A SIGNALLING INTERWORKING SOLUTION FOR HETEROGENEOUS NETWORKING

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ABSTRACT

IP based networking is seen to take the major role in the ongoing network and service converge process. However, a number of other networking solutions exist and it is anticipated that the future services will be carried to users over a diverse set of networks. This implies the need for interworking between the different network concepts and especially interworking between different signalling systems.

This paper introduces a signalling interworking solution that integrates IP routing with cell and circuit switching. A previously developed multiprotocol switching platform, which integrates PSTN, ISDN and ATM switching, has been expanded to include IP routing as well. Interworking between IP and ATM networks is based on an MPLS approach and a SIP based solution is used in implementing IP interworking with PSTN and narrowband ISDN. MPLS is used in creating a bridge between IP and ATM networks by mapping IP routing to the link level MPLS labels. In the narrowband solution, SIP is used to provide the means to implement a gateway from an IP network to a connection-oriented narrowband network.

KEYWORDS

routing, signalling, interworking, connection control, network convergence

1 INTRODUCTION

The conventional circuit and packet switched networks have offered network specific services to end-users, and networking concepts (such as ISDN and B-ISDN) 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 the 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 [1, 2, 3, 4, 5]. Interworking between packet and circuit based networks is a bit different thing. In the packet switched networks, such as IP networks, no paths are established between the communicating end-points and signalling in the sense used in the 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 [6, 7], i.e., between N-ISDN and B-ISDN, and this platform is further developed to include interworking with IP networks. The physical platform is based on the SCOMS

(Software Configurable Multidiscipline Switch) switching concept [8]. 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 [7]. 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.

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, residing 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.

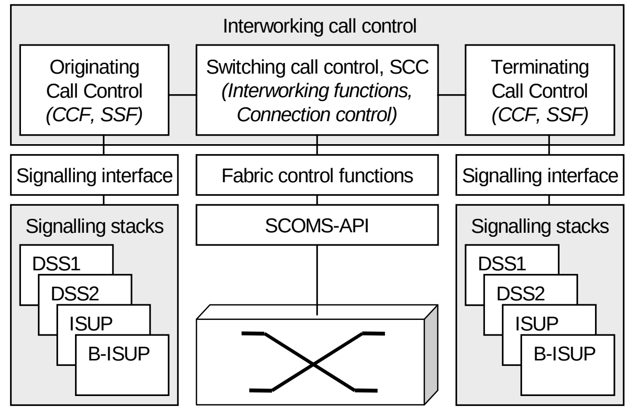

Fig. 1 Signalling software modules.

3 IP AND BROADBAND SIGNALLING INTERWORKING SOLUTION

Interworking between the IP and a connection-oriented broadband network implies carrying IP packets over a broadband transport media employing IP routing rather than pre-configured paths. Since it is desirable to run layer 2 broadband technology at maximum speed, IP route look-up cannot 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 multi-layer switching solutions [9].

We chose to use MPLS (Multiprotocol Label Switching) [10] as the basis for our IP and ATM interworking implementation. MPLS is a standard-based multi-layer switching technology allowing association of IP packet streams with labels and forwarding of the packets with a simple label swapping operation. When applying ATM as the link layer technology in an MPLS network, virtual connection identifiers are used as labels. This allows traditional ATM switches to perform routing functions while maintaining the speed of the native ATM technology. Since the whole SCOMS signalling concept is based on standards, MPLS is a natural choice, because it is the preferred standard-based technology for carrying IP over ATM-based public networks [11].

Upgrading an ATM switch to an LSR (Label Switching Router) requires the implementation of a label switch control component. Typically, the MPLS control component is separate from a forwarding component that handles the packets of user data. Separate control and forwarding components are also typical in other multi-layer switching solutions [12]. In SCOMS environment [6, 8], 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 for controlling the common 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 distributing the route information, which is further mapped on data link layer [10]. 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 routing 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 VoIP (Voice over IP) calls or VPNs (Virtual Private Networks) or for maintaining traffic engineering tunnels. CR-LSPs can also be given different priorities [13].

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 operating system. Thus, any routing protocol that is able to maintain the routing table may be run on the workstation.

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 [14], 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.

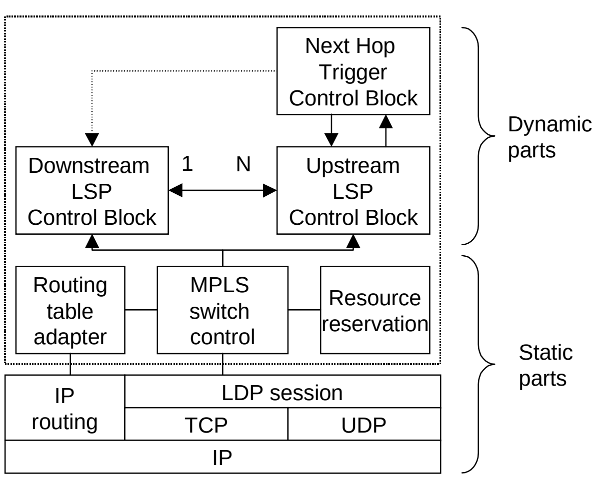

Fig. 2   MPLS control component architecture.

Interworking between an MPLS network 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 VoMPLS (Voice over MPLS) [15], have emerged.

Since CR-LDP is considered to be a signalling protocol, it can be applied for signalling interworking with 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. SCC converts message sequences and signalling parameters between MPLS and the other side CC. Since IP routing is not available in the conventional 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 involved.

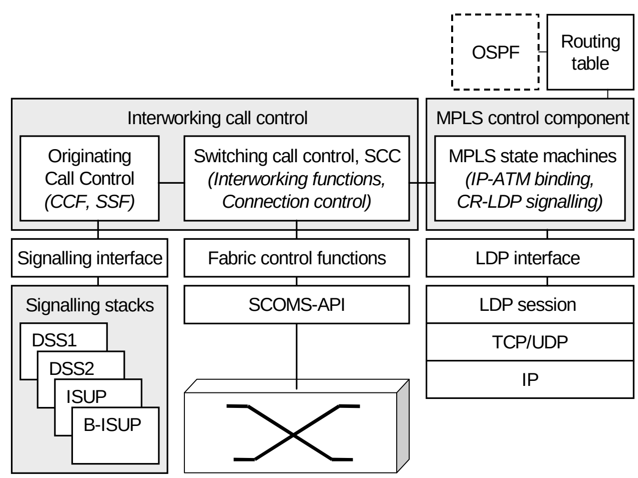

Fig. 3   Interconnection of MPLS control component and ICC.

MPLS does not fully solve the problem of connectionless IP, because it is designed to be an IP-centric backbone network technology, and CR-LDP is an MPLS-specific signalling protocol. MPLS may be used for interconnecting an IP-based broadband network to IP-based access networks or to connection-oriented narrowband networks. Since MPLS does not specify signalling for IP access networks or enable interworking between narrow-band connection-oriented networks and IP access networks, we need to deploy another IP-oriented technology to do this. A common IP signalling protocol is needed for 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, however, 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) [16] 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 resource 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. [16]

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 to codecs, which are much easier to add and use in SIP than in H.323 based solutions. 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 supported at both ends. [17]

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 for changes to SIP. SIP related protocols, e.g. RSVP and RTP, normally use UDP service (see Fig. 4).

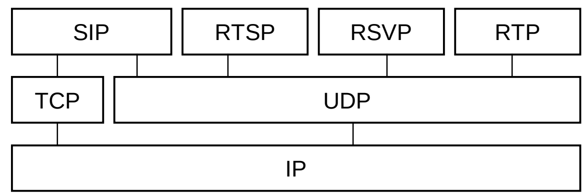

Fig. 4 Protocol suite in SIP applications.

In our solution, the SCOMS switch is designed to be a SIP gateway [16]. The SIP gateway sets up and terminates connections between IP and the other network and it handles resource allocation and additional required capabilities of the other network. This assigns the requirements for the switch to handle SIP user agent client and server functions. The location server is out of the scope; instead it is assumed that the actual location server is available somewhere in the network. This means that 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 the 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 carried. SCC is responsible for converting SIP messages into common signalling messages that CC uses with the content of the other side. For example, in the case of PSTN, SIP parameters are converted to information elements that correspond to ISUP parameters. When the source network is IP-based and the destination is PSTN, SCC receives a 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.

The FCF module manages the media gateway control functions. It 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 in the session description. FCF can be replaced with any functions, e.g. with MGCP (Media Gateway Control Protocol) or SGCP (Simple Gateway Controlling Protocol), to handle different switching devices.

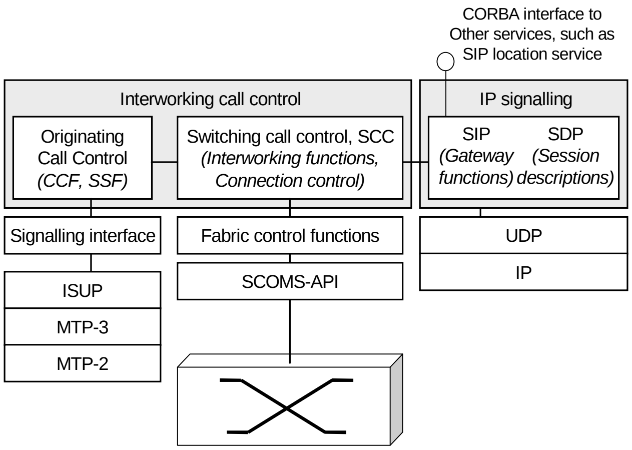

Fig. 5 Block diagram for IP signalling interworking.

5 CONCLUSIONS

The 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 is used to create 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 an IP network to a connection-oriented narrowband network. Mapping between the IP signalling and the signalling scheme of the other network is essential in providing interoperability, because the control mechanisms of the connection-oriented networks cannot be altered. Additionally, it is possible to use the SIP gateway to interconnect an access network to an MPLS backbone. This allows to open paths for IP streams through the backbone network, possibly with the utilisation of special QoS characteristics.

When implementing new IP-centric technologies, one design goal should be QoS based on both the 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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