Drivers for the Adoption of Multi-service Networks

Digitalization of entertainment and other consumer content makes it possible to use available transmission media resources more efficiently, to use universal storage solutions for the content while providing end user quality experience equal to or better than analogue media. This leads to the need for speech, music, pictures and streamed content to be delivered to homes and mobile users in digital form. Content delivery channels of this type exist or are becoming available in the form of digital telephone networks, digital mobile network systems and digital television. These technologies are examples of mostly single-service networks at the moment, although so-called “2.5 generation networks” (2.5G) can already be used for transmitting pictorial and data content. The challenge of the near future is to provide all kinds of services over single delivery channels in a cost-efficient manner. Facing this challenge in Internet Protocol (IP) based networks is the topic of this book.

Conceptually, there are three parties involved in such a delivery chain. The digital content is produced by a service provider, delivered to the end user by the network operator, and used by a customer. Let us next study the implications of the situation referred to above from the point of view of these three parties.
In this section, only the access network operator viewpoint is considered. We shall return to the interrelations of access and backbone network operators later in this book.

1.1 CUSTOMER PERSPECTIVE

Currently, a home user is typically using multiple access technologies for communication. Wireline telephony (“Plain Old Telephony System, POTS”) and cellular phones are used for two-way speech delivery. Digital cellular phones also support text and picture form messaging. Broadcast TV and radio are used for receiving audio and video content such as news and entertainment. Usage may be associated with a “flat-rate” subscription for the service or be free of charge. Cable TV infrastructure may be used as a transmission medium for paid audio and video content, in addition to being used for the distribution of broadcast programs. Paid content may be billed based on flat-rate subscription or usage-based.

Internet access can be handled via POTS local loop, Integrated Subscriber Digital Network (ISDN) over POTS, some variant of Digital Subscriber Line (xDSL), or a cable modem. Recent additions to the repertoire include wireless broadband access using meshed wireless routers or Wireless Local Area Networks (WLAN). Each of these technologies is associated with a delivery channel, as illustrated in Figure 1.1.
A noteworthy aspect of this situation is that the reception of different service types is based on different kinds of technology: POTS telephony and broadcast TV/radio are based on analogue technology, whereas Internet access and cellular telephony (in Europe and increasingly in other continents as well) is based on digital technologies. Thus, the home user currently needs a POTS telephone, radio receiver, TV receiver, radio receiver, cable TV set-top box, personal computer (PC), and xDSL Customer Premise Equipment (CPE). The mere existence of different kinds of equipment is no bad thing as such; it is often good to use equipment specifically designed for one service to have optimal usage experience. What is not optimal is the inability to receive all types of content in a single type of device, say, PC, if need be.

Second, with the exception of telephony and Internet use, the services are typically one-way “broadcast” type of services with an associated usage fee. This arrangement is rather inflexible; a subscriber of such a service pays for all types of content and not only the types the subscriber is interested in. Also, the selection of the content “on-demand” basis is highly desirable. Digital TV is now taking its first steps in Europe. Digital TV technologies allow for interactivity to complement the distribution of the content over the digital TV channel. This is a step in the right direction.

Third, the traditional arrangement ties the end user to a single “access network” provider who is also the service provider. Competition for the local loop access has not always succeeded optimally. Thus, for each of the access technologies, the customer has to pay a price that is not determined by competition in a free market.

Fourth, messaging-type services have become popular recently, allowing users to send notices to other users in near-instant fashion. In addition to “traditional” e-mail, other examples of messaging include the Short Message Service (SMS) and the Multimedia Message Service (MMS) of GSM/GPRS (Groupé Spécial Mobile/General Packet Radio Service) networks, and messaging on the Internet. Such messaging requires that users are “on-line” in order to receive messages addressed to them. In addition to telephone networks, this is possible for Internet messaging using xDSL and with the communication endpoint (PC) switched on.

Collecting some of the observations made so far, a wish list of the customer for information access technology would look as follows.
• Communication endpoints (e.g. PC, mobile terminals) should support accessing of different kinds of services. Dedicated terminals such as TV sets can be used when optimal usage experience or storing of received content is important.

• Converged access network systems should support the delivery of all kinds of services. The same network should support delivery of messaging, data, and streamed content as well as being suitable for supporting conferencing-type applications.

• The end-to-end delivery chain should make it possible to separate provision of services from provision of access to services. This allows the choice of the most adequate access technology according to the usage situation. Specific details of the access medium should be as invisible to the user of the service as possible.

• Interactivity should be possible, in addition to receiving broadcast or downloaded content. Specifically, support for near-instant messaging is highly desirable.

1.2 NETWORK OPERATOR PERSPECTIVE

The business need fulfilled by the network operator is to provide access to service types for the customer. Depending on access technology, the competition is more or less fierce. In copper local loops, for example, incumbent network providers are challenged by new entrants, cable modems, and wireless access technologies. In cellular networks, to take another example, most countries have multiple operators. Due to competition, operators need to consider both capital expenditure (CAPEX) and operating expenditures (OPEX) of their network technology platform. In brief, CAPEX considerations lead to the goal of utilizing built capacity as efficiently as possible, whereas OPEX aspects boil down to streamlining and automatization of technological solutions in use. Both of these aspects will be discussed in this book.

The progress of content digitalization, the advent of new services, and expectations of interactivity and converged technology platforms pose further challenges to the access network operators. It is in the interest of operators to develop technological platform support for advanced service types.
The convergence of the multi-service network has been a technological goal of the telecommunications industry for a long time. One of the first attempts was narrowband ISDN (Integrated Services Digital Network), supporting up to eight ISDN terminals within the customer’s premises and providing two simultaneous circuit-switched connections from a single ISDN CPE using ISDN’s 2D+ B channel technology. Alas, business adoption of ISDN occurred fairly late, in Europe during the latter half of the 1990s. In ISDN, the bit rate of a single channel was limited to 64 or 56 kbit/s because of the (Analogue/Digital) A/D conversion used in digital POTS network.

The next attempt was broadband ISDN, also known as Asynchronous Transfer Mode (ATM). ATM has advanced multi-service capabilities and can support high bit rates. As a result of a long-drawn standardization effort, the final ATM standard is fairly complex, and failed to be implemented end-to-end. An issue that became evident after taking ATM into production use, the management of ATM networks is complicated. In addition to managing the ATM network as such, the operator also needs to manage the protocol layers below (for example, Synchronous Digital Hierarchy, SDH) and above (for example, Internet Protocol, IP) ATM. Subsequently, in the Internet domain ATM is mostly used in backbone networks where the configuration is often static.

In the late 1990s, it turned out that the winning convergence layer was IP. The main reasons for it being victorious stem from existing wide-scale adoption of the technology in the Internet and IP not being “owned” by only a handful of vendors. In Internet design philosophy, the state is maintained at the communication endpoints and not in the network, allowing for cost-efficient design of networking equipment. IP is a good convergence layer in the sense that it can be run over multiple link layer technologies, including ATM. On the applications side, the Internet Engineering Task force has developed – and keeps on developing – a rich set of protocols for interfacing different kinds of service applications to IP using “Layer four” (L4) protocols such as Transfer Control Protocol (TCP) and User Datagram Protocol (UDP). In particular, the standard socket programming interface towards IP and multiplexing protocols such as TCP and UDP is well known.

The adoption of IP in different Internet access networks together with the rapid growth of Internet usage has brought with it very rapid growth of traffic volumes in the network. At the time of
writing, this growth has slowed down due to economic factors, but growth is expected to continue once a new wave of services becomes available. This fast growth has led network operators and other involved parties to pursue the goal of optimizing the protocol stack. A protocol stack of IP over ATM over SDH over Wavelength Division Multiplexing (WDM) is not optimal, neither from CAPEX nor from an OPEX point of view – at worst, all the protocol layers require software and hardware support as well as trained maintenance personnel.

Light protocol stacks such as IP over 802.X in copper-based networks or Internet Protocol/Multi-Protocol Label Switching (IP/MPLS) over WDM have received lots of deserved attention on the commercial side as well in research and standardization.

In brief, network operators are looking to light protocols stacks with IP as the unifying end-to-end layer as a multi-service support platform of the future. To accomplish this goal, management of multi-service Internet needs to be made more streamlined than that of ATM.

1.3 SERVICE PROVIDER PERSPECTIVE

Service providers compete in their ability to provide best service selection to the customer at the best price. This goal can be pursued by different strategies: providing a set of services and network access in “bundled” packages, or by providing innovative services with shortest time-to-market delay, for example.

It is in the interest of service providers to be able to provide services to as wide an audience as possible with as small an overhead as possible. The former goal leads to the ability of accessing the services with multiple technologies being desirable, with market mechanisms ensuring the interests of both the customer and the service provider. The latter goal means in practice that the service provider should be able to provide services for different access methods with as little tailoring as possible. The tailoring cannot always be fully avoided, as is the case with saving streamed content in the server in multiple encoding formats, but the per-access technology tailoring (conversion) can be made as automated as possible.

The service provider wants to have a flexible mechanism towards the network operator in providing services with
appropriate service-specific parameters specified as simply as possible. The contractual interface between the service provider and the network provider should be flexible to allow for the quick implementation of novel service types.

Eventually, the time-to-market consideration ultimately comes down to the abstract multi-service network interface being as streamlined as possible. With such an interface, service creation efforts can be concentrated on the construction of the new service, instead of having to manage a multitude of access-technology specific parameters.

1.4 SUMMARY

Having a single end-to-end convergence layer is in the interests of all parties, namely customers, network operators and service providers. The Internet Protocol (IP) emerged from the period of rapid technological development during the late 1990s as the winning candidate. Converged IP-based delivery of content service allows IP to be used as the common denominator for services above it, as well as different access technologies beneath it. Architecture of this type is illustrated in Figure 1.2.

![Figure 1.2](image_url)  
**Figure 1.2** An example of multi-service, multi-access technology scenario made possibly by IP
Different technologies can be used beneath the IP layer to support delivery of services to the customers. The link layer access network technology can be chosen according to the customer’s momentary needs. From the operator viewpoint, the transport network connecting to the end user link should advantageously be implemented with as few protocols as possible for flexibility, and should make as good use of the installed capacity as possible. The latter requirement, typically specific to access network operators, leads to the need to implement service quality support mechanisms in the network. Such mechanisms need to be implemented either on the link layer, or in the IP layer. This is the main topic of the present book.

Having a well-defined interface to specify the requirements of services is important for service providers. A central theme in service definition is service quality specification. In the following chapters, we shall study the generic requirements of different service types, network-sides service quality mechanisms in Internet Protocol networks.

Another major area of interest in this book is the management of services within a network domain, as well as between different parties of the end-to-end delivery chain. Technologies and the techniques for implementing this constitute a major part of this book.