is to compete backbone ISPs, their local resellers, and telecommunications operators. There are three competition fields allowing for revenue expectations. The first is high speed local access provision. The second is the development of corporate software solutions. And the third is provision of bundled telecommunications and data services. As previous sections in this document deal with the first field, the latter two will be discussed in the following paragraphs.

6.2.1 Intranets and Extranets

The company could get involved in VPN provision for corporations, allowing the secure exchange of information and co-operative working between geographically distinct points of presence. Internet VPNs, or intranets, are much more cost effective than private networks, and are usually offered with user-friendly hypertext interfaces. Extranets, in other words extensions to VPNs to provide limited access to clients or resellers of a corporation are also a very appealing application.

Intra/Extranet service provision requires advanced software engineering, and competition will come mostly from the software industry, which have already developed bare-bones products [9]. Enhancements to such products as adding multimedia features, could also be an opportunity for the company.

6.2.2 Multimedia Services

Offering a bundle of voice, video and data services to the residential and business customers, is the ultimate opportunity for potential ISP competitors. Revenue expectations are very high, since customers could include:

- residential subscribers who want to cut their telephone costs and 'surf' the World Wide Web;
- business subscribers, to whom videoconferencing and teleworking can be offered at an affordable price.

However, there are problems, as even voice over the public internet has not reached the quality of POTS yet [10]. Acceptable quality videoconferencing could only be possible within an intranet. But for domestic subscribers these innovative services could prove attractive even at a primary level, and thus generate revenue.

7 Conclusion

Success in the telecommunications industry is something that only the companies that are able to adapt quickly to the market trends will be able to reach. Profit building opportunities are not scarce, but require a thorough investigation of the available options. The above discussion on four segments of the industry, can be considered only as an initial report evaluating some of the advantages and disadvantages of each option. More detailed reports, studies, financial and market surveys, evaluations should be conducted before decisions on investment are taken.

One aspect that was not fully covered in this report, is the economic aspect. This was impossible to be dealt with in depth, with the information provided in the notes or in known public sources of information. Economic results were presented only from the subscriber side, just to give an image of the competition that the company would face. A full economic analysis of the solutions discussed, would be alone a report of much higher volume than this document.

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Siemens,	www.siemens.de	ADSL Forum,	www.adsl.com
tele.com,	www.teledotcom.com	Frame Relay Forum,	www.frforum.com
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