INSIGNIA: A Pan-European Trial for the Intelligent Broadband Network Architecture

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ABSTRACT This article summarizes the work carried out within the ACTS project INSIGNIA, which is targeted at the provision of interactive multimedia services through IN and B-ISDN integration. The basic concepts regarding the integrated approach are discussed with emphasis on the functional architecture. This discussion is followed by a presentation of IN multimedia services which were created based on these principles. An overview of the real-life trials which were conducted on a pan-European basis in order to evaluate the INSIGNIA services is also given. The results of this evaluation are examined from a variety of viewpoints, including functional architecture, user and network equipment, service logic programs and applications, as well as user acceptance and network performance.

The provision of multimedia services on a universal basis in a cost effective way is a challenging task for telecommunication networks in the near future. The technological components are already available: both desktop applications and transport technologies are mature enough to provide amazing multimedia services in specific contexts such as local area networks. The challenge is how to provide these services with no constraints in space and time at a reasonable cost. The Internet is now really universal, but the support of broadband multimedia channels with the desired quality is still an open issue. The deployment of public ATM networks which can also offer broadband ISDN (B-ISDN) access still seems an interesting option. One of the major arguments against the B-ISDN architecture is the complexity of protocols to provide multimedia services as network services. The length of the standardization process is another heavy burden. The intelligent network (IN) architecture, which is successfully used in the public switched telephone network (PSTN) and narrowband ISDN (N-ISDN), can complement the B-ISDN, providing a higher degree of flexibility to build services over components and simplifying the standardization process. The ACTS project INSIGNIA (IN and B-ISDN Signaling Integration on ATM Platforms) has investigated the integration of IN and B-ISDN, proposing a complete architectural solution which has been validated by field trials over a pan-European ATM network. Only already standardized B-ISDN protocols have been taken into account, which makes the introduction of this architecture in the real world in the near term quite realistic. This article presents the main results of the INSIGNIA project.

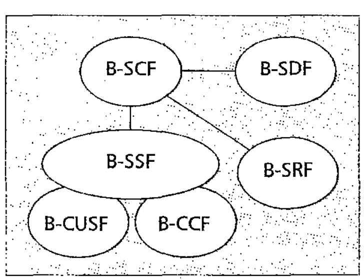


Figure 1. *Broadband IN functional architecture.*

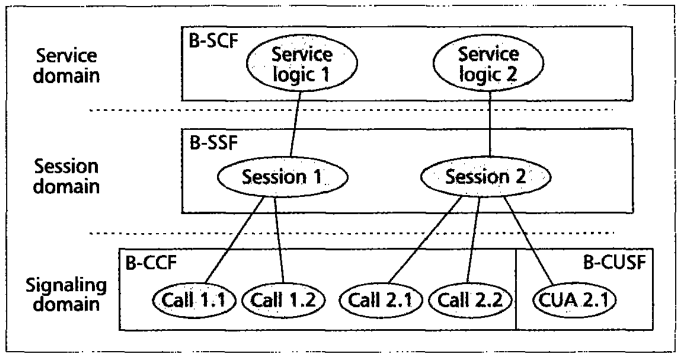
The integration of IN concepts into the B-ISDN architecture proved to be an effective approach to support of multimedia services. On one hand, B-ISDN "alone" can provide end-to-end ATM switched virtual channels (SVCs) to effectively meet the QoS requirements of multimedia applications running in a geographical area context. On the other hand, the specific benefits of IN/B-ISDN integration can be found at both the network and service levels. At the network level, the main advantage is that a general mechanism to coordinate several basic calls within a single control vision is provided by the IN. This mechanism is a valid alternative to the enhancements of B-ISDN control procedures and signaling protocols to support complex call configurations directly in the B-ISDN. The IN functionality complements and enhances the B-ISDN control functionality to provide additional services with no need to define dedicated ad hoc protocols. As far as the service level is concerned, integration with the IN definitely improves and shortens the process of service creation in broadband networks. The advantages of IN architecture in terms of flexibility and customization are well recognized in narrowband networks. These capabilities will prove even more important in a broadband environment. Not only are the services more complex, but the pace at which new services are envisaged and must be supported by the network is higher. The IN approach can guarantee efficient service creation and personalization capabilities in order to let network operators meet customer needs for broadband multimedia services.

In the next section an overview of the architectural model is given, in order to understand the basic concepts in the integration of IN and B-ISDN. The main focus of this article is on description of the practical achievements. We then describe the three multimedia services which have been developed. The fourth section concentrates on the real-life demonstration analyzing the trial architecture and the network and user equipment which have been deployed in the project.

THE INSIGNIA FUNCTIONAL MODEL

The functional architecture developed by INSIGNIA represents an extension of the IN functional architecture (Fig. 1) [1, 2]. The broadband service control function (B-SCF) contains the logic and processing capability required to handle IN-provided services, and is physically mapped in the broadband service control point (B-SCP). The broadband service switching function (B-SSF) will perform mapping between the events in the underlying B-ISDN network and service control. As in traditional IN architecture, the main role of the broadband specialized resource function (B-SRF) is to allow in-band interaction of the end user with the IN service logic. The B-SRF will support multimedia interactions and cooperate with the B-SCF to provide the broadband IN services. The physical entity which maps the B-SRF functional entity is the broadband intelligent peripheral (B-IP). The broadband call control function (B-CCF) models the activity of the B-ISDN network for the establishment of the calls/connections, while the broadband call-unrelated control function (B-CUSF) takes care of the call-unrelated signaling associations which allow out-channel interaction between user terminal and IN service logic. The B-SSF, B-CCF, and B-CUSF are mapped in a single physical entity, the broadband service switching point (B-SSP).

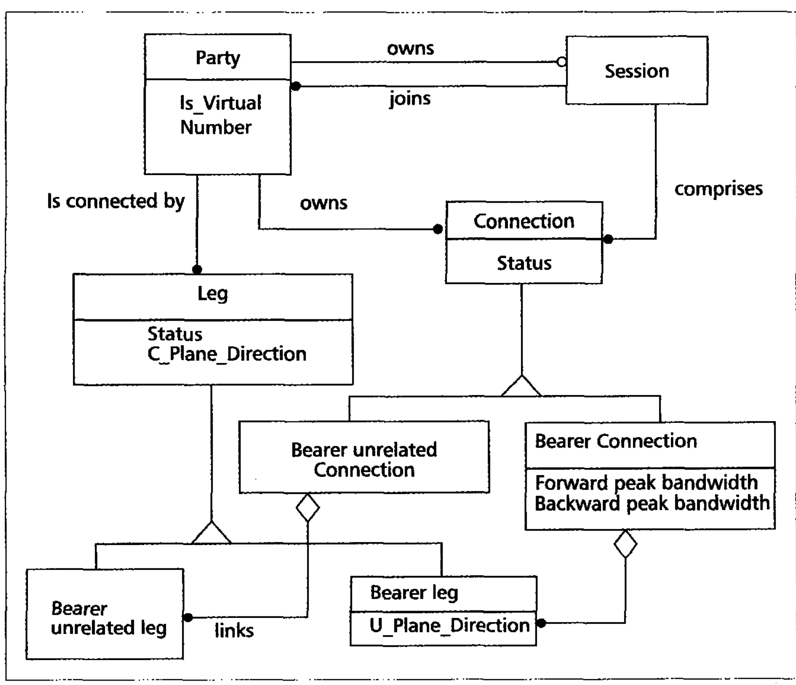
In the context of the integrated IN/B-ISDN approach, three control domains have been envisaged. In the *service control domain* overall control of IN services is carried out by the service logic programs in the B-SCF. The *session control domain* is introduced in the INSIGNIA architecture. The management of a set of basic calls and call-unrelated associations to provide a suitable topology for the realization of a given IN service is performed in this domain. In particular, the *session state model* is handled at the B-SSF level and represents the capabilities that can be offered by the network to control service logic [3]. Finally, the *signaling control domain* includes the B-ISDN functionality and its interaction with the IN architecture. It includes the B-CCF and B-CUSF. In Fig. 2 the relationships between the entities in the different domains are shown. It can be noticed how a single session object provides the service logic with a unified view of a set of calls and call-unrelated associations.



■ **Figure 2.** *Relationships among the different domains.*

The role of the IN has been extended far beyond traditional support of supplementary services. In the INSIGNIA architecture the IN service logic manipulates the topology of calls/connections needed to provide a service instance, instructs the network to realize this configuration, and controls the status of the different connections. The session model in the B-SSF and the SCP-initiated call setup capability in the B-CCF are the main tools for this kind of sophisticated IN control of network resources.

The session model represents a complex configuration of call/connections and call-unrelated associations, as perceived by the IN. This object-oriented model gives a common view shared between the B-SSF and B-SCF of the underlying network activities. The class diagram is shown in Fig. 3. The *party* objects represent the users and the virtual party SCP. The *bearer connection* objects represent the B-ISDN transport connections, while the *bearer unrelated connections* represent the call-unrelated signaling associations. The relationship between the parties and connections is reflected in the model by the *leg* objects.



■ **Figure 3.** *Session object model.*

The set of information flows (Table 1) on the B SSF/B SCF interface is based on this model: the B SCF can request to create or remove objects (i.e., parties, connections), and the B SSF will report any information in terms of object states.

A *service request* is sent by the B-SSF to the B-SCF to invoke an IN service, typically as a consequence of a trigger coming from call processing. An instance of the session is created in the SSF. *Request report SSM change* allows the B-SCF to request a report of a given object status. For example, it allows monitoring of when a connection has been successfully set up or released. The B-SSF will send a *Report SSM change* when the monitored status is encountered. The set of information flows numbered 5–11 in Table 1 allow the SCF to build and tear down the required connection topology, sending the requests to the SSF in terms of session objects. For example, *Add bearer to session* can be used to request the setup of a call/connection between two parties which are indicated as parameters in the information flow. The last three information flows in Table 1 are used to support out-channel user

	Information flow	Direction
1	Service request	B-SSF → B-SCF
2	Request report SSM change	B-SCF → B-SSF
3	Report SSM change	B-SSF → B-SCF
4	Continue	B-SCF → B-SSF
5	Join party to session and link leg to bearer	B-SCF → B-SSF
6	Add bearer to session	B-SCF → B-SSF
7	Add parties and bearer to session	B-SCF → B-SSF
8	Join party and bearer to session	B-SCF → B-SSF
9	Release Session	B-SCF → B-SSF
10	Release Connection	B-SCF → B-SSF
11	Drop party	B-SCF → B-SSF
12	SendSTUI	B-SCF → B-SSF
13	RequestReportUTSI	B-SCF → B-SSF
14	ReportUTSI	B-SSF → B-SCF

Table 1. *Information flows on the B-SSF/B-CCF interface.*

service interaction (USI) by means of the bearer unrelated connection objects. A detailed description of the information flows can be found in [3].

The B-SSF maps the session related requests of the B-SCF into requests for the B-ISDN network in terms of basic call/connection events on interfaces with the B-CCF and B-CUSF. A suitable call modeling derived from traditional IN has been defined, adapting the basic call and call-unrelated state models (BCSM and BCUSM) to the broadband context.

The main enhancement in B-CCF functionality is the SCP-initiated call setup feature, which allows the IN service logic to establish the required user plane connections. To realize the SCP-initiated call only the internal behavior of the B-CCF is enhanced. The standardized signaling protocols are reused, allowing the user equipment to be unmodified.

Services for Demonstration During the INSIGNIA Trials

Within the INSIGNIA project, a set of broadband multimedia services was selected in order to practically demonstrate the advantages resulting from the proposed IN architecture. More specifically, the multimedia aspects are highlighted by two interactive services: broadband videoconference (B-VC) and interactive multimedia retrieval (IMR), which is an evolution of a typical video-on-demand service.

Nevertheless, the new architecture should also support more conventional IN services which are related to the existing narrowband concepts. This aspect is demonstrated by the virtual private network (VPN) service, which is a generic network service demonstrated by a video telephony application. However, the VPN service is also able to complement the IMR and B-VC services by its functionality.

Emphasis was given in dividing service functionality between the various IN network components, especially in defining the role of the B-IP. The B-IP is used as a mediator which conveys information from the user to the service and vice versa, allowing in-band (audio and video) user interaction. Relevant discussion is carried out in the appropriate section for each service.

In the following, these three services are described in more detail, emphasizing the usage of the new IN concepts provided by INSIGNIA. Additional information about the services themselves can be found in [5].

Broadband Virtual Private Networks

The broadband VPN (B-VPN) service is already available for narrowband IN; therefore, it does not make use of all the concepts provided by INSIGNIA. However, this service provides a good starting point for depicting the functionality of an integrated intelligent broadband network.

The B-VPN service realizes a logical subnetwork of a B-ISDN which appears to a specific group of users as a private broadband network. Figure 4 depicts the general situation. VPN customers are represented by two user groups, X and Y, each of which forms a VPN. Locations A2, B1, and C2 are on-net locations for VPN X; B2 and C3 are on-net locations for VPN Y.

IN provides mechanisms to realize a VPN, such as a private numbering plan, call routing based on number translation, profile screening, follow me, and remote access [6]. These mechanisms are executed by a service logic program located at the SCP.

Figure 5 shows a typical network configuration for a VPN call, which is the reference configuration for the exemplary scenario shown in Fig. 6.

Figure 6 shows a scenario for an admitted on-net VPN-call. During the call setup, the calling user provides its private number as a calling party number to identify him/herself as a VPN member and the private number of the called user as a called party number. These private numbers trigger the invocation of the B-VPN service logic. To ensure the integrity of

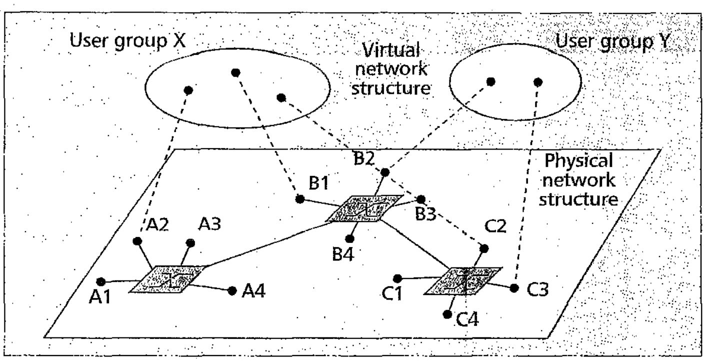


Figure 4. *Physical and virtual (logical) networks.*

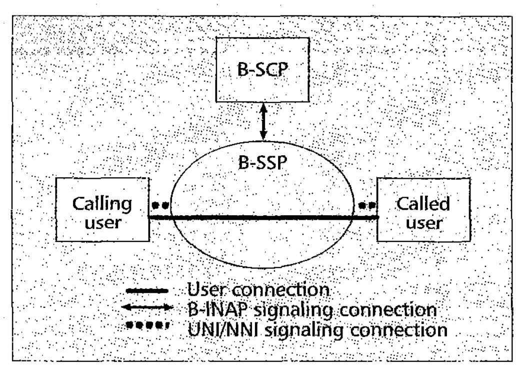
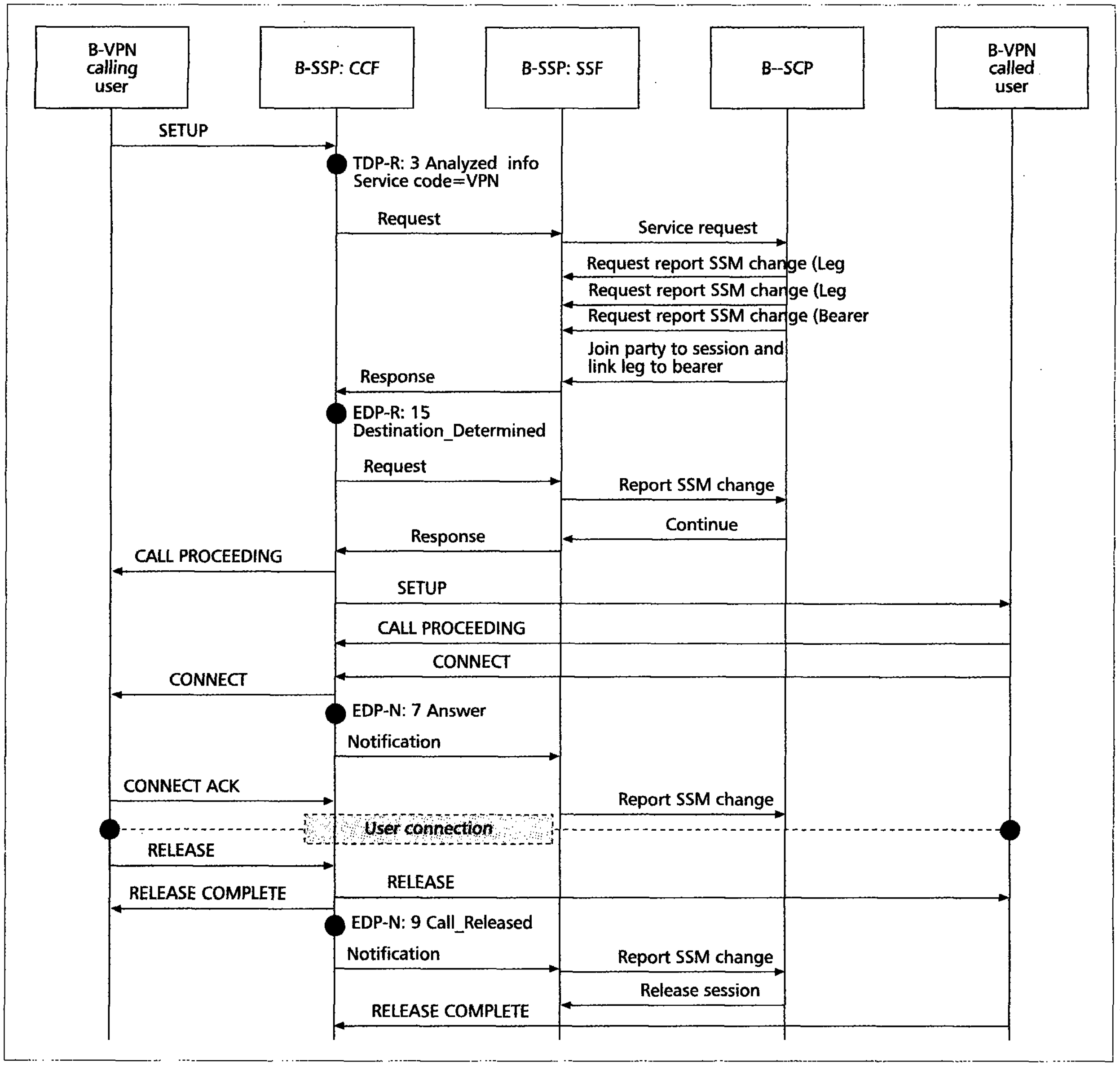


Figure 5. *Network configuration for a VPN call.*



■ **Figure 6.** *Establishment and termination of an admitted B-VPN call.*

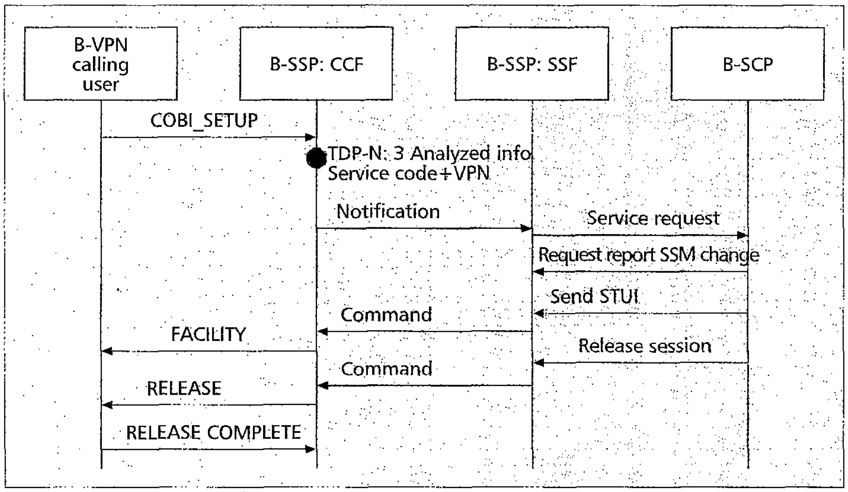
the VPN, the VPN service logic has to check the membership of the users in the VPN (authentication) and the rights to place the required calls (authorization). After authentication and authorization, the service logic has to translate the private party number into a real network address to which the VPN call is to be routed.

Figure 6 reports the signaling messages on the user–network interface (UNI) between the users and the B-SSP, the BCSM events (detection points) within the B-CCF, and the B-INAP messages on the B-SSP/B-SCP interface. The main actions during the scenario shown in Fig. 6 are as follows:

- Authentication, authorization, and number translation are performed according to the information provided within the Service Request message.
- To monitor the evolution of the VPN call, reports of events changing the status of the call are requested (even for exceptional cases).
- The result of the number translation is provided by the Join party to session and link leg to bearer message.
- To allow combination with other IN services, the final address to which the call will be routed is provided to the service logic after reaching the detection point Destination_Determined within the Report SSM change message to finally check the admission of the call.
- Since the session remains active after establishing the call only for monitoring purposes, it is closed by the service logic after the call is released.

Some B-VPN features can be realized exploiting the USI [1]. The USI relies on the call-unrelated associations to allow an out-channel interaction between the user and B-SCP. To demonstrate the usage of this feature, the scenario for the B-VPN follow me feature is described (Fig. 7).

The follow me feature allows a VPN user to modify the entries of the VPN subscription tables. The user connects to the follow me service by establishing a call-unrelated association with the help of a COBI-SETUP message. The trigger mechanism with detection points is used to complete the connection via the B-SSF toward the B-SCF. The B-SSF creates



■ **Figure 7.** *Invocation of the follow me function.*

the SSM and sends the Service Request message to the B-SCF containing the SSM data and the USI information provided by the user. With this data and information, authentication and authorization of the requesting user is performed. USI information from the service is sent back to the user via Send STUI and FACILITY messages.

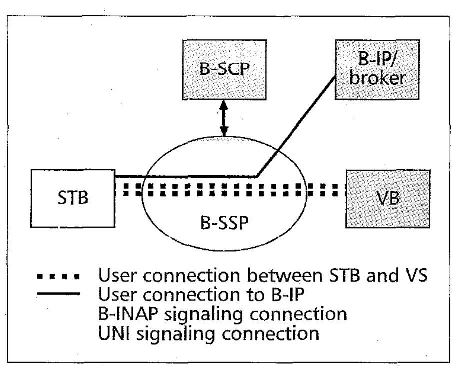
Interactive Multimedia Retrieval

Interactive multimedia retrieval (IMR) is a service that fully exploits the flexibility in connection allocation and control provided by the intelligent broadband network. Each instance of this service involves two parties in a single IN session by which the handling of more than one connection and the use of SCP-initiated calls can be demonstrated.

IMR provides the user with the means to retrieve audiovisual information stored in remote video servers (VSs). This information is sent on user request only, and can be selected and retrieved on an individual basis. This service consists of two parts: an IN part, where a flexible brokering facility is provided between the user and the available service providers; and a non-IN part, which involves the actual playback of the selected material from the VS to the user.

The IN network configuration for IMR contains a set-top box (STB) which is employed by the user in order to perform the necessary service selection and viewing of the desired contents, and a VS from which the digital contents are downloaded. The bearer connections set up during each IMR session are ATM end-to-end. Figure 8 shows the IMR network reference configuration.

From the IN viewpoint, IMR makes use of the following features: number translation, service provider selection, authentication/authorization, type of content selection, SCP-initiated call setup, and handling of multiple connections within a single service session. Number translation in particular comprises a set of advanced functions such as day of week and time of day routing, special date routing, and area of origin routing. The IMR service functionality is divided between the B-SCP and the B-IP by realizing the service provider selection, authentication/authorization, and type of content selection functions as autonomous programs. These programs are triggered by the B-SCP, executed within the B-IP, and the result of the execution is reported back to the SCP which decides how the service should proceed.



■ **Figure 8.** *IMR reference configuration.*

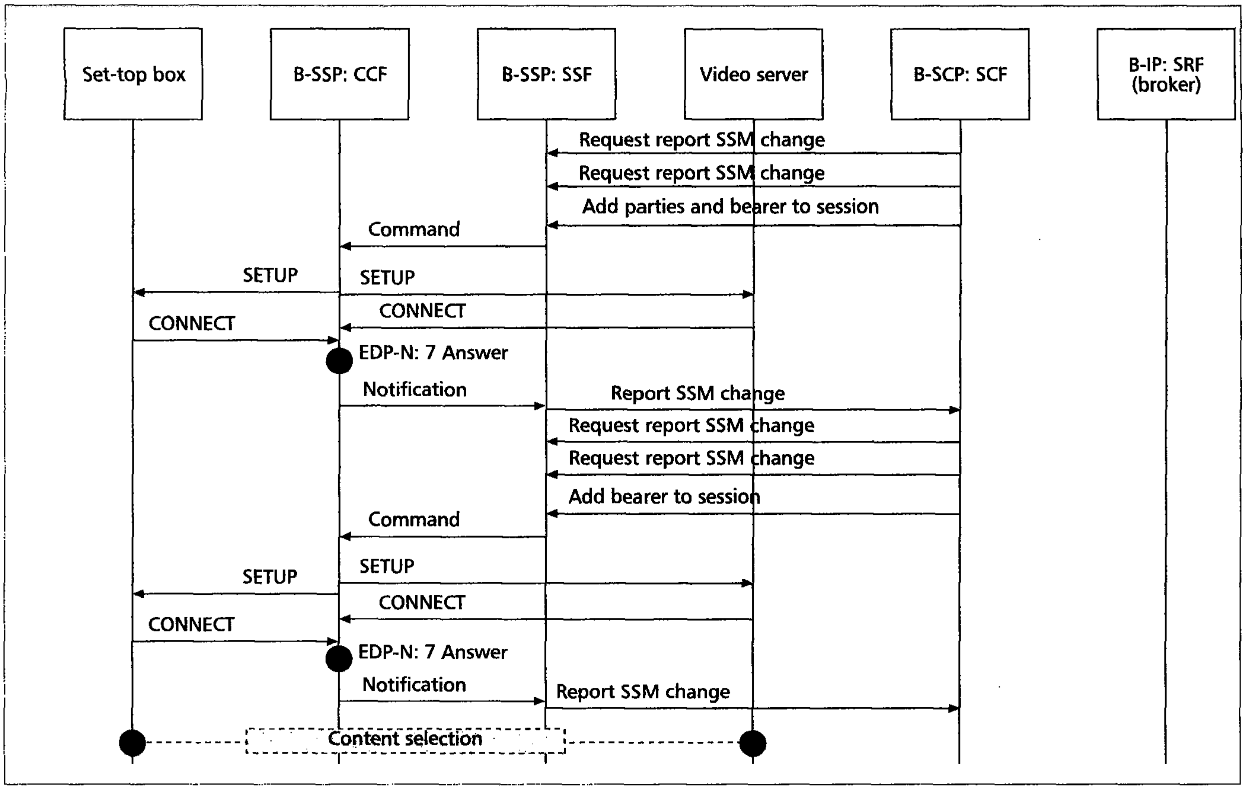
A first realization of the INSIGNIA IMR service is described in [7]. This realization has been enriched with additional features, like bandwidth negotiation [8, 9] and modification [10, 11], reconnection to the broker, and advanced error handling. An IMR session is activated when a user dials the appropriate IN number. Consequently, the B-SCP connects the user to the B-IP where authentication/authorization, service provider selection, and type of content selection takes place. If these steps are successfully completed, the B-SCP disconnects the user from the B-IP, resolves the destination VS address, and connects the user to the appropriate VS. This is accomplished via two SCP-initiated calls, one of which is used for data transmission and the other for stream control operations (Fig. 9). At this point the user selects the desired content, and the playback of the digital stream begins. Interaction can take place in the form of DSM-CC commands for stream control (stop, fast forward, etc.). When playback ends the B-SCP reconnects the user to the B-IP, where he can either choose another service provider or terminate the IMR session.

A significant advantage in using IN for realizing the IMR service is economy in utilization of network resources. In general, the user may never reach the stage of connecting to the VS because of either a change of mind or failure during the authentication/authorization procedure. Since these functions are performed via signaling, the resources that have to be reserved are significantly lower than for a non-IN approach. Another important benefit of the use of IN is reducing the dependencies between the user terminal, broker, and service provider. This adds a lot of flexibility in operations like management and upgrade of the IMR service. For example, user profiles, charging rates, or routing policies can be altered without imposing modifications on either the user interface or the VSs.

Broadband Videoconference

The B-VC service is an example of a complex multimedia communication service. It supports more than two parties, several media types (e.g., video, audio, control, whiteboard data) [12, 13], and involves in some cases more than one service session. Therefore, it is an ideal example to illustrate the use of the advanced signaling capabilities arising from IN/B-ISDN integration. Figure 10 shows a typical connection configuration of the B-VC service. There are fully meshed audio and video connections as well as a control connection from each party toward a central service control instance. As in the IMR case, the service functionality is divided between the SCP and the B-IP.

Basic conference control functions

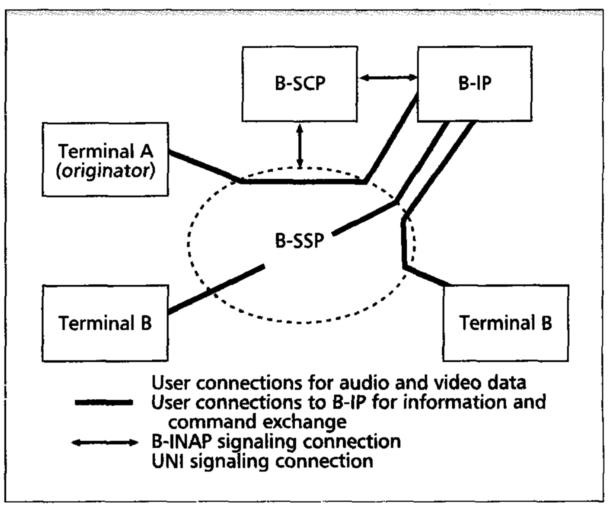


■ **Figure 9.** *Connection of the STB to the selected video server.*

are realized by the B-SCP. The B-SCP is mainly responsible for setting up the connections (audio, video, etc.) needed for the B-VC service and their supervision to manage exceptional cases. The B-IP is used in all cases to convey information between the user and the service. The user may activate a B-VC session by dialing the appropriate IN number. Consequently a conference-related operation can be carried out. If this operation is not related to a running conference (e.g., static conference management), the service session is terminated upon completion of the operation. On the other hand, if the operation is related to a running conference (e.g., join conferee), an interaction between the recently initiated B-VC instance and the instance that handles the running conference has to take place. The B-IP handles the correlation of the two service instances. In some cases the service instance may remain active after the completion of the requested operation. Moreover, the B-IP implements logic which is in charge of high-level conference management, e.g., administration of conference and user records.

The B-VC service example demonstrates, in the best possible way, many advantages of the broadband IN approach, especially the following:

- The user is able to use the features of the videoconference in a very abstract way. The concrete conference establishment is completely performed by the IN.
- The level of abstraction introduced by the IN helps to provide a smooth service migration toward improved networks. For example, the fully meshed configuration of point-to-point connections can be replaced by point-to-multipoint connections as soon as such connections can be efficiently supported by the network without affecting the user interface [14].
- The fact that the complex connection configuration for a single instance of the B-VC service is kept together in an IN session is of great help for administrative purposes.

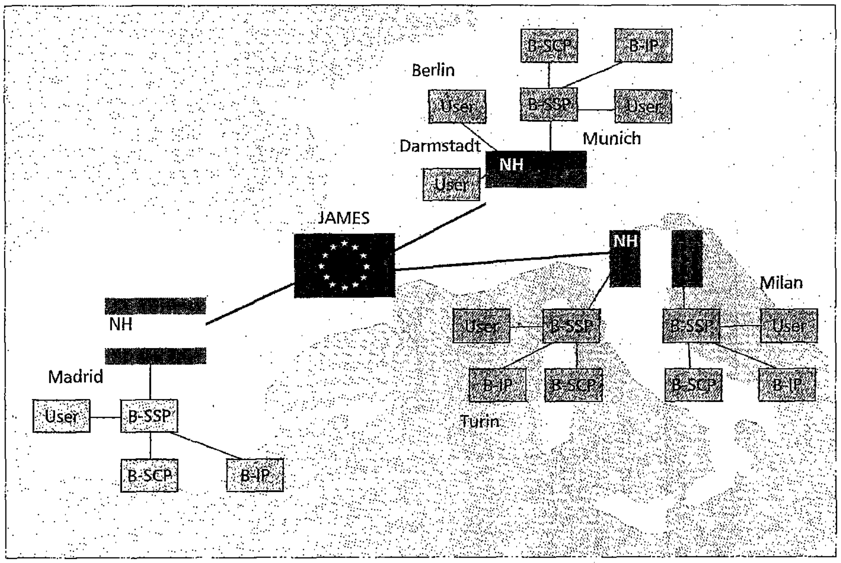


■ **Figure 10.** *Broadband video conference reference architecture.*

- The broadband IN concept proposed by INSIGNIA is very flexible in the sense that it facilitates the porting of services (e.g., B-VC) initially designed for non-IN environments into the IN concept.

THE INSIGNIA TRIALS

The INSIGNIA project is structured around two experimental phases. The first took place from spring to autumn 1997, and the second one takes place in summer 1998. During the trials extensive verification of signaling and IN capabilities is made



■ **Figure 11.** *The INSIGNIA network architecture.*

by means of geographic connections involving three European countries participating in the project activities [15].

Figure 11 illustrates the network configuration of the INSIGNIA trials, showing the sites and equipment involved in the experiments [16].

Three national hosts (NHs), located in Germany, Italy, and Spain, are interconnected by means of the facilities provided by the consortium of European operators (JAMES network). Within the NHs four main sites (Madrid, Milan, Munich, and Turin) provide ATM switching and IN capabilities while two additional locations (Berlin and Darmstadt) are equipped with user terminals and play the role of remote users for the Munich site. Standard signaling functionality allows users access to INSIGNIA services and the interconnection of sites. An INSIGNIA-specific IN protocol (B-INAP) is used between B-SSPs and B-SCPs and at the SCF/SRF interface as well. Services can be provided on both a local and a geographic basis by allowing SSPs to access directly connected as well as network-reachable SCPs.

Intelligent Broadband Network Capabilities in ATM Systems

The INSIGNIA service infrastructure is based on classical IN elements which have been enhanced in the broadband environment.

Broadband Service Switching Points — ATM nodes have been enhanced to B-SSPs in order to accomplish the task of bridging users and IN capabilities. Three prototypes of B-SSPs have been provided by different project partners (Italtel, Siemens AG, and Telefónica I+D) on the basis of a common high-level design of the service switching function [17]. Two basic approaches were used for the enhancement of available equipment, that is, integrated signaling/IN capabilities and external servers (Fig. 12).

The integrated approach provides better performance since it makes use of a machine-internal fast interface toward the matrix control functionality. On the contrary, the external approach, based on communication protocol stacks connecting the server and the management system of the controlled cross-connect, gives worse performance but provides good flexibility in an experimental environment.

Broadband Service Control Point — INSIGNIA makes use of a B-SCP provided by a project partner (GPT) on the basis of its narrowband product. The system has been enhanced by introducing advanced service creation capabilities and a B-INAP-based protocol stack interfacing the system with SSPs and intelligent peripherals. On the basis of the new broadband platform, service logic programs for the control of multimedia services have been developed.

The service logic for all three IN services was developed by using an object-oriented graphical service creation environment (SCE). This environment was tailored around the INSIGNIA SCP and is an extension of a commercial narrowband product. Actual service development is the last stage of the INSIGNIA service creation process. It was preceded initially by a textual service description stage which was followed by the production of formal service specifications by means of the Specification and Description Language (SDL) [18]. A detailed description of the INSIGNIA service development methodology can be found in [19].

Broadband Intelligent Peripherals — As in the narrowband context, the B-IP allows user–service in-band interaction, which becomes multimedia interaction in the broadband environment. This type of equipment plays a new role with respect to the narrowband one. INSIGNIA B-IPs are used in order to complement the SCP role in providing complex services like IMR and B-VC. Some service-related features such as user authentication/authorization, the transmission of content previews, and conference databases are handled directly by the B-IP.

During the first project trial two separate implementations of the B-IP targeted for the IMR and B-VC services were provided. For the second experimental phase, a single system able to handle both services has been integrated.

The B-IP is based on a Sun workstation running Solaris 2.5. An ATM board with a synchronous digital hierarchy (SDH)/STM1 optical interface allows connection of the system to a B-SSP. Several protocol stacks are used for the different communications handled by the B-IP. UNI signaling is used for the dialogue with the B-SSP, while a B-INAP-based IN stack enables SCF/SRF communication. In the U-plane either HTTP or an SSCOP-based dialogue, depending on the service, is used.

B-IPs are provided to INSIGNIA by a collaboration between CSELT, GPT, GMD-Fokus, and NTUA.

Customer Premises Equipment for INSIGNIA Services

Due to its experimental nature INSIGNIA adopted equipment which could easily be modified and tailored to fulfill the project requirements. For this reason, workstations and personal computers were used as CPE for all INSIGNIA services.

B-VPN Terminals — B-VPN is a network service which can be demonstrated by means of a wide range of applications. During the first experimental phase INSIGNIA chose video telephony since it represents an interesting service for both residential and business users and fully exploits the benefits of

ATM. In the second trial broadband virtual intranet (B-VI) is added as a second application exploiting the B-VPN service capabilities.

The first implementation of B-VPN made use of PCs equipped with UNIX and a video telephony application using 2 Mb/s bandwidth. The second experimental phase makes use of the same type of application running on workstations. In addition, IP-based Intranet applications (e.g., Web browsing, file transfer) are used for B-VI.

Both types of terminals are equipped with an International Telecommunication Union — Telecommunications Standardization Sector (ITU-T) Q.2931 and ATM Forum 3.1 compliant protocol stack for UNI signaling. For the second trial the stack has been enhanced by means of Generic Functional Protocol capabilities used for USI.

B-VPN terminals were initially provided by Siemens AG (first trial) and are now based on GMD-Fokus applications.

B-VC Terminals — Access to this service is made by means of UNIX workstations equipped with advanced video and audio capabilities and running in the framework of a generic multimedia CPE software platform, which was specifically designed in order to provide a runtime environment for multimedia applications. The B-VC application handles the transmission and presentation of audio/video flows between a number of involved conferees. In addition, a whiteboard is provided for the exchange of graphical information. The whiteboard is shared among all active conferees.

Different options (e.g., PAL/SECAM, NTSC, and Motion JPEG) are available for the video flows, whose typical bandwidth is 2 Mb/s. Several coding rates are provided for the audio information, although typically 64 kb/s bandwidth is used. Whiteboard information is transmitted at the same rate as the audio channel.

The B-VC terminal can be used for the video-telephony-based B-VPN as well and is therefore equipped with the same UNI signaling stack described earlier.

The B-VC application has been developed by GMD-Fokus.

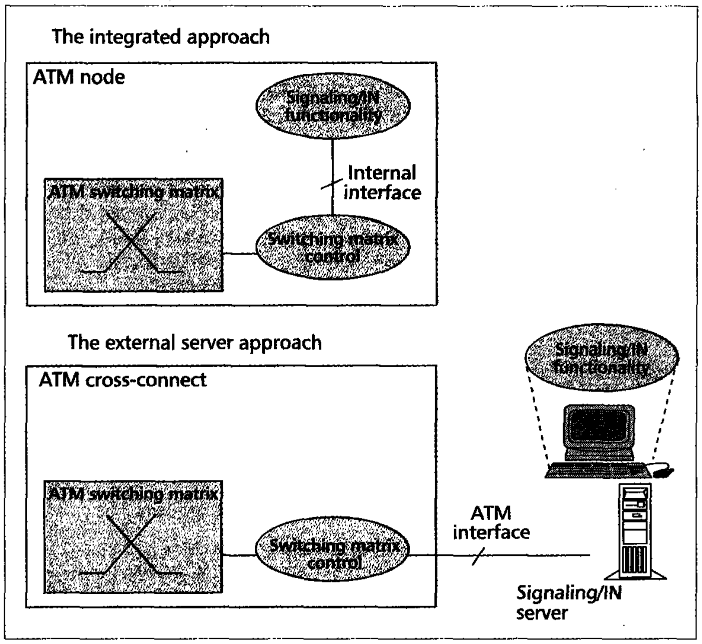
IMR Terminals — Two types of end systems are used for this type of service, namely STBs and VSs. STBs are located on the user premises, while the servers are handled by service providers. INSIGNIA makes use of two implementations of STBs and VSs. In the first case IMR is accessed by means of a dedicated STB, while the second solution allows generic multimedia CPE to make use of the service.

In the dedicated solution the STB is based on a PC running Windows NT and equipped with dedicated applications for IMR based on the ARMIDA™ system [20]. User interaction with the intelligent peripheral takes place via a Web browser. Video information is handled by specific interface boards and decoders (NIU-100 and M-BIRD, an ATM board with a 100 Mb/s TAXI interface, and an MPEG II decoder). The STB makes use of a video overlay board which allows video information to be directly sent to the PC display. As an alternative, a TV set can be connected to the PC.

In this first solution the VS is based on a workstation (Solaris 2.5) equipped with an ATM adapter and running an object-oriented database handling the stored video contents.

Both systems run a signaling UNI protocol stack compliant with ITU-T Q.2931 and ATM Forum 3.1. STB and VS applications are provided by CSELT.

In the generic multimedia CPE solution, a dedicated application on the CPE allows usage of IMR. In this case the interaction with the B-IP takes place by means of a Java applet responsible for displaying the pages from which the user will be informed of available selections, as well as handling user input. The applet translates all the upper-level user transactions to TCL/TK commands, which are then sent to the interpreter, where execution takes place.



■ **Figure 12.** *B-SSP implementation alternatives.*

In this second solution the IMR server is a Windows NT 32-bit application, coded in Visual C++ 4.0 with the aid of the object-oriented MFC classes. It uses the Windows NT ATM API 1.0 implemented by NTUA, which is supported by the underlying ATM driver.

Again, both systems make use of standard UNI signaling. The generic multimedia CPE solution is provided by a collaboration between GMD-Fokus and NTUA.

CONCLUSIONS

The main conclusion drawn from this work is that the delivery of broadband IN services is a feasible task which can be based on an extension of existing narrowband principles. This is the case of the INSIGNIA functional model, which successfully integrates the IN and B-ISDN concepts into a unified architecture by separating call and connection control and introducing an object-oriented approach to the association of the network resources used for the realization of an IN service. This theoretical background was able to deliver, in practice, three broadband multimedia services which were successfully tested locally and internationally. Moreover, it is flexible enough to accommodate new as well as existing services.

The results of the INSIGNIA trials show that, among the various possible alternatives regarding the provision of interactive multimedia services, broadband IN is one of the most advantageous since it efficiently caters for quality of service and real-time constraints. Taking into account that the work carried out within this project has been evaluated in terms of user acceptance and network performance issues, it is obvious that INSIGNIA, although a pilot network, stands out as an exemplary approach toward the definition of a complete framework for the evolution of telecommunication services. Experiments aimed at obtaining feedback about the network behavior have been extensively carried out. Questionnaires were distributed to demonstration attendants, by means of which the users' perception of the services offered by the INSIGNIA networks was obtained. Performance measurements made during actual operation of services allowed to thorough analysis of the behavior of single-system components as well as the overall network. Encouraging results were obtained which show the suitability of the INSIGNIA architecture for support of multimedia services by means of IN.

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BIOGRAPHIES

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