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Network and Service Interoperability in the Infocom Era

The changing market of telecommunication services, characterised by the fast growth of the Internet and mobility services, emphasises the need for true interoperability between different networks and services/ applications provided on heterogeneous networks. The requirements for interoperability apply not only to the network transport infrastructures, but also to the control and intelligence layer, to provide advanced services across different network boundaries. These needs are strongly related as well to the perspectives of voice-data-fixed-mobile convergence processes fostered by Internet paradigms.

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Introduction

The market of telecommunication services is rapidly changing due to many factors such as technological advancements, convergence processes (for example, convergence of information, telecommunications and entertainment technologies, convergence of fixed and mobile services and networks), liberalisation, competition, changing end-user requirements etc. There is in general a growing expectation, especially from business customers, for the establishment of globally interoperable multimedia communications. More and more, enterprise mission-critical applications are relying on telecommunication services and networks capabilities to meet increasing needs for security, seamless availability, one-stop-shopping integrated offers and high quality of service. The fast growths of Internet and mobility services are impacting dramatically the way customers access and use telecommunication services. Customers will want to use existing and new services independently of their actual position and whatever customer premises equipment they use. At the same time, service providers and network operators want their services to be available as widely as possible. In order to make this possible, services and networks need to be interoperable in a multi-operator and multi-network context.

True interoperability between networks and services is one of the most important requirements in an information and communication environment that is rapidly evolving toward complexity and heterogeneity. Competition in the standards arena and in the markets, the speed of technological evolution and the changing requirements of customers are bringing faster deployments of new networks and services, often based on proprietary or pre-standard and mono-vendor solutions. This way of deploying telecommunication networks and services generates high risks in terms of scalability, evolution and interoperability of the solutions.

So there is an increasing need of guarantees for proper interworking among different networks and services, owned either by a single operator or by multiple operators. This is of particular relevance also for the convergence processes among telephone, data, fixed, and mobile services and networks.

This paper examines some aspects of these issues, outlining the role of Internet technology in the migration path from traditional vertically integrated systems towards horizontally interoperable networks which are increasingly independent of the transport technologies and open to externally provided services and applications.

Interoperability Layering and Scenarios

Interoperability layering

Interoperability has to be examined taking into account the different needs and implications involved at the various layers which may be identified in the telecommunication industry, as shown schematically in Figure 1.

Interworking and interoperability concern the transport layer, the intelligence and services layer, the applications layer, and the management features of the networks and services.

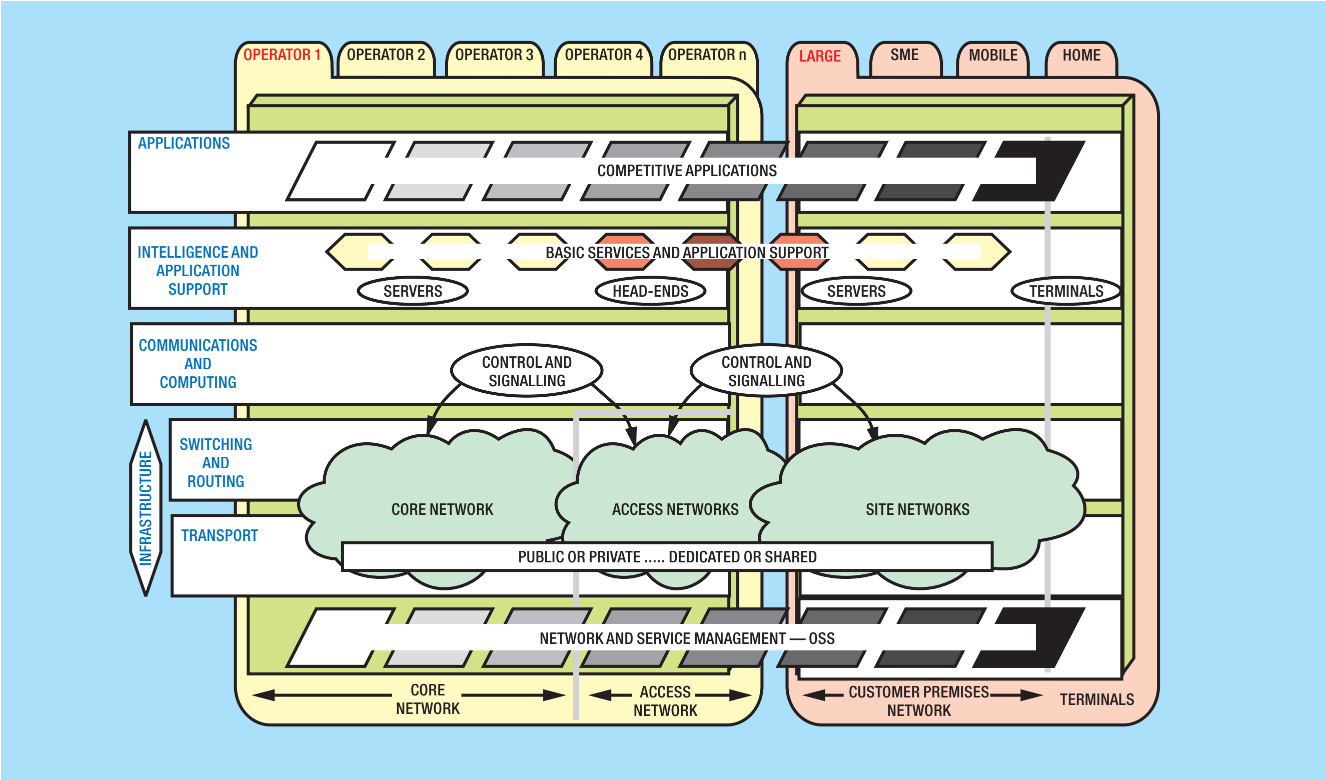


Figure 1—Layering model for interworking and interoperability

In the transport layer networks and sub-networks, interconnectivity has to be assured independently, whether they constitute the access or the backbone part of an end-to-end connection, or they are dedicated or shared, public or private. Besides the physical and logical connections of the networks, a proper interoperability among the control and signalling features of the networks is required to provide seamless networking of the customers' information.

In the intelligence and services plane, interoperability among basic services is needed as well as interoperability among 'intelligent' functions to provide advanced network services across boundary network dominions, such as intelligent network (IN) and mobility services, personal number, global virtual private networks (VPNs), and to support integrated fixed-mobile services (for example, VPN with wireline and wireless extensions). In the future, such functionality can be incorporated within terminals, network elements (service control points (SCPs) for INs, service nodes (SNs), operational support systems (OSSs), etc.) and servers and head ends. The interworking at this layer is challenging, because traditional telecommunication services have been deployed on the basis of proprietary platforms embedded in the central switches and/or in centralised intelligent nodes (for example, SCP, Internet protocol (IP), SN), with a model for network control and service provision mostly vertically integrated. Critical issues concern security and lack of adequate international standards.

Interoperability at the applications layer ensures the correct operation of customer business and/or enterprise processes. In the competitive environment problems can arise in the provision of interoperability among applications developed in competing networks because of possible commercial impacts. Only if adequate incentives exist for service providers and operators to organise interoperability to their mutual benefit, can interoperability at applications layer be pursued.

Competition will indeed develop mostly on the market plane, hence at the applications layer, while on the other planes an evolution can be foreseen towards a mix of competition and cooperation among the various actors, aiming at a cooperative development of the technological and intelligence capabilities of the networks. This could increase the global market of the services and of the applications to the benefit of all the interested actors.

As far as the management plane is concerned, needs for OSS interconnections are increasing owing to network-interconnection requirements, number and service portability among different providers and network operators, and network unbundling mandates from regulators.

Interoperability between the management systems allows the management functions to be carried out effectively (configurations, faults, traffic, accounting) in a competitive environment to ensure an adequate level of quality of the end-to-end service.

OSS interconnection among competitors is a complex issue for a number of reasons especially when there is the need to exchange information on customer data and services. Appropriate international and industry-wide standards are essential to facilitate any type of OSS interconnection.

Interworking scenarios

Interworking and interoperability is becoming an increasing challenging task for the various actors operating in the forthcoming infocom era. Many problems may arise because of complex environments involving multiple media, multiple protocols and interconnection of networks outside any single organisation's dominion control.

Today the pace and magnitude of changes, the diversity of network elements and hierarchies, the diversity of services and options for carrying them and multiple business imperatives make the network engineering function much more complex compared with the past. The internetworking scenario is further complicated by a growing uncertainty in the mix of traffic types.

As shown in Figure 2, a broad range of new technologies is deployed, each characterised by its own features and standards. For example each network has its own parameters related to the quality of service (QoS), policy for call acceptance, engineering rules for the management of the traffic and congestion relief. Each of these networks is being used for quick provision of new services and applications; moreover a clear trend is emerging where increasingly the same services are provided with different network technologies (for example, voice over data networks).

At the same time the proliferation of service providers and network operators implies that an increasing number of them are involved in end-to-end connections. The customers' terminals and equipment are increasing in terms of typologies and features, rising further interworking issues; meanwhile the same services are being provided on different types of terminals (for example, texts on TV, video on PC).

Market and regulatory factors will tend to allow customers to use new services irrespective of whether they are customers of the operator that has launched the service, and of the customer premises equipment (CPE) they use. Operators will want to make their services available as widely as possible. To make this possible, services will need to be interoperable across competing networks. Interoperability of services between different networks, and between the networks and the equipment used by the customer to access them, is essential to users who need to be able to make calls to other users irrespective of whether they are directly connected to the same network.

An overall network interworking scenario must envisage the interworking among a number of different public and private networks, with a wide variety of terminals and CPEs and with a broad range of service centres.

Interoperability Issues for Data Networks

Impact of the Internet and voice-data convergence

The expansion of Internet services and the advancement of related IP technologies are quickly changing the shaping of the telecommunications sector.

Internet traffic is growing very rapidly; investments on data networking equipment and in particular on technologies that foster the convergence of voice and data are growing rapidly. This evolution is happening much faster than originally envisioned. Taking into account the above considerations, voice-data convergence is one of the major issues in the evolving telecommunications marketplace. Voice-data convergence will have different benefits in the short-term, mid-term and long-term time frame. In the short-term the main benefit is related to lower costs, mainly due to the current regulatory environment, which makes it cheaper to handle telephone calls over the Internet (or corporate intranets) than by using the public telephone network. In the mid-term the main benefits are related to the development of enhanced services based on voice-data service integration. In the longer-term the main benefits rely on reduced infrastructure costs by commonly handling voice, data, and video services over a data packet network.

This requires proper inter-operability between the IP network and the PSTN, including intelligent network (IN) services and the deployment of interoperable mechanisms to control IP network resources and to guarantee high QoS levels.

Interoperability with PSTN/ ISDN

The possibility of providing advanced services such as freephone, call screening, call waiting, call forwarding, mobile roaming, credit card calling, voice mail, caller identification, number portability, and directory assistance over the IP network represent one of the hottest issue in the telecommunication sector. This requires the interoperability between the IP network and the public switched telephone network (PSTN) not only at the transport layer but also at the signalling and control layer. The issue is of particular relevance because present data networks include generally only the transport infrastructure, without a clearly identifiable signalling and control layer, as shown schematically in Figure 3. The definition and the deployment of an intelligent control layer for the data network and its interoperability with the Signalling System No. 7 (SS7) and the IN of the PSTN is currently being analysed by the telecommunication industry and in standardisation fora.

To deliver advanced services across hybrid (PSTN and IP) networks, proper interworking must be built between the protocols used within the data network and the SS7 functionality that is inherent in the PSTN. This will provide service equivalency and seamless service with the PSTN, will enable advanced

Figure 2—Interworking scenarios

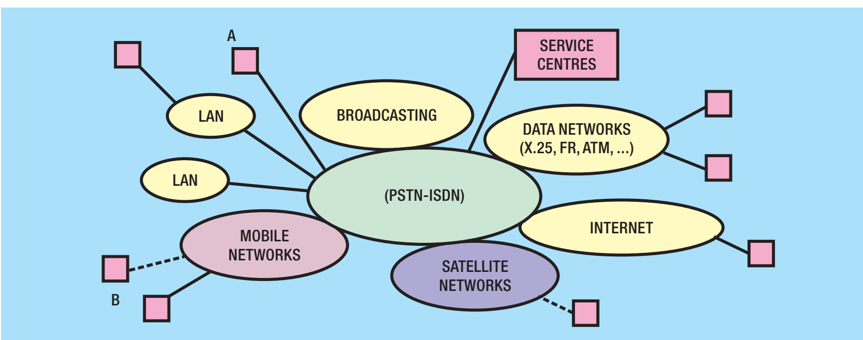
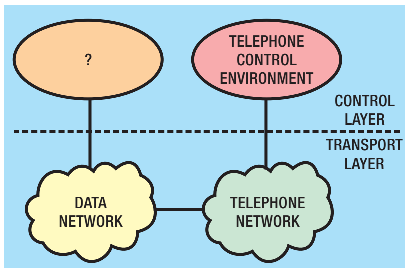


Figure 3—The missing components for a converged voice/data environment



services across boundary network dominions and will avoid multistage dialling (presently a voice-over-IP (VoIP) user must first dial the gateway, then enter a PIN number for authentication, and then dial the destination number). However, reaching agreement on IN/IP integration is a difficult process, because of the proliferation of standards; for example, H.323, SIP, IPDC, MGCP. Moreover such types of standards are primarily 'on-net' call management schemes, in which the call-signalling information shares the same call paths used to transport the VoIP services. Information for call control—such as credit authorisation, physical IP address, calling name or transport route assignments—must be contained within the IP network used to transport the user information.

This limits a service provider's ability to offer network features such as dynamic call routing, prepaid cards, subscriber roaming, 800 services and other services that require access to nationwide, or 'off-net', databases.

The next phase of standardisation is much more complicated aiming at adding signalling transfer point (STP) functionality on the IP network as well as access to SCPs to achieve a true integration of IN and a common IP-PSTN service infrastructure as shown schematically in Figure 4. All this needs to be centrally coordinated and controlled in order to allow carriers to handle billing, administration and global route control.

Control of QoS and network resources

As regards the control of QoS and resources within multiservice IP networks, a major issue is the quality of voice and of other real-time services. Obtaining acceptable quality of voice transmissions over an IP network is challenging because of the connectionless character of this network which implies there is no explicit mechanism for ensuring that a customer obtains a specific level of quality. For voice transmissions, a key problem is the time delay the network creates as a voice packet travels from sender to receiver. In the Internet the best latency that can typically be achieved is about 260 ms but, with a large volume of traffic, the performance of voice calls can easily be unacceptable. Fax is much less sensitive than voice to Internet delays, and that is why fax over the Internet is likely to be a successful service before voice.

Other important issues are the network engineering mechanisms, such as the management of resources, the control of traffic, the relief of network congestion and the protection against faults. While the PSTN has been standardised and engineered during the past few decades with high levels of service availability and network resource optimisation, connectionless data networks are less mature and many of the above mechanisms have yet to be found to achieve an overall reliability equivalent to that of the voice networks.

IP and asynchronous transfer mode (ATM) are presently considered as the transport technologies of future networks. IP has exploded as an industry standard with the growth of the Internet, and it is almost universally recognised as the best platform support for multimedia services. However, IP, because of its connectionless nature, cannot provide the guarantees of QoS levels required by real-time services. On the other hand, ATM can simultaneously transport multiple types of traffic including real-time traffic, so that many techniques of IP-ATM integration have been developed to benefit from the best characteristics of the two technologies. Many of these techniques are proprietary and do not interwork each other; others have been standardised (for example, LANE and MPOA) but do not scale for wide-scale public network applications. In parallel, other techniques have been developed to achieve adequate QoS levels, introducing forms of service class prioritisation (for example, DiffServ) with differentiated treatment of traffic in relation to different classes of IP services, or introducing new protocols for explicit control of both QoS and network resources, similar to that of connection-oriented networks (for example, resource reservation protocol (RSVP) and multi-protocol label switching (MPLS)).

These techniques may be implemented at the edge of the IP network or directly in the hosts and in the user terminals so that the various applications can indicate explicitly their requirements. Many of these techniques will be implemented, so that a rather complex set of interworking configurations can arise as shown schematically in Figure 5. In particular, the provision of end-to-end QoS levels across multiple networks dominions appears very challenging and requires careful attention in the standardisation fora.

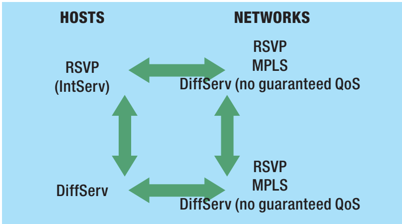
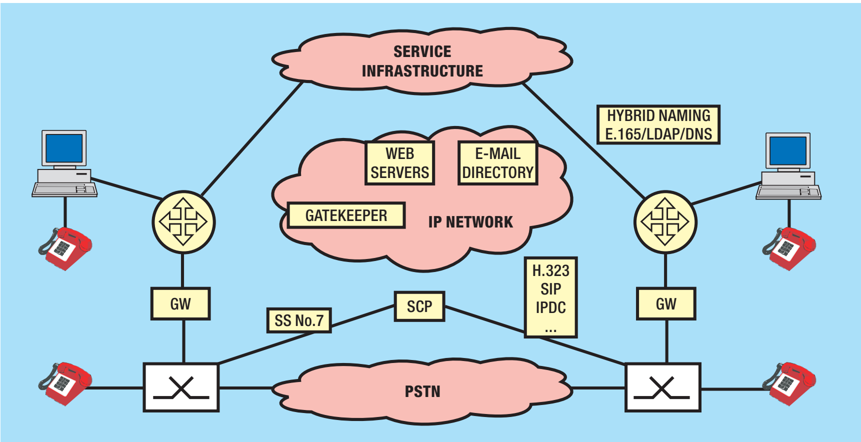


Figure 5—Interoperability issues in multiservice IP networks

Figure 4—PSTN-IP-IN interworking



Fixed-Mobile Interoperability

Fixed-mobile convergence

Interest in convergent solutions for the provision of fixed and mobile services has grown recently because of the new liberalisation conditions and the induced levels of competition. A service paradigm based on joint mobile and fixed service offerings can create business opportunities and benefits on both commercial and operations sides.

Integrating the transport networks involved in the convergence configuration is important for network efficiency, while the integration in the IN platform is key to enabling the development of new convergent services. The current IN standardisation process in ETSI is aimed at the definition of a capability set based on core INAP CS3 which should apply for both fixed and mobile networks. One of the most interesting services that can be provided, especially for the business market segment, sharing the same IN, is the VPN, which allows the integration of fixed and mobile users on a single service platform.

However, the above scenario cannot be realised in the short/medium term because, in most cases, two separate IN platforms are already working in the two reference networks. A good level of consistency between independent IN platforms can be recovered by adopting the concept of virtual home environment. A virtual home environment feature enables the user to maintain his/her service profile and terminal usage mode through different networks and can offer the same service to fixed and mobile users. This feature is reached through network interoperability, realising a complete alignment of the user data between the involved networks.

IP multiservices fixed-mobile network

Recent studies predict that IP multimedia services will soon contribute significantly to the overall mobile market, which by the year 2005 could range between 80 and 140 million users. Present estimates show that access flexibility and the possibility of being reached everywhere are considered to be of extreme importance by people usually working with a PC.

One of the main technological drivers to allow the provision of data communications to mobile users is the wireless application protocol (WAP), standardised by WAP Forum. WAP is a de facto open global standard suite of protocols which allows access to the Internet (and in general to World Wide Web (WWW) information) by a mobile telephone implementing a *micro browser*. In fact, WAP is derived from the hypertext transfer protocol (HTTP) and transmission control protocol/Internet protocol (TCP-IP), simplified in order to cope with mobile data services (low bandwidth, high latency, and unstable connections).

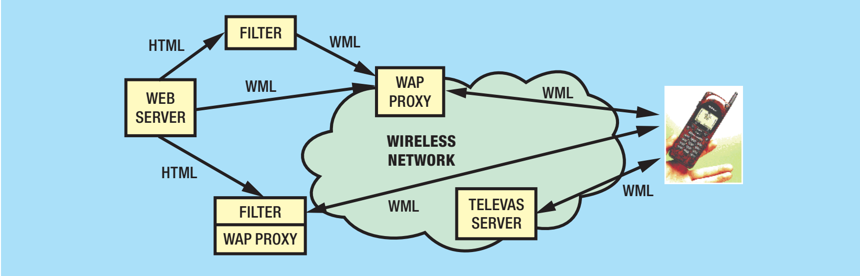


Figure 6—Configurations of WAP services

The WAP protocol is a typical example of a technical solution able to ensure the interworking among services designed originally for different kinds of networks. In particular, WAP-based technology enables the design of advanced, interactive and real-time mobile services, such as mobile banking or Internet based new services (e-mail, text-only web browsing), which can be used in digital mobile telephones or other mobile devices. A WAP proxy is located between wireless and WWW environments. It includes a gateway and a content coder/decoder, and can get, as shown in Figure 6, the content provided by a standard web server through a wireless markup language (WML) derived from the hyper-text markup language (HTML). The WAP protocol also allows the provision of telephony value-added services (TeleVAS) such as unified messaging.

The WAP specification enables applications from different equipment suppliers to work consistently on the digital networks and provide interconnection to data services and the Internet. WAP is independent from the underlying network technology (global system for mobile communications (GSM), code division multiple access (CDMA), time division multiple access (TDMA), etc.). Handset manufacturers, representing over 75% of the world market, have committed to producing WAP-enabled devices.

Carriers representing nearly 100 million subscribers worldwide have joined the WAP Forum. The WAP Forum considers that this commitment will provide tens of millions of WAP browser-enabled products to consumers by the end of 2000. Other approaches to data communications for wireless and portable devices are proposed by the Knowledge Wireless Consortium and, to a certain extent, by the World Wide Web Consortium—W3C. Also the SIM Toolkit, based on SMS transmission, can provide access to a server, mainly for information services, telephone banking and mobile commerce.

Multimedia service provision in the mobile networks will be challenging as mobile computing environments require additional mechanisms with respect to wireline network. Wireless channels are prone to burst and location-dependent error; furthermore, contention for the wireless channel is location dependent, and mobile users may move from lightly loaded cells to heavily loaded cells. As a consequence, wireless channel resources are highly dynamic; resource contracts that are made in one cell may not be valid when users move to another cell. Owing to these dynamics, the mobile computing environments require sophisticated interworking mechanisms for adaptation at customer devices and at network boundaries.

Conclusions

Interoperability among networks and services will be a major requirement in the forthcoming infocom era.

Different types of operators with different needs will rely on different technologies and will benefit from different network architectures, so that the general environment will be characterised by a multitude of heterogeneous network options.

Nevertheless services and applications need to be created, provided and used with minimal restriction, fostering an evolution process of network towards a global internetworked architecture. The widespread diffusion of IP, and related technologies, as a reference platform for data networking will dramatically change the model for the creation, deployment and provision of services both in the fixed and the mobile networks. It will also allow a migration from the traditional vertically integrated telecommunications model towards a horizontally layered model much more oriented to openness and interoperability.

Biographies

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CSELT

Enzo Garetti received the degree in Electronic Engineering from the Politecnico of Turin in 1970. He was then employed in CSELT, working on telephone signalling, digital switching and broadband ATM networks. He has worked in many RACE Projects, in standardisation activities and in strategic study projects of EURESCOM. He has been responsible for switching system architectures and head of the Network Architectures Department. At present, he is Assistant to the Director of the Switching and Network Services Directorate of CSELT and is working within ACTS projects. He holds a number of patents and is the author of many technical papers.

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Romolo Pietroiusti received the degree of doctor Engineer in Electronics from University of Rome in 1972. From 1974–76 he was the researcher in Ugo Bordoni Foundation on digital transmission and optical-fibre systems. In 1976, he joined Telecom Italia (formerly SIP) where he has been engaged mainly on research and development activities on network architectures and technologies. Currently he is responsible for technological strategies in the Strategies Department, working mainly on the evolution of information transport techniques, networking services and fixed-mobile convergence. He has been responsible for standardisation working groups in ETSI and in ITU. He is the author of about 70 technical papers.

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Alessandro Farnesi received the degree in Electronic Engineering from the University of Rome 'La Sapienza' in 1991. He joined CSELT in 1995 working initially on the set-up and management of the Italian national host. He worked within ACTS Project AC234 (CONVAIR). At present he is involved in the coordination of CSELT's participation in international research programmes.