INTERWORKING SUPPORT IN A MULTI-DISCIPLINE SWITCH

K. P. T. Raatikainen

VTT Information Technology, Telecommunications

P.O.Box 1202, FIN-02044 VTT, Finland

pertti.raatikainen@vtt.fi

Abstract The evolving multimedia services are foreseen to be delivered to customers over heterogeneous transport networks. The ATM technology has been considered as the most obvious choice, but other transporting concepts have also been studied and entirely new ones suggested, especially, for IP based communications. Diversity in transporting concepts implies that network nodes, such as switches and routers, should connect to different kinds of networks. This introduces the need to support multiple switching disciplines in a single switching fabric and, additionally, a clear need for interworking. As a solution to the emerging problem, this paper introduces the concept of multidiscipline switching to integrate different switching systems into a compact fabric and to offer interworking between the connected networks.

Keywords: Switching, Interworking, Multimedia, Call Control

1. INTRODUCTION

Transport networks for delivery of future multimedia services are foreseen to be based on heterogeneous transport and switching technologies. Relevant alternatives include, e.g., ATM (Asynchronous Transfer Mode), conventional PSTN (Public Switched Telephone Network), various IP (Internet Protocol) based concepts and new label switching concepts. ATM is a mature concept, capable of offering support for a large variety of services, and has often been envisaged as a unifying transmission and switching technology. Today it is mainly a trunk network solution, but is expanding also to the access network side. This is based on the new access technologies, such as the various Digital Subscriber Loop (DSL) concepts aimed at extending usage of the traditional copper based local loops that can offer high bit rate ATM connections to residential users.

CATV network operators are introducing different cable modem solutions for interactive service delivery. Although standardisation is not settled,

estimates for usage of CATV networks for multimedia delivery are expected to show quite high growth rates in the very near future [1]. The conventional telecommunications network has a stable position and it can be envisioned to hold this position for quite a many years and will be used for delivering most varying set of services. This is even more obvious when taking ISDN into consideration. The narrow-band ISDN, especially, is becoming more and more popular for private access.

An interesting ongoing trend is the rapid growth of Internet which has boosted popularity of the TCP/IP (Transport Control Protocol/Internet Protocol) protocol suite. The IP based data networks are foreseen to continue growing and the need for IP routing and switching increases. Consequently, a number of concepts to carry IP traffic have been suggested. Transmission of IP over ATM has been a standardisation target [2, 7] and has inspired vendors to develop competing solutions, e.g., IP switching, IP/ATM, ARIS and Tag switching [7, 8]. IETF has started to develop a harmonising concept to be called Multi-Protocol Label Switching (MPLS) and, additionally, has founded a working group to study service differentiation mechanisms to accelerate routing and switching of IP packets [6, 14]. Progress of these techniques is in the early stage, but great expectations are placed on them.

IP over ATM introduces unnecessary overhead and duplication of functionality [14] lowering the available payload bandwidth [1]. As a result, other transport concepts have been proposed. Examples are concepts that convey IP traffic directly in physical level transport frames, e.g., in SDH/ SONET (Synchronous Digital Hierarchy/Synchronous Optical Network) [6] frames. Concepts called IP over photons are also under intense research [5].

Referring to the above, it can be concluded that in the near future the numerous multimedia services will be offered to users over a diverse set of networks, deploying different transport and switching technologies. Due to this, there will be an increasing need for equipment capable of supporting multiple switching schemes and offering interworking between the different networks. This paper introduces a multidiscipline switching concept to support switching and routing of multimedia traffic carried over heterogeneous networks while offering interworking between the dissimilar networks. Chapter 2 presents the concept of multidiscipline switching highlighting the major implementation issues related to interworking. Chapter 3 introduces an experimental switching solution to offer interworking between circuit switched PSTN, packet switched IP and cell switched ATM networks. Chapter 4 has the concluding remarks.

2. MULTIDISCIPLINE SWITCHING

A conventional telecommunications switch connects to a homogeneous transport network while a multidiscipline switch operates in a heterogeneous network environment. Therefore, a multidiscipline switch connects to different kinds of networks and has to support parallel switching concepts. In order to cope with different switching disciplines, the switch must have a common way to route the dissimilar data units through the switching fabric and implement sophisticated software solutions to manage connections and the physical fabric.

2.1 Switching Bus

The switching bus often implements special containers (internal to the switch) to convey the different size data units (coming from the dissimilar networks) through the physical bus (see Fig. 1). In order to share its capacity between the supported systems, the switch can have a separate routing and switching mechanisms for each transport system or, alternatively, a common mechanism for all systems. Depending on the selected solution, the switching resources are shared either permanently or dynamically between the connected systems. Interworking is performed on a higher level, so the bus itself does not need to know about possible interworking needs. The problem of allocating switching capacity for the parallel switching schemes and dimensioning of a ring shaped switching bus is discussed in [3, 4, 13].

2.2 Network Interfaces

Since a multidiscipline switch interfaces to different sorts of networks, it has to implement a diverse set of line interfaces. The main function of a line interface is to adapt the switch to an external network and convert incoming data streams to the form accepted by the switch.

Since the physical switching bus does not normally include much intelligence, the interfaces should be equipped with capabilities to support interworking. The switch can also include units that perform specialised interworking functions, such as audio and video coding conversions and synchronisation of service data streams. Provided that the data to be switched do not require any data conversions, necessary interworking functions can be implemented in the line interfaces. In this elementary case, interworking functions include processing of incoming data units to the form accepted by the receiving network. An example is the case when a conventional 64 kbps PDH channel is converted into an ATM channel. The PDH line-card collects time-slots of individual channels to assemble AAL packets and then ATM cells. These are further encapsulated into ATM containers, internal to the switch, for passing them through the switching bus. In the opposite direction, a

similar process can take place in the ATM interface or ATM cells are directly routed to the PDH interface which performs the relevant interworking functions. This means that either both or just the other one of the interworking interfaces must be able to process the switch specific ATM and PDH containers.

Figure 1 A multidiscipline switch supporting three different transport systems.

If manipulation of the incoming data is required, special units are implemented to perform the necessary processing. The input line interface directs the received data first to the special processing unit which later sends the processed data to the destination interface. An example of such a case is a voice over IP application where one of the communicating parties is connected to an IP network and the other to a PSTN network. Voice in the 64 kbps PDH channel is PCM coded using ITU-T standardised A- or μ -law. In the IP network, the voice coding can be based on ITU-T's H.323 recommendation. Now, interworking means despite processing of data units to fit into the form of the other network also the relevant voice coding conversion.

2.3 Switch and Connection Control

Due to the different nature of the associated transport technologies, their signalling and connection control procedures, connection types and quality of service (QoS) measures may deploy entirely different control disciplines. Therefore, a multidiscipline switch must combine several control and service architectures into a compact control system. Each architecture requires its own set of protocols and thus a straightforward solution is to implement the protocols (of each virtual switch) separately. In this way, each protocol stack

and associated call control functions work as if they were run on top of a physical switch of that particular network architecture.

Interworking between the connected systems can be accomplished by implementing a common call control application which is placed on top of the control stacks. A general control block is needed to manage resources of the physical switch (e.g. configuration of the switch), convert application level connection commands to physical connections and perform physical level routing of the data units.

3. AN EXPERIMENTAL SWITCH

An experimental multidiscipline switch SCOMS (Software Configurable Multidiscipline Switch) is being developed at VTT Information Technology and Helsinki University of Technology. It integrates (64 kbps PDH) time-slot, (ATM) cell and (IP) packet switching into a single fabric. The switching platform comprises the switching bus, interfaces to connect the switch to trunk and access networks and the switch control unit (see Fig. 2). Additionally, special plug-in-units can be implemented to perform coding and alike interworking functions.

3.1 Switching Bus

The physical switching platform is based on the Frame Synchronized Ring (FSR) concept [10], developed and patented by VTT Information Technology. This platform has characteristics necessary to implement the various fundamental features of a multidiscipline switch, e.g., inherent support for real-time multicasting, flexible addressing capabilities and support for simultaneous switching of different size data units.

Basically, FSR is a slotted ring consisting of nodes connected together with unidirectional point-to-point links. Due its sophisticated MAC (Medium Access Control) and the use of destination release policy, FSR supports spatial reuse of the switching bus enabling multiple simultaneous connections. Data is conveyed through the bus in fixed size containers that can be dimensioned individually. This allows implementation of multiple virtual switches into a single fabric. FRS's performance has been analysed, e.g., in [9] and [10], and compared to other interconnection networks in [11]. A bridging solution, utilising FSR as the backbone technology for delivering multimedia services, is introduced in [12]. Dimensioning of the FSR bus in multidiscipline applications has been analysed in [3] and [13].

On the physical level, each "virtual switch" occupies selected FSR nodes which are equipped with associated line-cards. Individual FSR nodes can be configured freely to support either of the three switching schemes. Switch

configuration can be changed dynamically by replacing a line-card by another type of line-card and modifying configuration registers in the switch control unit.

3.2 Containers for Data Unit Switching

Since the data units, i.e., time-slots, cells and packets, are of different size, special containers are assigned for each traffic type. In the PDH networks, the basic unit of data is an 8-bit byte and time-slot switching refers here to switching of these 8-bit bytes. A PDH container is fixed to convey 16 time-slots (belonging to an individual 64 kbps connection) at a time. The payload size of 16 octets keeps the container's assembly delay low enough to guarantee required delay performance of conventional digital PSTN traffic.

Switching of ATM traffic is supported by another container size that can hold exactly one cell at a time. Bit rates and quality measures of individual ATM connections may differ from each other and even the bit rate of a single connection may vary with time. Thus, the nature of cell switching differs greatly from time-slot switching and it was justifiable to assign separate containers for the PDH and ATM traffic.

In IP networks, the packet lengths vary from a few dozens of octets to 64k octets and to manage with the long and varying packet sizes, the IP packets must be segmented into mini-packets. These are the data units to be encapsulated into IP containers. Since IP traffic is bursty in nature, the process of switching IP packets resembles that of ATM cells. However, manipulation of IP packets differs greatly from manipulation of cells.

Routing of the PDH, ATM and IP containers through the switch is based on FSR's internal addressing mechanism. In a line interface, the PDH channel numbers, ATM channel identifiers or IP destination addresses are mapped to FSR addresses. These are further used inside the switch to route the containers from the source interface to the destination one. In the destination interface, the containers are disassembled and the received time-slots, cells or packets are reassembled and directed onto the outbound line.

3.3 Interworking and Network Interfaces

Each of the three virtual switches are equipped with associated line-cards to have connections to the trunk and access networks as shown in Fig. 2. ATM traffic is carried over STM-1 links in the trunk network and over E1 or ADSL (Asynchronous Digital Subscriber Line) links on the access network side. The PDH virtual switch is equipped with (2 Mbps) E1-cards to connect both to the access and trunk networks. The narrow-band ISDN and nx64 kbps cards are

used to offer additional links to customers. IP traffic is carried over STM-1 links in the trunk network and over Ethernet links on the access network side.

Figure 2 Block diagram of an experimental multidiscipline switch with interworking capabilities.

Since each of the three virtual switches has its own container type, interworking between the connected systems on the switching bus level is not possible. Conversion from any incoming system to any other outgoing system has to be performed on the line interface level. If heavier processing is needed, interworking units designed for specific service applications are attached to the switch. In Fig. 2 the switch is equipped with interworking units which allow voice connections between PDH and IP as well as between ATM and IP networks. All interworking voice connections are directed first to the associated interworking units and then to the destination line-cards.

3.4 Switch Control

Operation of the switch is controlled by a workstation which for the moment implements call control and physical fabric control functions. The control workstation is connected to the switch with an ATM/STM-1 link, and all protocols receive and transmit their signalling messages in reserved ATM virtual channels. Therefore, a non-ATM line interface must map the incoming signalling messages to a specific ATM virtual channel, assigned for transferring the signalling to the control workstation. ATM/STM-1 was chosen for the workstation connection, because it is a cost-effective way to have a high-speed signalling link which offers a straightforward way to

manage various control and signalling connections. An Ethernet interface would be another alternative to connect the workstation to the switch.

Since the switch implements three totally separate and incompatible switching schemes, the call control block includes separate signalling software packages for each system (see Fig. 3). If interworking capabilities were not implemented, calls originating from the PDH network must terminate at the PDH interfaces. Likewise ATM connections could be set up only between the ATM interfaces and IP connections between the IP interfaces.

Figure 3 Interworking call control architecture.

Interworking between the different networks is performed by a shared interworking call control layer. Since the originating and terminating ends of the connections may reside in different kinds of networks, the call control layer decodes, processes and forwards connection setup requests from each protocol stack. The call control interworking function maps the connection setup parameters between the different networks and maintains status information of all the established connections.

At the bottom layer, all protocol stacks use services of the common fabric control layer. The fabric control layer offers network specific Application Programming Interfaces (APIs) that implement functions necessary to reserve switching resources and manage connections through the physical switch.

4. CONCLUSIONS

Diversity in networking technologies and lack of a unifying transport solution is leading to a situation that evolving multimedia services will be delivered to users over a diverge set of networks. The ATM technology has been envisaged to become the prevailing technology due to its flexibility. However, ATM faces unavoidable transmission overhead which leads to inefficient use of transport capacity. Thus, other transport and switching concepts have also been considered. Obviously, there will be several alternatives to carry multimedia services which implies that switching nodes will

connect to networks that utilise different transport and switching technologies. Due to this, there will be an increasing need for equipment capable of supporting multiple switching schemes and offering interworking between the different networks.

In this article, a multidiscipline switching concept SCOMS is introduced as a compact solution to tackle with the incompatible transport and switching systems. The benefit from multidiscipline switching is to share the physical switching resource between different networks. Additionally, more complex services can be implemented if interworking between the different networks is supported. A generic solution, housing two or more virtual switches in a compact unit, would effectively cut down installation and maintenance costs of the future broadband networks.

Implementation of several switching schemes into a single fabric poses a number of demanding research and development topics. Problems to be solved include, e.g., switching of different size data units, non-compliant call control and signalling methods, varying buffering needs and different QoS requirements. Innovations, related to distributed switching and separation of physical fabric control from call connection and service control, enable development of such a switching equipment.

An experimental switching solution integrating 64 kbps based circuit, ATM cell and IP packet switching with interworking capabilities is presented. The physical switching platform is based on the Frame Synchronized Ring (FSR) concept. FSR's ring-shaped switching bus is dimensioned to perform effectively by implementing separate transport containers (internal to the switch) for circuit, cell and packet switching. Control of the switch applies multi-layered control architecture, dividing the control functions into fabric, network and service control layers. Signalling protocols of the different networks are implemented separately, although, they use services of the common fabric control layer. Interworking between the networks is supported by a shared interworking call control module that is able to manage calls that originate and terminate at different sorts of networks.

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