A Signalling Interworking Solution for Heterogeneous Networking

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1 Introduction

The conventional circuit and packet switched networks have offered network specific services to end-users, and networking concepts (such as ISDN and BISDN) that offer integrated services have just added the number of different and co-existing networks. The advent of interactive multimedia services and the rapid growth of Internet have put the network operators in a new situation. The forthcoming as well as the existing services should be offered to users over a diverse set of networks and new innovative solutions are needed to integrate the different networks together.

Since large investments are involved with today's networks, there is an obvious need to utilise the existing infrastructure and develop means to offer interworking capabilities between these networks rather than to develop a new and unifying networking solution. Development of a new network concept would take a long time and as history has shown consensus about the technological solutions would possibly never be met. Therefore, it can be envisaged that interworking is the way to go.

Signalling interworking can be seen to lay the foundation for real network level interworking. Several efforts have been taken to develop signalling interworking between narrow and broadband networks and standardisation bodies such as ITU-T have developed standards for signalling interworking [2, 3, 9, 10, 11]. Interworking between packet and circuit based networks is a bit different thing. In packet switched networks, such as IP networks, no paths are established between the communicating end-points and signalling in the sense used in circuit switched networks do not exists. However, the strong upswing of IP networking is pushing the development towards heterogeneous networking and interworking between conventional telecommunications and IP networks is becoming a key matter.

In this paper, we present an interworking signalling solution that integrates circuit, packet and cell switched networks. We have earlier developed an interworking signalling solution for circuit and cell switched networks [15, 16], i.e., between N-ISDN and B-ISDN, and this platform is further developed to include interworking with IP networks as well. The physical platform is based on the SCOMS (Software Configurable Multidiscipline Switch) switching concept [14]. Chapter 2 goes through the main details of the developed narrowband and broadband interworking signalling solution. Chapter 3 presents the IP and broadband and

Chapter 4 the IP and narrowband signalling interworking solution. Chapter 5 includes the concluding discussion.

2 Narrowband and broadband signalling interworking solution

The interworking between connection-oriented technologies is quite straightforward, because a path is established to transport data between end-points. It does no matter whether the path is a broadband virtual circuit or a narrowband circuit or a combination of both. The path is normally established from the calling end-point, node by node, to the called end-point. The procedures involved when crossing network boundaries are straightforward and may be defined quite easily. Problems arise when the actual user data and related quality of service (QoS) or signalling information is carried over network boundaries.

The earlier signalling interworking implementation of the SCOMS system integrates ATM signalling with N-ISDN and PSTN signalling [16]. The implementation is composed of software modules that are compiled separately and linked together to form the entire software package. The major modules are the Interworking Call Control (ICC) module and the signalling stack modules (see Fig. 1). The ICC module includes the basic and generic Call Control (CC) and Switching Call Control (SCC) modules. The CC module implements a Service Switching Point (SSP), which offers different call control functions (CCF), basically call models, for the originating (CC-O) and terminating (CC-T) sides of a call. The CC module also contains Service Switching Functions (SSF), basically a set of functions required for interaction between CCF and Service Control Functions (SCF). The SCC module interconnects CC instances and provides interworking functions and protocol specific bearer connection control functions. The Fabric Control Functions (FCF) module includes all the functions needed to control physical hardware connections. FCF utilises Application Programming Interface (API) of the physical switch.

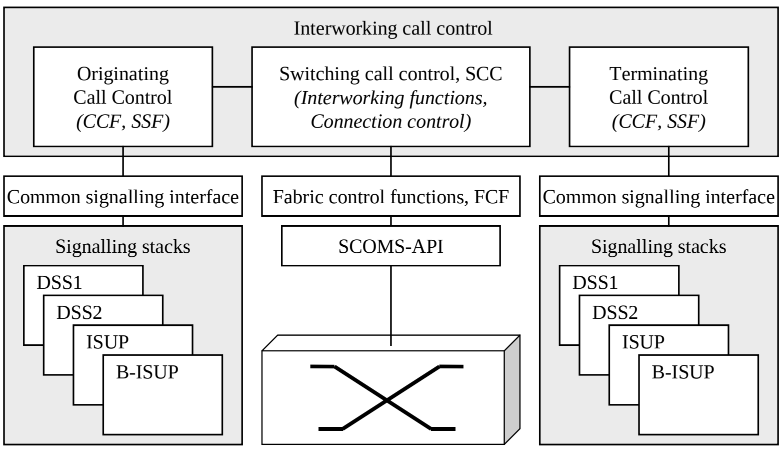

Fig. 1 Signalling software modules.

The signalling stacks (DSS1, DSS2, ISUP and BISUP) function independently below the interworking call control layer. Each stack implements signalling and necessary lower layer protocols. The signalling stacks communicate with the call control application in the CC module via a common signalling interface, named SIGIF. Since the different signalling protocols use the same primitives, it has been possible to develop this common and well-defined interface, primarily based on DSS1.

3 IP and broadband signalling interworking solution

Interworking between IP and a connection-oriented broadband network implies carrying IP packets over a broadband transport media, based on IP routing rather than on pre-configured paths. Since it is desirable to run layer 2 broadband technology at maximum speed, IP route look-up can not be performed at each node inside the broadband network. Instead, packet delivery must utilise layer 2 connection identifiers that represent the routes calculated by an IP routing protocol. The idea of integrating layer 2 and layer 3 functionality has produced several so called multilayer switching solutions [17].

We chose to use MPLS (Multiprotocol Label Switching) [4] as the basis for our IP and ATM interworking implementation. MPLS is a standard-based multilayer switching technology allowing association of IP packet streams with labels and forwarding of the packets with a simple label swapping operation. When using ATM as the link layer technology of an MPLS network, virtual connection identifiers are used as labels. This enables traditional ATM switches to perform routing functions while maintaining the speed of the native ATM technology. MPLS is also an appropriate choice, because the whole SCOMS signalling concept is based on standards, and MPLS is the preferred standard-based technology for carrying IP over ATM-based public networks [12].

Upgrading an ATM switch to an LSR (Label Switching Router) requires implementation of a label switching control component. Typically, the MPLS control component is separate from a forwarding component that handles the packets of user data. The division of components is also typical in other multilayer switching solutions [1]. In SCOMS environment [14, 15], the control component is a software module located in an external control workstation and therefore the distinction is very clear. Both the ATM signalling software and the MPLS control component may be used to control the same physical transmission media, and the virtual channel space is divided between the different technologies. Consequently, two separate logical networks are built over the same physical network.

In an MPLS network, there are two different ways of delivering route information for LSP (Label Switched Path) establishment. One possibility is to utilise an IP routing protocol for delivering the route information, which is further mapped on data link layer [4]. The routing information is considered static rather than dynamic and the LSPs provide best effort QoS. Additionally, an LDP (Label Distribution Protocol) is needed for distributing labels in the MPLS network.

Another possibility for delivering route information is constraint-based routing utilising CR-LDP. It is an extension of LDP and supports creation of explicit paths and LSPs based on constraints such as QoS. It can be considered as an MPLS signalling protocol, because it allows to set up LSPs for special purposes like Voice over IP (VoIP) calls or virtual private networks (VPN) or for maintaining traffic engineering tunnels. CR-LSPs can also be given different priorities [5].

The SCOMS switch is able to function as an edge router in an MPLS network. Ethernet interfaces that are used to connect an access network to a backbone network are controlled by traditional routing software, while the MPLS interfaces are controlled by the MPLS control component. Routing information is read from the routing table of the control workstation. Since the routing protocol is not an integral part of the software, the MPLS control component is independent of it.

The MPLS control architecture differs significantly and is separate from the other SCOMS signalling software architecture (see Fig. 1 and 2). The MPLS control component is implemented as a set of Finite State Machines (FSM) that utilise the services of LDP. FSM architecture, specified in [6], enables merging of several upstream LSPs to one downstream LSP, thus making the solution more scaleable. The number of merged upstream LSPs to one downstream LSP is fully configurable. Thus, the same control component may be used with a non-merge capable LSR as well.

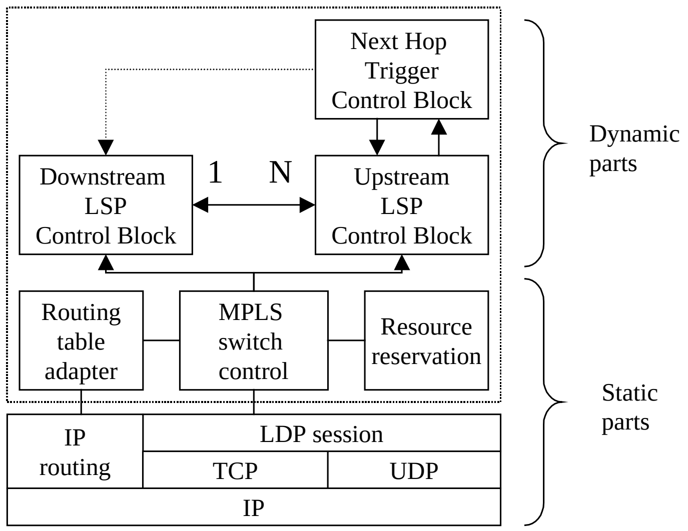

Fig. 2 MPLS control component architecture.

Interworking between MPLS and other networks is an area that has not been well defined in standards. However, the demand for such interoperability exists and grows because new applications that require interworking, such as Voice over MPLS (VoMPLS) [13], have emerged.

Since CR-LDP is considered as a signalling protocol, it can be applied for signalling interworking with other connection-oriented networks. In our solution, CR-LDP is not specified as a separate FSM; instead it is implemented in the form of special information elements, interworking functions and interfaces to the MPLS control component. Connecting the MPLS control component to the ICC module by using a generic interface allows us to interconnect the MPLS network with any other network that is equipped with signalling functionality (see Fig. 3). On the MPLS side, CC is replaced with a control block and SCC maps signalling parameters between it and CC on the other side. Since IP routing is not available in telecommunications networks, the applied routing scheme is chosen based on the type of interconnection. In the interworking situation, the control block (downstream or upstream) is chosen based on the knowledge that the LSR is either an ingress or egress router to that LSP.

Interworking with an MPLS network is meaningful only if the user data is IP traffic or alternatively the data is converted from a stream form to IP and vice versa on hardware. Therefore, it is logical to route the streaming data coming from narrowband circuit switched networks through ATM VCs and IP-based data coming from IP access networks through MPLS LSPs if additional data conversions are not performed.

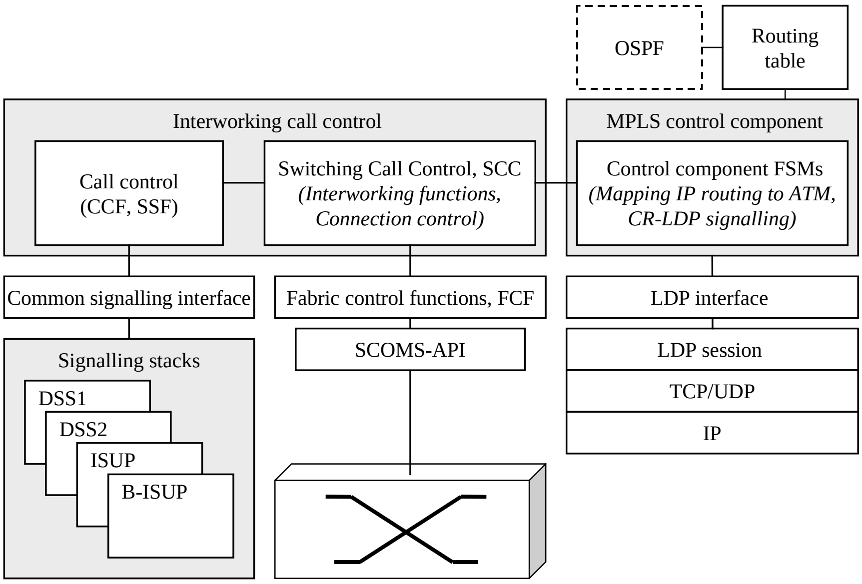

Fig. 3 Interconnection of MPLS control component and ICC.

MPLS does not fully solve the problem of connectionless IP, because it is designed only to be an IP-centric backbone network technology, and CR-LDP is an MPLS-specific signalling protocol. MPLS may be used for interworking between access/narrowband networks and an IP-based broadband network. Since MPLS does not specify signalling for IP access networks or enable interworking between narrowband connection-oriented networks and IP access networks, we need to deploy another IP-oriented technology to enable this. A common IP signalling protocol is needed to enable dynamic connections.

4 IP and narrowband signalling interworking solution

Narrowband networks such as PSTN and ISDN are old-established and based on well matured technologies. Since the effort of introducing a new IP-routing based control scheme (such as MPLS) to these networks is out of question, the meaning of interworking between IP and narrowband networks differs from that of IP and broadband networks. Gateway functions can be used at the edge of a narrowband network to enable interworking. These functions require an IP signalling protocol and additionally mapping between the signalling protocol and the narrowband network signalling.

We chose to use Session Initiation Protocol (SIP) [7] as the IP signalling protocol. SIP is an application-layer control protocol for creating, modifying and terminating sessions with one or more participants. The sessions include Internet multimedia conferences, Internet telephone calls and multimedia distribution. SIP is a quite modular protocol, which defines call signalling, user location and registration services. All supplementary services like QoS, directory access, session description and conference control are allocated in different separate protocols that are orthogonal to SIP. SIP is part of the IETF multimedia data and control architecture currently incorporating protocols such as RSVP (Resource reSerVation Protocol) for network resources reservation, RTP (Real-time Transport Protocol) for transporting real-time data and providing QoS feedback, RTSP (Real-Time Streaming Protocol) for controlling the delivery of streaming media, SAP (Session Announcement Protocol) for advertising multimedia sessions via multicast and SDP (Session Description Protocol) for describing multimedia session features. [7]

Another possibility would have been to use the H.323 protocol suite, but it was considered too complex for this application. H.323 uses hundreds of different elements to define all the required functionality it can have and due to the dependency between components many of the elements may have to used even if they were not needed. As a conclusion, H.323 is not a modular solution that would also work modularly.

One of the modularity issues is related codecs, which are much easier to add and use in SIP compared to H.323. As H.323 requires that each codec has to be centrally registered and standardised, SIP can use any codec. In SIP, codecs are identified as strings and SDP is used to convey the codec information strings between the end points. In this way, any codec can be used as long as it is known at both ends. [8]

While H.323 requires a reliable transport mechanism, SIP can also manage with unreliable transport service, i.e. it uses UDP (User Datagram Protocol) or TCP (Transmission Control Protocol). Basically, SIP can use any transport mechanism that is able to offer byte stream or datagram service without the need to have changes to SIP. SIP related protocols like RSVP and RTP usually use UDP service (see Fig. 4).

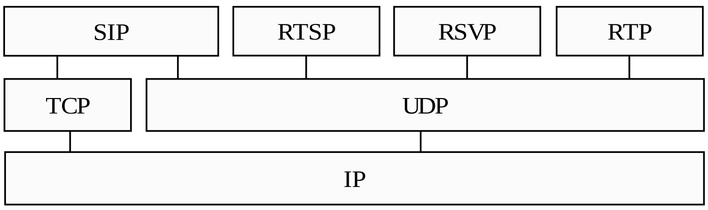

Fig. 4 Protocol suite in SIP applications.

In our solution, the SCOMS switch is designed to be a SIP gateway [7]. The SIP gateway sets up and terminates connections between IP and the other network and it handles resource allocation and other required capabilities for the other network. This assigns the requirements for the switch to handle SIP user agent client and server functions. Location server is out of the scope; instead it is assumed that the actual location server is available somewhere. The SCOMS switch has to know where the location server is to query end-user locations.

A typical interworking situation occurs between SIP and PSTN (see Fig. 5). The interworking functions of SCOMS software allow interworking also with ISDN and ATM networks. Interworking between SIP and CR-LDP implies the use of SIP for signalling in the access network and CR-LDP for resource reservation in the backbone network.

SIP works on the top of UDP and uses SDP to form session descriptions that identify the multimedia traffic being transported. SCC is responsible for converting SIP messages into common signalling messages that CC uses with the content, i.e. information elements, for ISUP protocol. When the incoming network is IP and the outgoing is PSTN, SCC receives parsed SIP message, calls FCF for media gateway functions, forms the corresponding ISUP message and sends it to CC on the PSTN side. In the opposite direction, the functions are executed in the reverse order.

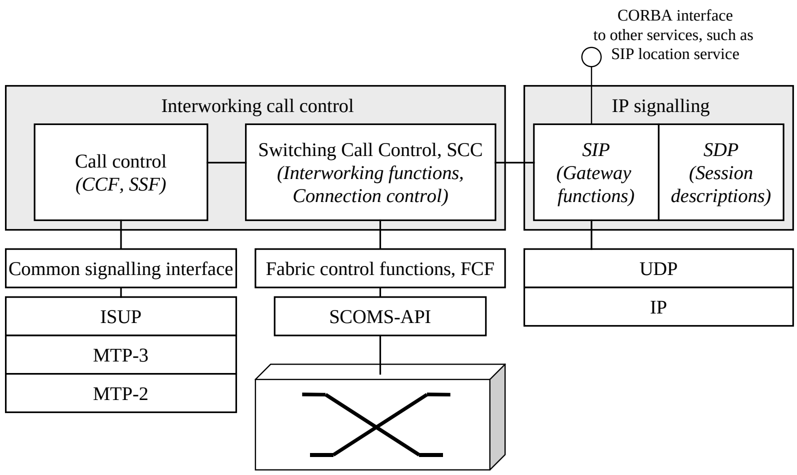

Fig. 5 Block diagram for IP signalling interworking.

FCF manages the media gateway control functions. FCF can be replaced with any functions to handle different switching devices, e.g. with MGCP (Media Gateway Control Protocol) or SGCP (Simple Gateway Controlling Protocol). FCF includes functions to command the switch to decode multimedia traffic coming from one network and encode it for the other network. The coding scheme for IP network is selected by the session description.

5 Conclusions

New multimedia services along with the convergence of existing telecommunications networks are pushing the development towards heterogeneous networking. This implies the need for network nodes capable of interworking with different networking technologies. In order to have real interworking, various kinds of call and connection control information as well as network status information have to be exchanged between the interworking networks. Signalling is used to convey that information and thus signalling interworking can be considered as the key element in the process of network convergence.

In this paper, we have introduced a signalling interworking solution to integrate IP routing with circuit and cell switched networking. Previously, we have developed a system that integrates circuit and cell switching into a single switching fabric. The switching fabric operates as a PSTN, ISDN and ATM switch allowing interworking between the supported networks. The implemented signalling interworking solution is based on the IN concept and ITU-T standards.

IP routing and IP interworking with circuit and cell based networks have been added to the switching system. The interworking solution was not as straightforward as it was between circuit and cell switched networks due to the differences between the involved networking technologies. We chose to use an MPLS approach in implementing IP interworking with ATM and a SIP based approach in implementing IP interworking with PSTN and narrowband ISDN.

MPLS creates a bridge between IP and ATM by mapping IP routing to the link level. Displacing the traditional ATM Forum and ITU-T control models with an IP-centric control module enables transfer of IP traffic through a backbone network in the same way as in connectionless packet networks. The connection-oriented nature of ATM is exploited by offering QoS paths through the network for special purposes.

SIP provides the means to implement a gateway from IP network to a connection-oriented narrowband network. Mapping between IP signalling and other network signalling is essential to enable interoperability, because the control mechanisms of the connection-oriented network can not be altered. Additionally, it is possible to use the SIP gateway for MPLS backbone access when the data can be delivered in IP form through QoS paths.

When implementing new IP-centric technologies, one design goal should be QoS based on both fine-grained integrated-services (Int-Serv) and coarse-grained differentiated services (Diff-Serv) technologies. The developed MPLS implementation supports the Int-Serv type of QoS, but the scalability of the solution is questionable, because the users are allowed to establish connections through the network for individual calls and application flows. Diff-Serv would ease the scalability problem, because it is based on traffic or service characterisation instead of maintaining per-flow path reservation through the network. To enable Diff-Serv, the functionality for mapping Behaviour Aggregate (BA) classes to LSPs would be needed.

Another important scalability feature is related to efficient use of the available network resources. A convenient solution would be the use of a routing protocol capable of observing the bandwidth usage, such as OSPF with traffic engineering extensions. This would not require notable changes to the MPLS implementation. The future work will include the study of IP-based service characteristics and advanced IP QoS features. The MPLS solution can be enhanced to offer other valuable services and functions, such as VPNs and traffic engineering.

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