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## TESUS I Activity Report for Participant C3, Institute for Applied Informatics at Research Centre Karlsruhe

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According to the original definition and the workpackages of TESUS I, the role of partner C3, the Institute for Applied Informatics (IAI) of the Research Centre Karlsruhe (FZK), is to provide for technical specifications, to develop extended systems for teleconsultation purposes and to perform extended preliminary tests with so far available equipment in the fields of enhanced services specification and high performance networking. The manpower granted by the project board was only available in the workpackages seven to ten.

The efforts undertaken by IAI can be thematically summarised as:

- A Designing an interactive teleconsulting scenario in which a distant surgeon in the role of an expert consultant can remotely control an endoscopic guidance system.
- B Designing a platform independent control system to manage extended surgical sessions based on standard network management protocol SNMP.
- C Market analysis and test of improved audio/video codecs for high quality visioconferencing, teleconsulting and teleeducation sessions.
- D Set-up and demonstration of a H.320 compliant, hybrid visioconference system using ATM links for reliable transmission and value added services in an intranet and providing for an H.320 compatible gateway to the ISDN wide area network.
- E Preliminary and basic tests for interworking of existing TESUS systems and imaginable future ATM systems via the standards 'ATM-Forum LANE 1.0' and 'ATM-Forum MPOA 1.0' including basic tests for VTOA.
- F System design for a value added VR based, centralised surgical training service with real-time graphical simulation.

In terms of the relevant TESUS workpackages

- WP7 Enhanced Services Specification
- WP8 ATM Platform
- WP9 Medical Validation of the ATM Platform
- WP10 Interworking Specifications

the following concordance arises:

|      | A | B | C | D | E | F |
|------|---|---|---|---|---|---|
| WP7  | X | X |   | X | X | X |
| WP8  |   |   | X | X |   |   |
| WP9  |   |   |   |   |   |   |
| WP10 |   |   | X | X | X |   |

Following the thematical works A to E are described more precise:

**A Teleconsulting by controlling a remote endoscopy guidance system**

During surgery there often arises some need to get an additional advice from an expert at a remote site. With the visioconferencing equipment used in TESUS the transportation of the video arising from the endoscope to the expert's site is no problem, but the consultant is not able to direct the surgeon's view to some spots of his own interest but must advice the local assistants to get his appropriate view-port.

In case of the endoscopic guidance system which usually does not move with high speed and where the movements need not to be extremely precise it is possible to enable the remote expert to remotely control it, leaving an overriding control at the surgeons site.

The idea at IAI, the central engineering department of the FZK and the section for MIS at Tübingen was, to enable the endoscopic guidance system FIPS for remote control via the existing TESUS visioconferencing systems.

FIPS is driven by four servos controlled on a time base, which means that each of the four servos can be independently switched on and off to achieve the desired movement of the endoscope. The communication to the servos is realized by a microcontroller that can be accessed through a RS232c interface at a minimal speed of 9.6 kbps.

The TESUS conferencing systems usually provide a proprietary RS232c interface which can be configured for a transparent transport of serial data at that speed.

So a protocol was specified defining special control bytes for the four servos (respectively the four degrees of freedom for the movement of the endoscope) and a fail safe format of protocol data units to transport the

commands, applying redundancy and a two out of three proving mechanism to avoid bit errors leading to false behaviour of the system. Each PDU consists of a header and a trailer byte and four payload bytes for each servo. So, even if only one servo has to change its state, the desired state of each servo is retransmitted in every command, thus increasing the stability and fail safety of the protocol. From each byte of the PDU only the inner four bits are of any means thus allowing the definition of affinity classes to improve safety transmission in case of any bit errors on the line. Each PDU is then transferred three times and only if two of the three PDUs have the same meaning the command is delivered to the servos of the endoscopy positioning unit. In case of transmission errors or the loss of link the stop command is generated by the receiving microcontroller. With this protocol a control cycle of 18.75 ms can be achieved on a 9.6 kbps link.

The first test phase focused on using the built in RS232c interface of the TESUS codecs. Unfortunately, despite nearly all H.320 room systems offer such an interface, they are not interoperable with different manufacturers or with different codec types of the same manufacturer. Therefore the second phase of testing focused on using a separate analogue modem link. This set-up could successfully be tested.

At the far end side a DOS-application providing the expert with a simple keyboard driven interface was used first, then the DOS-System was replaced by a microcontroller with an attached special 'joystick' for FIPS thus allowing to control the endoscope like in a local scenario.

In the last phase of this test setup both microcontrollers were equipped with ISDN BRI cards thus allowing the remote control of the endoscope over the same medium as the visioconference.

## ***B A platform independent control system on standard network management protocol SNMP***

Data networks of today are wide spread and consist of an increasing number of active nodes which usually are from different manufacturers and which usually are running different operating systems. The configuration and monitoring of these networks can only be economically done with management systems that allow to do all the configuration and monitoring procedures remotely from one or several 'central' positions. At the medical systems of interest in TESUS (visioconferencing and teleconsultation) the tasks of configuration management and monitoring are quite similar to those in modern networks. As a consequence of that studies are undertaken at the IAI whether a system independent network management protocol like SNMP is capable to fulfill medical applications' requirements too.

SNMP is a protocol that is based on the UDP/IP transport stack. It mainly allows three different basic operations: GET, SET and TRAP. With these basic operations the managed systems are monitored and configured as well. The system state even of very complex systems is represented by a database called MIB (management information base) that resides on the managed system itself. Monitoring is done by GETting the values of the MIB

variables of interest or actively by the managed system by sending a TRAP message when certain alarm marks are reached, configuring and altering of state is done by SETting some MIB variables to new values.

The interpretation of MIB variables in a specific system must be realised by the manufacturer himself thus providing an open and standardised interface by moving the programming task from the system itself to the MIB.

At the managing side a special SNMP application deals with the SET, GET and TRAP messages by creating or receiving and evaluating them. These applications are in terms of SNMP called managers. The only knowledge which must be available at a manager is the structure of the MIB of the managed system. Then, if the manager has the appropriate rights to do so – which are managed themselves by so called community strings for each managed system which must exactly be entered by the manager – he only needs to send the adequate SET for a specific MIB variable to control the system. But managers can also be built as comfortable graphical user interfaces which hide the MIB structure and the SET, GET and TRAP messages from the user and providing him with the opportunity of an intuitive operation of the managed system. So often one can find management platforms that allow the integration of different MIBs as well as the plug-in of intuitive GUIs.

In the efforts undertaken at the IAI in this sector a concurrent remote control of an endoscopy guidance system via SNMP was the goal. Therefore a special endoscope MIB was designed and an SNMP agent and manager where programmed for a Windows platform on PC.

The reliability of the UDP communication and some typical delays (from the network and the processing latency) where studied with a virtual endoscope. This means that only the MIB was manipulated and queried but no real endoscope was connected to the electrical output of the agent, yet.

The result of these preliminary studies is, that SNMP seems to be applicable for an integrated configuration management and monitoring of a complex medical scenario and also for the control of less sensitive devices like endoscopy guidance systems in tele-consultation scenarios.

Currently these studies are continued in the direction of an improved system independency by encapsulating the SNMP messages into the HTTP protocol and providing GUIs as JAVA programs, so called SERVLETs.

***C Test of improved Audio/Video CoDecs for high quality visioconferencing, tele-consulting and tele-education***

The ISDN technology used for the current TESUS systems only allows the transportation of video in CIF quality at a frame rate of 15 frames per second (fps).

To fulfill the extended requirements of surgeons for best quality live video several audio video codecs where and are beeing tested at the IAI.

CellStack Video codec manufactured by K-Net Ltd. UK provides a bidirectional audio and video transmission in PAL and NTSC quality via a private ATM network using oc3c interfaces and AAL5 with UBR characteristics. Frames are coded using JPEG on each frame, so called mJPEG (motion JPEG). The codecs are well applicable for the transmission in private networks where no traffic contracts (policing, shaping) are required. Transmission in public networks usually fails due to the lack of burst tolerance in the intermediate crossconnects and switches.

OptiVision Ltd., Palo Alto, USA, provides scalable MPEG (I or II) codecs which offer audio and video transportation over TCP/IP protocol on different networks providing a minimum standard of quality. The input/output quality can be PAL and NTSC as well as S-Video (Y/C) or D1 digital video. Basic tests were recently performed on switched 100 Mbps Ethernet with impressive results except the end to end delay of the transmission which apparently cannot be less than 200 ms (compared to 60 ms at the CellStack Videos). A big advantage of the Optivision systems is that the receiving station need not be equipped neither with a special video monitor nor with a hardware decoder; with a decreased quality video even displays on a PC with a software MPEG decoder. Tests with these features are being continued currently.

***D Setup and demonstration of a H.320 compliant, hybrid visioconference system using ATM links for reliable transmission and value added services in an intranet and providing for an H.320 compatible gateway to the ISDN wide area network***

Visioconferencing systems as introduced with TESUS require at least three ISDN BRIs (Basic Rate Interfaces) for each foreseen location of a system. Room systems are rather heavy and not very portable. The idea in IAI activity D was, to enable common desktop systems for visioconference under the H.320 standard without the need of having three BRIs at each station but providing a centralised access to the public ISDN network from each station. A further requirement was, that all the stations in an intranet should be able to communicate on a point-to-point base without the need of ISDN access and without further communication costs.

A solution could be found with products from First Virtual Corporation (FVC), Santa Clara, USA, who adapt widespread desktop conferencing systems from market leader PictureTel to a low cost ATM intranet and providing for a gateway into the ISDN public network.

In the intranet an adaption software called MOS (media operating system) receives the calls from the H.320 desktop application and converts them into ATM-Forum LAN-Emulation 1.0 calls on the ATM network. Physically ATM 25.6 Mbps links are used conforming to the UNI 3.0 (User to Network Interface) standard with ILMI (Interim Layer Management Interface) protocol, switch topologies are usually built using PNNI (Private Network to Network Interface) on physical oc3c 155 Mbps links and the IISP (Interim Inter Switch Protocol). The H.320 PDUs are then encapsulated in AAL5

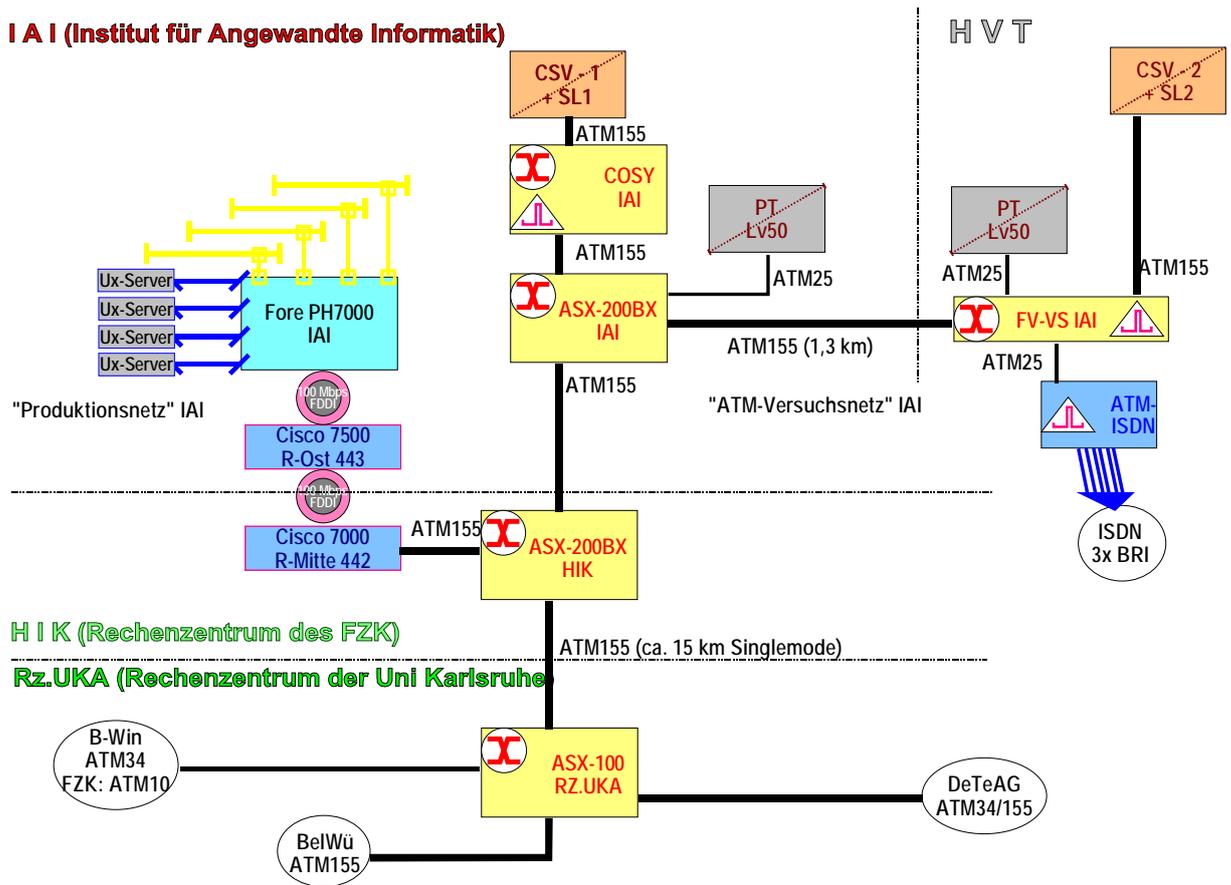
(ATM Adaption Layer class 5) frames of the ATM and transported through the ATM network in (a series of) signalled virtual circuits (SVC). From the entered end-system address in the desktop application the MOS software is able to decide whether a call leads to an end system in the ATM intranet or to a remote system in the ISDN public network. For the latter case a special ATM to ISDN gateway is used which decapsulates the data from the ATM network and sets a regular call into the ISDN public network using 128 kbps or 384 kbps links in bonding mode. The gateway can be equipped with one or two BRI cards where each card provides for four BRIs or with one or two PRI (Primary Rate Interface) cards, thus allowing from at least four simultaneous calls to 60 simultaneous calls at 128 kbps or from one call to 10 simultaneous calls at 384 kbps.

The visioconferencing application is also compliant with the T.120 standard thus allowing so called video collaboration on H.320 calls. So users can share any Windows application running on either of the PCs participating in the call by means of seeing what the partner is doing with the application, remotely controlling the partners application or even his whole PC or by means of concurrently entering and manipulating information in the shared applications. In addition there are the common collaboration tools available, like whiteboard, chatting and file transfer. The T.120 collaboration is transported in one D channel of H.320 calls in the ISDN network providing with a transfer capacity of about 14 kbps netto. When using intranet connections there is an escape from that bandwidth limit allowing the collaboration to be set-up in a separate LANE channel with a dedicated bandwidth of 10 Mbps.

The test set-up of IAI consists of three end-systems and two gateways (4times BRI each) connected via four switches, two of FVC and two Fore ASX200BX backbone switches. It is shown in a first phase in the picture below.

The interoperability of this system with the TESUS systems could be approved in a series of sessions between IRCAD Strasbourg and FZK, Section for MIS of University Tübingen and FZK and as a highlight during the summer academy of the Landesbeauftragter für den Datenschutz Schleswig-Holstein in Kiel, Germany, on August 25, 1997. There a multipoint conference on base of 384 kbps links could be established between the auditory in Kiel, the IRCAD in Strasbourg, an operating theatre of the University Hospital in Tübingen and the ARTEMIS testbed in FZK. At the auditory in Kiel a live rectoscopy in Tübingen was presented which was online commented by Dr. Nord from IRCAD Strasbourg und interrupted by two on-line demonstrations of ARTEMIS and the Karlsruhe surgical VR trainer.

## IAI (Institut für Angewandte Informatik)



Currently efforts are undertaken to extend the ATM network from local to wide area range thus allowing the improved services of the ATM intranet to be used in long distance calls at low costs through the private high performance network.

### **E Preliminary and basic tests for interworking of existing TESUS systems and imaginable future ATM systems via the standards ATM-Forum LANE 1.0 and ATM-Forum MPOA 1.0 including basic tests for VTOA**

In addition to the work of area C and D at IAI studies were started, how improved and additional services for the TESUS network could be set-up. An important task is to deliver an improved video quality to the medical TESUS partners. This can be managed by defining an additional video service, for example in form of VoD (video on demand), on the base of MPEG compression which allows the digital image resolution to be enlarged from approx. 282x212 pixels<sup>2</sup> of CIF to approx. 533x400 pixels<sup>2</sup> and the frame rate from approx. 15 fps to the full common European frame rate of 25 fps. In that context ISDN links will no longer fit to the requirements. In co-operation with FVC and in combination with the H.320 hybrid system a solution could be found to set-up an additional VoD service via the ATM links with the MOS software. FVC is able to offer system extensions called 'V-Caster' and 'V-Server' that allow the real-time transmission and digital recording to hard disk of surgical sessions in MPEG II quality as well as the playback of stored MPEG II clips from the VoD server from the same GUI as used for the H.320 conference.

The participating stations have to be equipped with a hardware MPEG II decoder for getting the full quality video, but even conventional H.320 stations can take advantage of the MPEG video which can also be re-coded from MPEG II into H.261 coding (with respective loss of quality) on the fly by the V-Caster and V-Server.

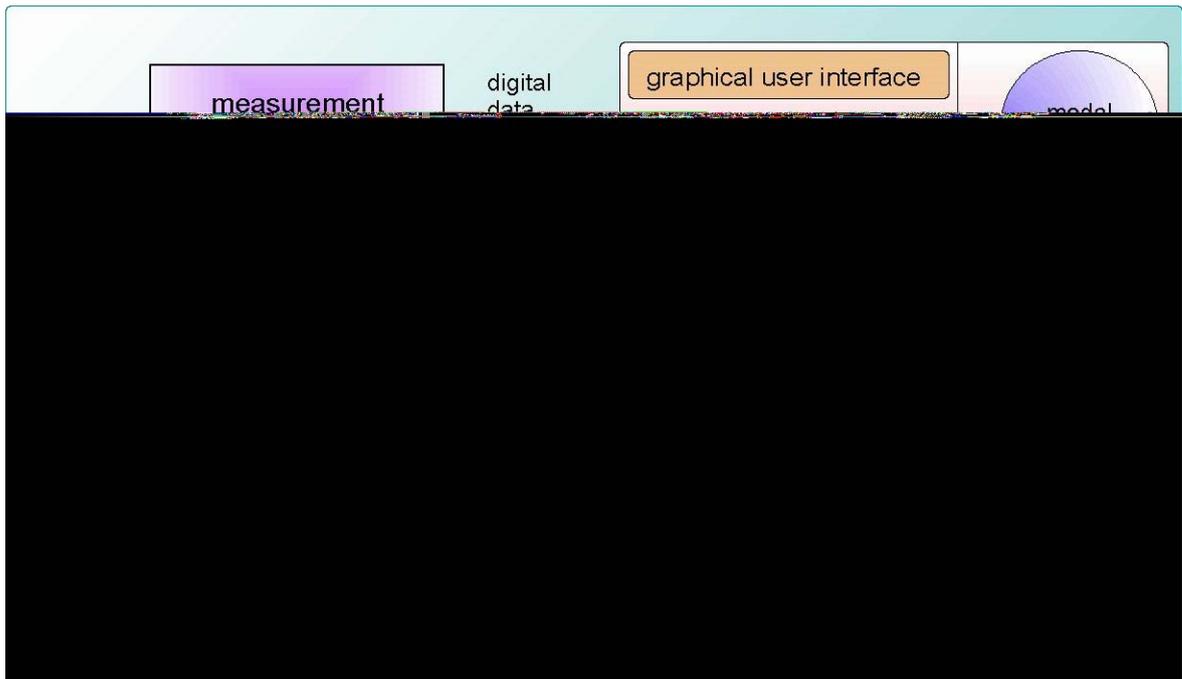
As the system of this type require ATM links between the partners for using the full quality efforts were undertaken to get at least a test link between IRCAD Strasbourg and the Karlsruhe University from France Telecom and DeTeAG. The Karlsruhe University is connected via ATM to the DeTeAG ATM net on one hand and to the FZK on the other hand by fibre optics links. Unfortunately in a special meeting to co-ordinate and arrange such a test link France Telecom as well as the German DeTeAG clearly stated that they won't do any activities for supporting these efforts. As a consequence contacts to private carriers where built, especially to the 'City Netz Karlsruhe GmbH' who might be able to offer private links via the 'Arcor' and 'EdF' high performance networks in the near future.

The above described system runs on ATM-Forum LANE 1.0 and PCs only. Therefore a more open and portable solution was searched, especially with respect to the lack of ATM links between most of the TESUS partners and to the restrictive manner of France Telecom and DeTeAG. Such an open system could be found with the above mentioned OpiVision codecs who settle on every network offering a certain level of quality of service by using TCP/IP, even on a shared 802.3 network that is not heavy loaded. As mentioned above receiving systems even don't need to be equipped with a hardware decoder.

Besides the improvement of video quality it was considered very important to offer ISDN quality telephony at no or lowest costs. Vienna Systems Inc., Canada, are offering such a solution which gets installed for test purposes at the FZK in the next future. With the 'Vienna Ways' system Telephones are attached to IP networks in several ways (directly, via a workstation, ...). A telecommunication server then acts as a PBX (private branch exchange) and commits ISDN quality calls in the IP network and - if connected to the public ISDN network - to the public telephone net. ISDN quality inside the IP network can be achieved by a special coding type (Lucid) with 7,3 kbps only. As data networks usually are rated with very low costs compared to telephone networks thus the costs for regular telephones can be significantly be lowered between the TESUS partners participating in that solution. The gateway service to the conventional public telephone network prevents from investing into two separate telephones and even can lower telephone costs more: if every partner site will provide a gateway to the public network, long distance calls can be routed to use the shortest or the cheapest route inside the public telephone network (which usually is the same). For example: a call from FZK to Brussels would be routed inside of the cheap data network to Partner C2 (Hôpital de Louvain) in Brussels where it is passed to the public network by the Vienna-Gateway and rates only as a local call inside the city of Brussels.

*F System design for a value added VR based, centralised surgical training service with realtime graphical simulation*

The IAI is well known for its 'Karlsruhe Endoscopy Trainer' based on the real-time graphical simulation system KISMET. Unfortunately the hardware which is necessary to produce the realistic graphics in real-time is very expensive and can't be afforded by smaller hospitals or self employed surgeons. Thus the idea has risen to offer the graphical simulation as a value added service in a good equipped centre with enough graphical computing power.



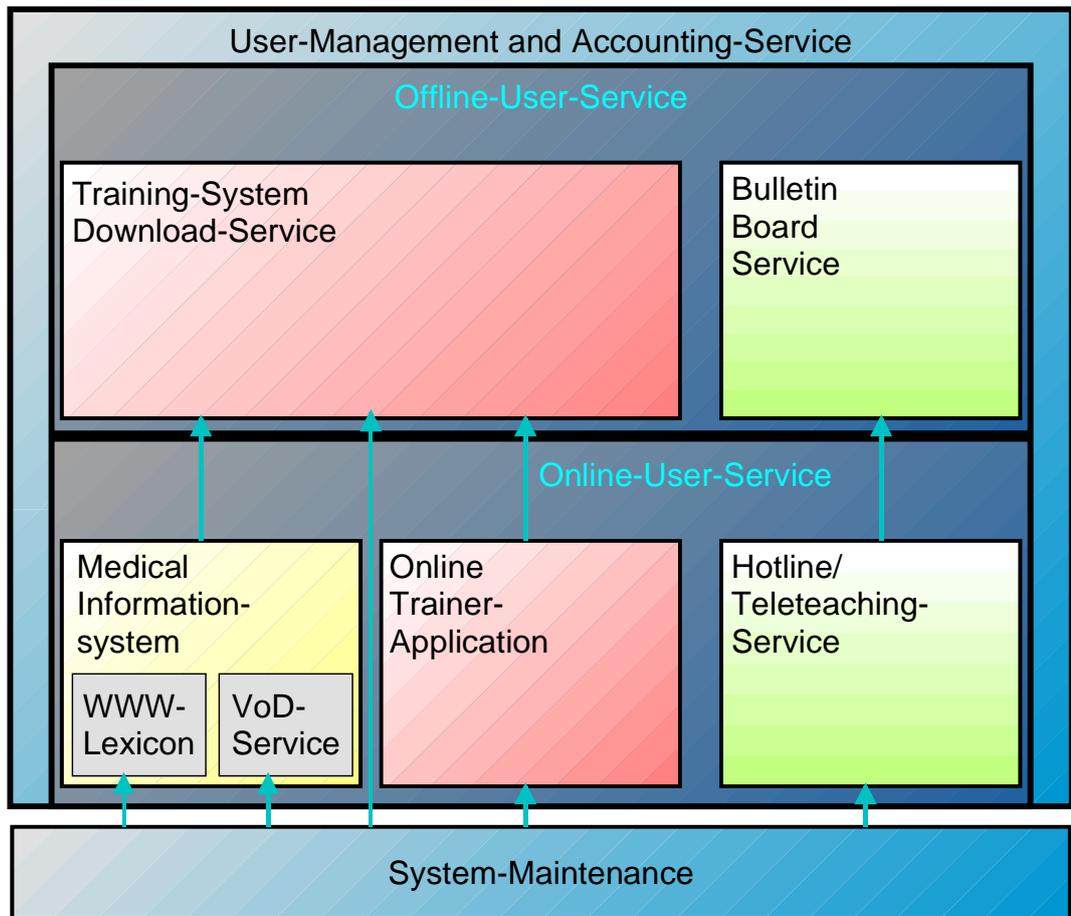
The client would only need an appropriate input device which is built as a mock up of the really used devices in surgery but connected to the simulation centre by network instead of working directly in local preparates or local simulation environments.

In addition to the pure training of certain surgical procedures the service centre should offer an integrated medical hypermedia system that allows an easy access to background information, stored examples, to a hotline and a bulletin board for expert guidance and interchange of experiences.

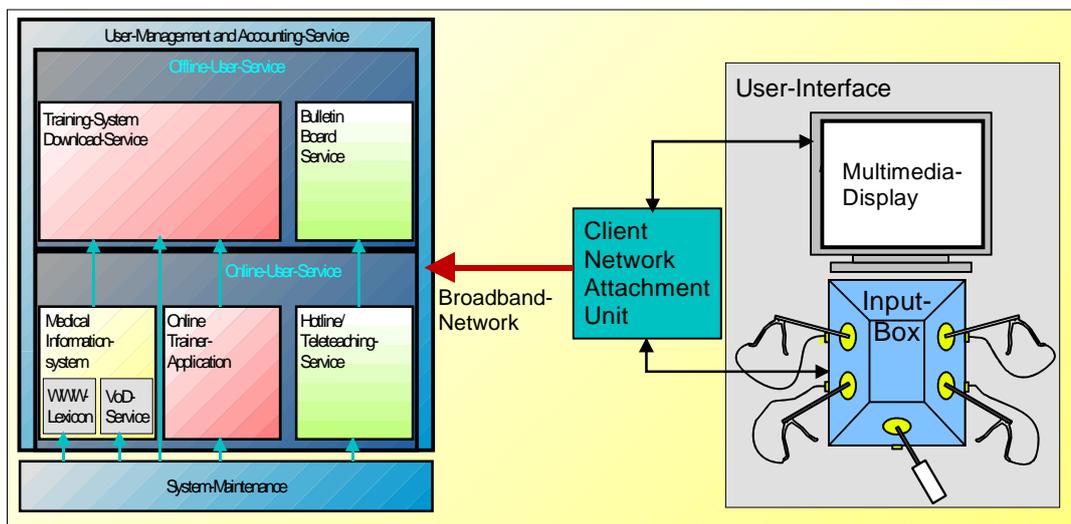
If the client side has enough computing power to run the simulation locally the service centre could provide an system update service so that all the clients work with the most recent system version all the times.

The rough system design for such a Teletraining Service has been done by the IAI and it is presented in the following figures:

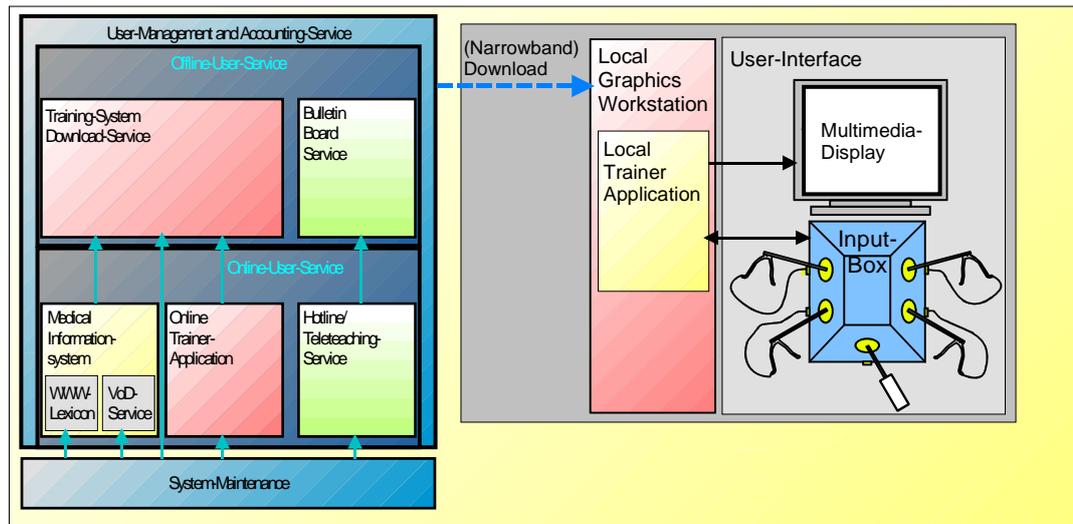
a Service Centre Functionality



b On-Line Client



c Off-Line Client



We hope that you could get a good impression of the works done for TESUS at the IAI. If you have further questions or need more detailed information, please don't hesitate to contact us.