Operational Support Systems and Audiovisual Transmission

Best Practice Document

Produced by UNINETT led working group on AV (No UFS120)

Author: Bård Støfringsdal

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Contact: campus@uninett.no

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Executive Summary

This is a supporting document applicable to UFS 116 and deals with shared resources when a number of rooms are used in connection with operational support and external and internal audio and video transmission (monitoring and remote control of AV installations, broadcasting/streaming of lectures, multi-party video conferences, infosystems, etc.).

INTRODUCTION I

Under the direction of the GigaCampus programme, UNINETT has set up a work group for Audio-Visual (AV) equipment. The work group consists of participants from universities and colleges throughout Norway, from UNINETT and from the consultancy company COWI.

UNINETT Technical Specifications documents (UFS) have been developed which provide functional descriptions for recommended designs for AV equipment used in Norwegian universities and colleges. The adopted designs are based on the experience of the members of the work group.

UFS 120 is a joint supporting document for the functional descriptions provided in UFS 116 and describes recommended configuration of operational support common to several rooms. Recommendations are also made for various ways of transmitting audio and video internally within a campus and to external partners. Alternative systems for the broadcast or streaming of lectures and systems for multi-party video conferences are specifically described. A general description is also provided of relevant additional joint functionality for video conferencing systems, as well as of integration with unified communication systems.

While technical systems for broadcasting or streaming lectures are developing rapidly, there are as yet not many standardised systems or products which can be easily integrated with AV installations in individual rooms, as described in UFS 116.

This document will primarily provide an overview of alternative systems based on the required functionality, and is intended to be used as an aid in the process of needs analysis and specification of functional requirements. Selected systems must be adapted to the needs of the users, to other AV installations and to the operational organisation in each case.

The document is not intended to be used independently of the other UFS documents produced by the AV equipment work group.

Technical and functional system requirements for different components or systems are described in UFS 119. Note that UFS 119 does not cover all the systems described in UFS 120.

1 Document Structure

UFS 116: Functional description, AV equipment for classrooms and meeting rooms describes recommended configurations for the furnishing of various types of room. The document also includes useful background material for use in the planning and evaluation of suitable configurations and proposals for user interface descriptions. The term “teaching rooms” includes all types of auditoriums, seminar rooms, classrooms or presentation rooms primarily used for lectures or presentations. Meeting rooms are rooms intended for meetings and group work or other student-organised activities, often with flexible furnishing suitable for different types of use.

Two supporting documents have also been developed:

UFS 119: Technical and functional system requirements for AV equipment describes the necessary specifications for ensuring the correct quality and uniformity of systems. This document is intended to be used as the basis for all purchasing, irrespective of complexity or size.

UFS 120: Operational support systems and audiovisual transmission deals with resources shared by a number of rooms used in connection with operational support and external and internal audio and video transmission (monitoring and remote control of AV installations, broadcasting/streaming of lectures, multi-party video conferences, infosystems, etc.).

OPERATIONAL SUPPORT II

Remote monitoring of the status of AV installations and remote operation of control systems in individual rooms are extremely useful tools for achieving an efficient and robust operational situation. Such facilities are normally supplied as part of control systems and are in most cases proprietary products adapted to the manufacturers' own control systems. However, it should be noted that some manufacturers also support monitoring and remote operation of control systems produced by other manufacturers. A number of manufacturers offer different versions based on installation either on a local PC or on a common server accessed from any PC. All the relevant makes of control systems can currently be supplied with support for remote monitoring and operation via a computer network, although the simplest models do not normally support external connectivity. Some control systems also support SNMP, which provides possibilities for integration with other network monitoring systems.

In combination with room monitoring, such systems can also replace the traditional control room at the back of an auditorium and can thereby provide better user support even in an operating organisation with limited resources. Note however that this necessitates the availability of operating personnel with relevant skills.

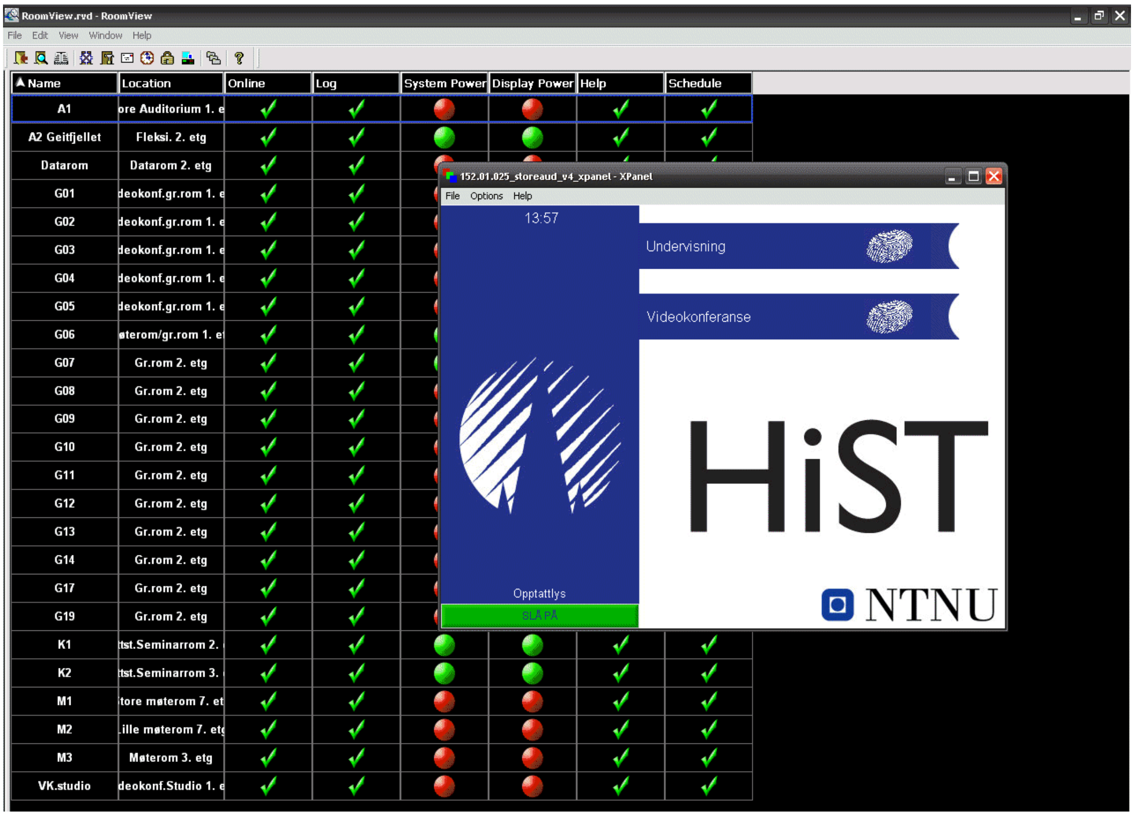

Figure 1. An example of a screenshot from operational support software. An overview showing the operational status of each room and a user interface for remote operation of one of the rooms.

It is recommended that all control systems in teaching rooms, standard meeting rooms and video conference rooms be supplied with a system for assisted presentation, operation and monitoring by way of the computer network, cf. the recommendations in UFS 116 for different types of rooms. Technical and functional system requirements for integrated control systems are provided in Section 5.1 of UFS 119.

2 Monitoring equipment status

Modern teaching premises contain a number of different systems for monitoring and operational support:

- Building automation (demand management, remote control and monitoring of heating, ventilation, sunshades, lighting, and so on, based on sensors and switches or control panels in individual rooms)
- Fire alarms
- Closed circuit television and access control (CCTV)
- Network monitoring (SNMP)
- Operational support systems for AV equipment

These systems normally function independently of each other with only limited exchange of information between them. This is practical with regard to robustness, compatibility and the simplicity of interfaces, even though it is technically possible, for example, to use information from CCTV/access control and from motion sensors and impulse switches to detect activity in rooms containing AV equipment.

It is an advantage if all components and rooms can be handled through a common interface in order to attain a robust, user-friendly system for monitoring equipment status. This necessitates both a remote monitoring system which supports all the control systems comprising the installation and two-way communication between all the equipment units to be monitored and the control systems in the individual rooms.

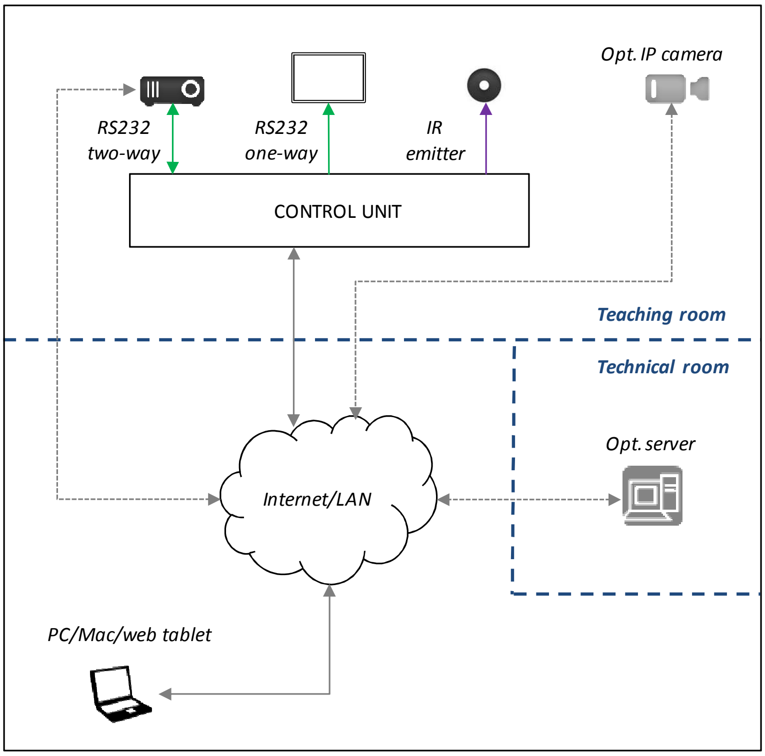

Figure 2. Schematic diagram of the transmission of control signals between equipment components, control unit and shared operational support system.

AV equipment is generally not Ethernet-compatible and is normally based on local control by means of infrared (IR) or RS232 connection from a control unit located in each room. Some equipment units have network connections for monitoring, configuration or transmission of source material (typically video projectors, flat-screen displays, video conference equipment and advanced audio and video processors), but these are rarely used for their general control. On the other hand, it is relatively common to monitor the status of video projectors through a computer network, cf. Section 2.1.

The most important units to monitor are video projectors, owing to the need for regular replacement of lamps and filters. It is also an advantage to be able to receive status information from other important equipment such as video conferencing codecs, audio processors, scalers, Blu-ray players, etc. This is particularly important in the event of electrical power cuts, in which the receipt of status information is often essential for establishing robust reset routines.

Status information for individual equipment units is normally transmitted via control units in the individual rooms to a common server or PC in which room-monitoring software is installed. Proprietary protocols are generally used, making the integration of control systems from different manufacturers difficult. However, it should be noted that some manufacturers also support monitoring and remote operation of control systems produced by other manufacturers, as mentioned in the introduction to Part II Operational support.

Some control systems also support SNMP, which provides possibilities for integration with other network monitoring systems. Because this is as yet only implemented to a limited extent by control system manufacturers, it is advisable to check for SNMP support, especially if this is an important criterion when making new purchases. However, because of the increasing merging of the AV and IT worlds, it is expected that more manufacturers will support SNMP in the near future.

Under any circumstances, it is recommended to combine operational functions for AV equipment and network services in a shared room or operational centre. This is advantageous with respect to both resource use and for ensuring good communication between AV managers and IT operations personnel. In many cases these will also be the same staff.

2.1 Two-way communication with equipment units

All equipment which is to be able to transmit status information to the control system must have two-way communication with the control unit, normally by means of bi-directional RS232 or IP-based connection. It is important to ascertain that the control unit which it is planned to use has adequate bi-directional ports, based on an analysis of how many equipment units should be able to transmit status information. Be aware that in most models of control units, only a small number of the RS232 ports support two-way communication, which is often the crucial characteristic when selecting a model. Alternatively, it is possible to expand the control unit using external IP-based units providing one or more RS232 ports.

Most projectors these days are supplied with network connection and special software for monitoring lamp life and so on. This software normally also supports notification via SMS or e-mail when the time for replacing the lamp or filter is approaching. This can be an alternative if the control unit does not provide enough bi-directional ports.

2.2 Areas of use and information requirements

In addition to keeping track of service intervals for projectors, it is useful to be able to receive fault notifications from other equipment components and to see which components are switched on or connected. This can be a useful aid to the prompt discovery of faults which lead to operational shutdowns, making it possible to correct faults or if necessary reschedule planned activity, thereby avoiding interruptions in teaching.

In daily operations, however, status information from the individual control units is the most important information, indicating which rooms are in use or switched on. This can be used both for *ad hoc* room reservations and to switch off equipment in rooms which users have vacated without switching it off. This depends on being able to ascertain whether there is anybody in the room, typically by means of motion sensors or an IP camera installed in each room (cf. Chapter 4 Monitoring in connection with remote support).

Many remote monitoring systems have a user interface which includes a common overview of key parameters for all rooms and easy access to detailed information and remote control of individual rooms. This is an important function, particularly in the case of systems serving a large number of rooms.

3 Remote support and assisted presentation

The principal intention of remote support or assisted presentation is to assist a lecturer or meeting organiser when the need arises, without entering the room in question. This applies in the event of equipment failure, uncertainty regarding operation or the connection of portable equipment, and so on, or when help is required in the actual presentation of the lecture or meeting. The latter is particularly important when setting up and, if necessary, controlling distance learning and video conferences.

Systems are based on remote control of equipment in a room by way of a PC, Mac or web tablet, using a user interface which is either identical to that displayed on the control panel in the room or may if desired include advanced functionality which is not intended to be available to ordinary users. It is also possible to include expanded functionality such as controlling AV players even if the room control panel has only on/off, source selection and sound level controls.

A good solution is to use a portable PC with a touch screen (tablet PC) or a web tablet, which will result in operation resembling an ordinary touch screen control panel. The software is often supplied as part of a control system and is typically integrated with a remote monitoring system (cf. Chapter 2 Monitoring equipment status), but developing user interfaces for each individual room type nevertheless requires a certain amount of additional programming.

To obtain full benefit of the possibilities for remote control it is important to be able to see what is happening in a room at all times. This may be achieved, for example, by installing a controllable IP camera in each room, covering the vicinity of the presentation wall. IP cameras can also be supplied with built-in microphones, although the audio quality is limited and can only be used for simple functional control or information, and not for adjusting the sound system. Various aspects of remote monitoring of rooms are discussed in Chapter 4 Monitoring in connection with remote support.

It is also necessary to be able to communicate with a lecturer. Many control systems include integrated solutions for two-way communication with lecturers by means of a microphone and loudspeaker installed in the control panel, but a mobile telephone will also often be an acceptable solution, provided that the number of the system operator is clearly displayed on the control panel.

In many cases a system for remote support and assisted presentation will obviate the need for the traditional control room, or projection room, found at the back of many auditoriums. Experience shows that these rooms are rarely used as anything other than technical rooms to house equipment, primarily because of the operating organisation's limited resources. Setting up additional connections and equipment for remote control in the projection room also increases expense. If a tablet PC is used for remote control as suggested above, it will also be possible to use this as an extra control panel locally in the room for special events requiring local assisted presentation (panel discussions and so on).

4 Monitoring in connection with remote support

As described above, it is important to be able to see what is happening in individual rooms in order to provide effective assistance for the purpose of remote support and assisted presentation. This can also be used in connection with *ad hoc* room reservations or to switch off equipment in rooms which users have vacated without switching it off.

Audio transmission is considered of lower importance, except when needed to assist a lecturer or meeting organiser in carrying out set-up or fault rectification. Audio transmission will also present significantly more problems with regard to confidentiality, especially in meeting and group rooms where users normally wish to be in control of who can follow conversations. It should therefore be possible for any systems for audio transmission to be switched on and off manually by the users in individual rooms.

The situation is different with regard to video transmission, both because confidentiality issues are less significant and because the system operator needs to be able to see what is happening in individual rooms even when there is nobody in them. However, there are situations in which users will want to prevent anybody seeing what is happening in a room, for example in the case of private conversations or some practical classes in health education. Moreover, knowing who is able to observe events in a room is a significant factor connected with users' perception of privacy.

High-resolution video from individual rooms are not necessary, but it is useful to be able to remotely control a camera (pan, tilt and zoom). The camera should be located so that it is possible to obtain an overview of the vicinity of the presentation wall.

Ideally, a switch and status indicator should be provided in each room, giving users the possibility of seeing when the system operator wishes to activate the IP camera, which they may either accept or reject within a period of, say, 15 seconds. After this time window, the camera will be switched on automatically. This functionality may also be integrated into the control system. Unfortunately a solution of this type is not easily implemented, and users may have to accept that they cannot control whether the system operator is able to see what is happening in a room. Of course, IP cameras must under all circumstances be adequately protected against access from outsiders, preferably by using a combination of a dedicated VLAN for AV equipment and password protection.

Information obtained from the Norwegian Data Inspectorate regarding the use of IP cameras for this purpose has led to the conclusion that it is sufficient to provide notices at each entrance to the building as well as inside each room, advising that the rooms are monitored by cameras in connection with operational support for AV installations. It will therefore be up to the individual institutions to decide what technical arrangements and routines they wish to adopt for providing such advice.

VIDEO CONFERENCING INFRASTRUCTURE III

5 Requirements for network infrastructure

Video conferences and distance learning are becoming an increasingly important element of what universities and colleges have to offer. This applies particularly to colleges which have many decentralised units which must be linked together. In addition, many institutions are in the process of establishing so-called unified communication systems as an integral part of the tools used by individuals, and seamless integration between dedicated rooms for video conferences and distance learning and video conversations from individuals' own portable PCs, irrespective of location, is becoming increasingly important. Moreover, an increasing amount of media content, such as IPTV, infosystems, IP telephony, streaming of lectures, and audio and video distribution between rooms, will be distributed via the local area network (LAN).

This development naturally entails a dramatic increase in the need for robust handling of real-time data traffic, and special focus must therefore be directed towards taking into account the future demands of such traffic when designing new network infrastructure. The keywords are capacity and bandwidth, Quality of Service (QoS), multicast streaming, IGMP Snooping, response time and delay. Recommended configurations for network infrastructure are described in other UFS documents, see https://ow.feide.no/gigacampus:ufs. Apart from this, the requirements for network infrastructure will not be considered here.

The coming AVB standards for IP-based audio and video transmission, described in Section 9.2.1, will also require that switches and routers support AVB, so as to achieve maximum quality and robustness.

See also Part IV "Audio and video transmission".

6 Multipoint control unit

When considering whether to purchase a multi-party video conference unit, also known as a multipoint control unit (MCU), the following should be taken into account:

Many universities and colleges need to be able to arrange high quality multi-party conferences, often several parallel conferences.

The most commonly used video conferencing codecs have optional multi-party functionality, but only of limited quality. In practice, reduced quality is experienced when several parties are connected together, and the maximum bandwidth is reduced. Built-in multi-party functionality also has limited flexibility with regard to video configuration (the way in which the various participants are displayed). If high video quality (HD/720p or better) or support for a large number of simultaneous participants is desired, the video conferencing codec's built-in multi-party functionality is in practice not very suitable unless a particularly advanced codec is chosen. On the other hand, built-in multi-party functionality is useful for *ad hoc* meetings, or in cases where an additional participant is to enter a normal two-party conference.

The alternative is to invest in a dedicated MCU or lease this service from an external provider. If a dedicated MCU is acquired, this resource should be shared by the entire institution and the capacity should be considered based on all existing and planned video conference and distance learning requirements in the years ahead. The need for simultaneous connection to several parties should also be taken into account. For example, colleges with a large amount of decentralised teaching (such as Harstad University College (HiH) and the nursing faculty of Sør-Trøndelag University College (HiST)) have a greater need for this type of service than traditional universities. In many cases, amalgamation of institutions also results in greater use of distance learning and video meetings, and hence in increased demand for multi-party support.

When selecting the type of MCU, it will be necessary to consider the potential number of simultaneous participants and simultaneous conferences. The MCU should provide complete flexibility with regard to simultaneous conferences, with the number of ports being equal to the total number of participants in all conferences. As an example, a 12-port MCU should be capable of handling a 3-party conference, a 4-party conference and a 5-party conference.

These days support for a minimum of HD/720p resolution for all parties should be the standard requirement, with flexible video configuration and so-called full transcoding. Full transcoding means that all participants shall receive optimal audio and video quality based on the available bandwidth and the properties of their own video conferencing codecs, independently of the other participants in the conference.

The video conferencing market appears to be evolving towards the use of scalable video coding (SVC). Two or three of the larger suppliers currently offer proprietary systems based on SVCs. SVC is standardised in the MPEG-4 format. If or when more of the available client equipment is capable of supporting this type of scalability, the need for an MCU with transcoding capability will practically disappear. Downscaling will take place by discarding packets, and the MCU will in other words function more like a router.

The advantage in investing in one's own MCU rather than leasing such services is that one attains full control over this component of the video conferencing system, and that with adequate capacity and operational expertise, it will be possible to provide a simpler and more user-friendly system to end-users such as lecturers.

At the same time, leasing MCU services could become more reasonable if the demand is low or highly variable, and less demand is placed upon the operational organisation. In addition, costs will be moved from investment to allocated costs over time.

One should also consider how system-critical the MCU service is for the organisation. If one relies on MCU functionality for daily teaching, systems providing redundancy should be developed, for example by means of simple access to leased services or built-in multi-party functionality using a video conferencing codec, while providing good routines for fault logging and fault support.

Moreover, it is important to consider a potential investment in an MCU in connection with other centralised equipment for video conferencing and distance learning. To achieve a robust operational situation in communication with parties located outside the institution's computer network, additional units may be needed to handle firewall traversing and address translation. This could be important with an eye to both security and user-friendliness.

7 ISDN gateway

It is recommended that support for ISDN connectivity be provided by means of an external gateway, either as a local shared resource or as an external service. The individual video conferencing codecs normally only provide support for SIP and H.323.

If the organisation has older video conferencing codecs which only support ISDN connectivity, one should consider whether to replace these rather than making major investments in supporting outdated technology. However, it will be practical to have the ability to connect to parties who only have support for ISDN connectivity, not least because it is convenient to be able to connect via telephone lines.

Support for ISDN connectivity should be a resource shared by the whole institution, being available but not allocated major resources.

8 Other video conferencing infrastructure components

The following additional video conferencing components and functions may also be of interest:

- Firewall traversing (SIP/H.323)
- Address translation and conversation filtering (H.323 gatekeeper/SIP proxy, SIP registrar)

The main purpose of these functions is to ensure robust connection to external networks and organisations. This applies to security aspects, robustness with regard to conversation quality and user-friendliness when setting up conversations and conferences.

In addition, many institutions wish to integrate unified communication systems with the traditional video conferencing systems. Not least, it is of interest to be able to use one's own PC for communication with video conferencing clients outside one's own organisation. Moreover, systems in which one can be called up at a unique personal address and in which the connection request is forwarded to different clients or terminals depending on where one is located are a fundamental concept in unified communication which is expected to become far more important in future. This type of integration is still technologically relatively immature, and although development is rapid, there are few suppliers which can at present provide transparent, robust systems.

The need for the above-mentioned functions must be considered on the basis of the following factors:

- Complexity and the number of video conferencing endpoints in the organisation or institution
- Network capacity
- Network structure and the need for connection to external parties
- Requirements for accessibility and low user threshold

This list is not exhaustive.

The different manufacturers offer different products and systems to provide the above-mentioned functionality, to a varying extent combining different functions in one and the same product.

It can be difficult to evaluate how great the demand for such additional functions actually is, and whether the investments are in proportion to their usefulness from the point of view of both the users and the operating organisation. This applies not least in connection with dialogue with the suppliers. This document does not contain a detailed review of these issues. To obtain background information, we recommend the use of Wikipedia and other net-based knowledge bases, and also consulting UNINETT's technical personnel.

Systems for recording and streaming of video conference sessions are dealt with in Part IV "Audio and video transmission".

AUDIO AND VIDEO TRANSMISSION IV

The ability to distribute or receive lectures and presentations in the classroom is becoming an increasingly important function. This is because of the need to improve the efficiency of resources used in teaching and the desire to make it possible for students to follow lectures without being physically present in the auditorium.

Systems for audio and video transmission between different rooms on a campus or to external parties are primarily used for:

- Decentralised teaching
- Adaptation of teaching to flexible group sizes, so that more students than there is room for in the auditorium or seminar room can follow lectures simultaneously
- Repetition and possibilities for following lectures which one has missed
- Showing live demonstrations and training situations to a large audience. This is of particular interest in medical studies.

9 Centralised distribution of audio and video

Point-to-point transmission between rooms is a natural element of a larger system for the flexible distribution of lectures and presentations. It will normally be practical to route all signals by way of a common point, typically a centrally-located telecommunications room.

The objective of this sort of distribution system is to achieve flexible routing of one or more audio and video streams from each of the relevant source locations to one or more reception locations. The receiver can either be a distribution unit located at the central hub, or some other room on the campus. The system should not result in noticeable quality deterioration, irrespective of the signal format and distance between source and receiver.

9.1 Transmission by twisted pair or fibre-optic cable

In most cases, because of the cable lengths involved, it will be necessary to use encoders and decoders based either on twisted pair cables (Cat 5/6) or multi-mode (MM) or single-mode (SM) fibre-optic cable, adapted to the signal format and transmission distance. While this increases the equipment costs in each room, the circuit wiring will be less expensive than for conventional audio and video cables. A basis for selecting encoder and decoder types is provided in Section 9.1.3

9.1.1 Decoding and re-encoding at a central hub

One way of building up a centralised distribution system has traditionally been by using point-to-point transmission with all sources being decoded at a central hub. The actual routing can then be achieved with the help of conventional video matrices before the signal is re-encoded for forwarding to the reception room. In small systems this is a cost-effective solution which with the correct choice of encoder and decoder units can achieve almost transparent audio and video quality. The disadvantage is of course that it makes use of many boxes and unnecessary coding and decoding steps, which results in both reduced operational reliability and increased risk of signal degradation.

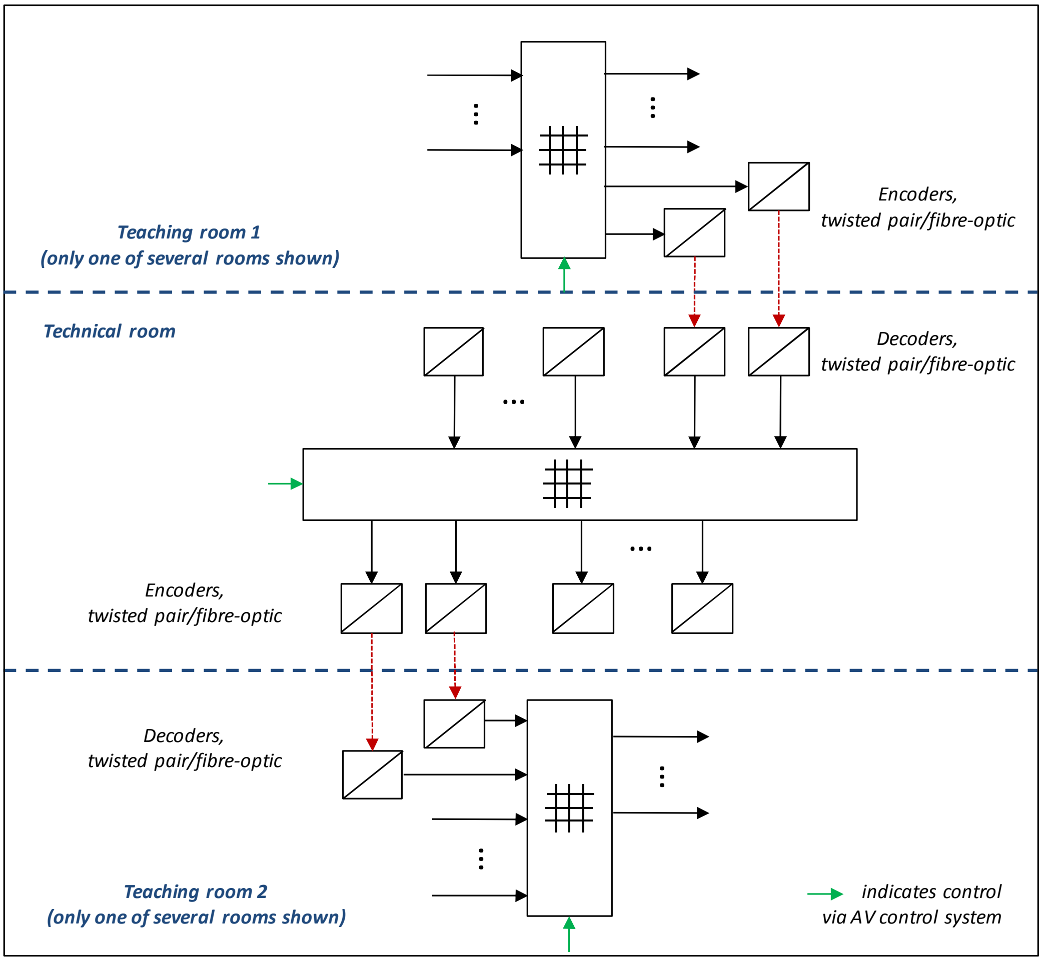

Figure 3. Schematic diagram of a centralised distribution system based on decoding and re-encoding in a central hub.

9.1.2 Signal routing without decoding and re-encoding

Several systems have recently emerged on the market which support signal routing and matrix functionality without decoding to the original signal format. These systems normally assume that all encoders, decoders and matrices/routers are of the same make and use the same type of transmission medium (twisted pair cable, MM or SM fibre-optic cable). Several systems also have modular structure in which different encoders, decoders and signal routing units can be installed in a shared chassis as required. Systems of this type have until now been relatively expensive and primarily of interest for use in larger installations, but they are now becoming competitive with systems as described in Section 9.1.1.

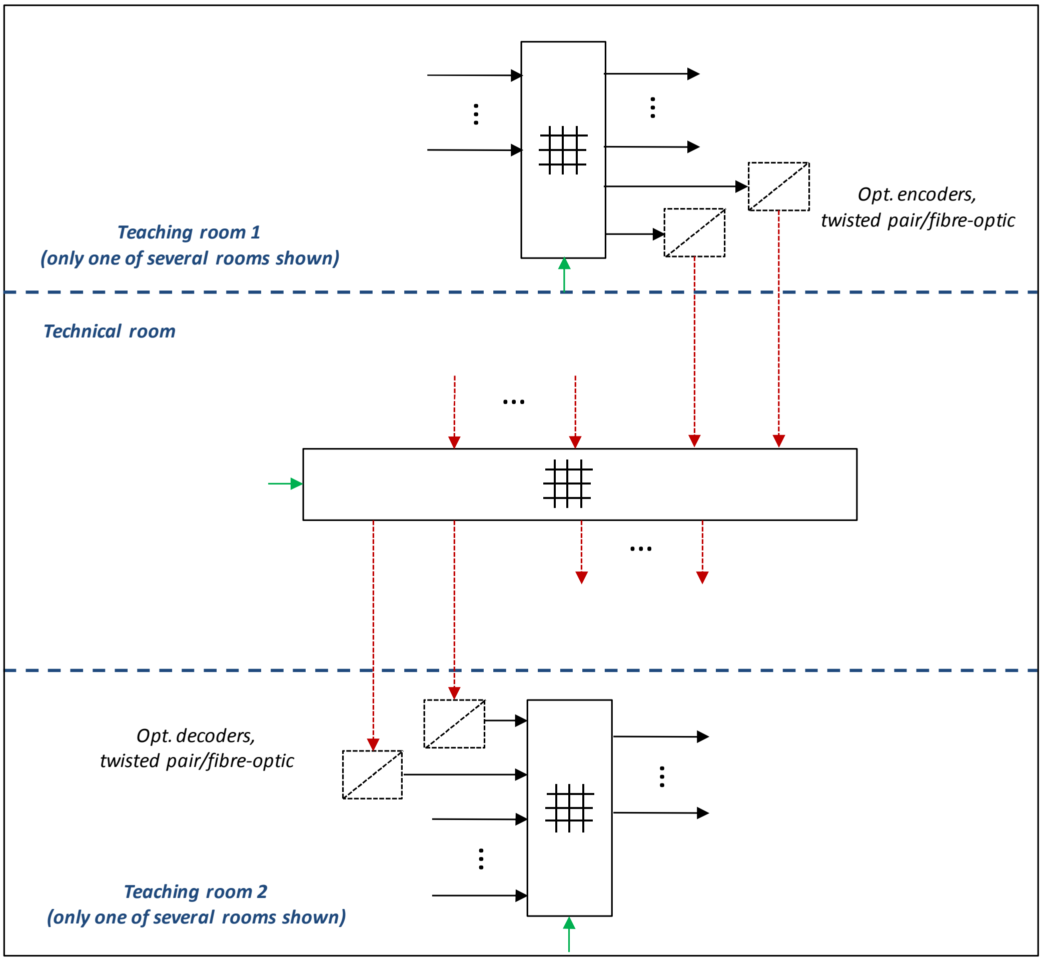

Figure 4. Schematic diagram of a centralised distribution system without decoding and re-encoding in a central hub.

9.1.3 Selection of encoder and decoder type

Selection of the type of converter must be based on the type of signal, required video resolution, cable length and any requirements for galvanic isolation. These days, all general infrastructure should be designed for at least WUXGA/1080p60 resolution.

The following is a general consideration of the various alternatives:

Twisted pair cable

Inexpensive wiring and inexpensive encoders/decoders. Can provide WUXGA/1080p60 resolution at distances of up to 100 metres, depending on cable type, type of encoder/decoder and source signal quality. Products are also available which are specified for use with greater cable lengths, but these support lower maximum resolution and are therefore not appropriate for transparent distribution systems which support high-resolution video signals.

Particularly in the case of analogue high-resolution signals (VGA/RGBHV) so-called skew compensation[1] may be needed.

Standard unshielded Cat 5E/Cat 6 cable can normally be used. Note that some systems for high-resolution digital video signals (DVI/HDMI) require two twisted pair cables per encoder/decoder set.

[1] Each colour in an RBG signal is transmitted separately over its own twisted pair in a Cat 5/Cat 6 cable. Skew is distortion arising because of differing lengths of the different pairs in the cable, and may be compensated for by delaying one or two of the colours after decoding.

If one is approaching the specified maximum cable length, it is advisable to test the planned equipment and cables, including the correct signal source and display configuration, before completing the installation. Note also that static source material (text and figures) is substantially more revealing with regard to signal degradation than, for example, video.

For a detailed treatment of problem issues connected with the transmission of video signals using twisted pair cables, see http://www.extron.com/download/files/whitepaper/tp_opt_wp.pdf .

SM fibre-optic cable

This needs significantly more expensive encoders and decoders than twisted pair cable, but potentially allows significantly greater cable lengths with close to transparent signal quality. Fibre-optic cable is also the only alternative which can be used between buildings where galvanic isolation is required. Transmission based on SM fibre is considered the most forward-looking solution and is also attractive because it enables the creation of a general cable structure for different types of high-resolution signals.

MM fibre-optic cable

A reasonably-priced alternative which was previously in common use but which is not recommended for new installations. Variations exist based on from one to four fibre-optic cables per encoder/decoder set. Decoders and encoders are less expensive than for SM fibre, but the price difference is not enough to justify the disadvantages compared with using SM fibre. MM-based systems also have a shorter range than systems based on SM fibre.

It is also expected that prices of fibre-optic encoders and decoders will fall in step with increasing volume of manufacture.

In principle, there is nothing to prevent combining different types of converters in the same system, but the potential cost reduction must be considered in relation to reduced scalability and flexibility, combined with operational considerations.

One may also consider using the LAN infrastructure for point-to-point transmission by way of twisted pair cables, by patching vacant ports in individual rooms directly through the telecommunications room. (NB: Connection cannot be made using a switch.) However, it should be noted that this type of configuration may result in unnecessarily great cable lengths and the patch point itself may lead to significant signal loss. In principle it is therefore recommended to use dedicated cabling between encoders and decoders.

In general it is advisable to plan a certain number of dedicated twisted pair and SM fibre-optic cable connections to all auditoriums and seminar rooms in new buildings or renovations. These should be terminated in a centrally-located telecommunications room where it will be natural to install any central matrix system.

The following is a comparison between extender systems based on twisted pair and SM fibre-optic cable.

Twisted pair cable	**SM fibre-optic cable**
- Low Price - Maximum length for high resolution (WUXGA/1080p60) video signals is 50-100 metres - Enables signal routing without signal conversion	- Higher price - Maximum length up to several kilometres - Provides galvanic isolation (necessary between buildings) - Resistant to electromagnetic interference

Table 1. Comparison between characteristics of encoder/decoder systems based on twisted pair cables and fibre-optic cables.

9.1.4 Integration with control systems

It will normally be practical to install a separate control system to be used for configuration and source selection in a matrix system. This simplifies both integration with the control systems in the individual teaching rooms and remote control by way of the operational support system. There is often also a need to control other components in the central distribution hub, as described in Chapter 10 Alternative distance learning systems. The encoders and decoders themselves do not normally need external control after they have been configured.

In many cases the control unit does not require its own control panel, but this must be considered when designing each separate system.

9.2 IP-based audio and video distribution

Proprietary network-based systems currently exist for audio and video distribution based on dedicated local networks, using either fibre-optic or copper wire technology. These systems are most commonly used in the professional audio and video industry (broadcasting, theatre and concert facilities), but have only to a limited extent been used in typical AV installations. The reasons are the price, the lack of standardisation and challenges connected with format support and bandwidth requirements for high-quality video signals.

Several good hardware encoders are available, based on open standards, which are very suitable for one-to-many distribution and for storage and recording, also in interconnection with other data traffic. These are principally based on H.264 (MPEG-4 Part 10) and depending on functionality they can encode video signals with resolution up to 1080p. However, it should be noted that a 1080p60/WUXGA video signal in H.264 format will require bit rates of 4-20 MB/s, depending on the source material and transparency requirements. With the current capacity of campus networks this bandwidth requirement in itself is not a problem, but if there are to be a large number of simultaneous streams approaching transparent quality, the bandwidth requirement will be considerable. An important point is that this type of traffic is sensitive to packet loss, jitter and network saturation, presenting challenges with respect to robustness, especially if dedicated physical networks are not used. Moreover, only a limited number of systems exist which ensure an integrated infrastructure in which logical signal routing can easily be controlled from a common operational platform – that is, hardware encoders and decoders which can easily be remotely controlled from a common user interface, preferably integrated with operational support systems as described in Part II.

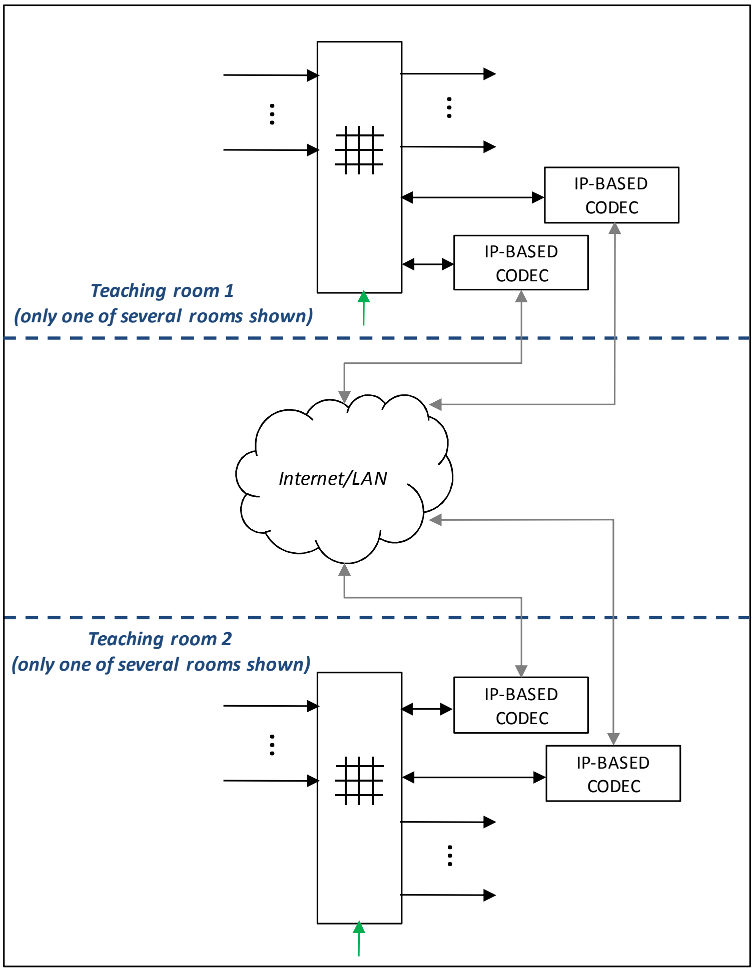

Figure 5. Schematic diagram of IP-based audio and video distribution

Until the various suppliers agree on a common standard to be implemented for an adequate number of different products, there is little indication that IP-based solutions will be particularly attractive as a basis for centralised audio and video distribution in universities and colleges. Another important point is of course that it is preferable to be able to use the LAN also for audio and video distribution, without needing to establish separate physical networks, and at the very least without needing to use dedicated wiring installations or cable types.

However, products are available in this category which may be of interest for use in certain cases. These are in practice streaming units (IP-based codecs) which are connected together in a local network, typically with a shared control unit located in the network which can be integrated with a standard control system.

It is expected that there will be a clear trend towards network-based distribution of audio and video, and that in the relatively short term a number of new products will appear which will make this type of system attractive with respect to both price and robustness. It is also worth noting that there is increasing interest in open standards for audio and video coding, in particular WebM with VP8 and Vorbis, which a number of major operators are planning or have implemented support for.

Scalability, obviating the need for dedicated wiring and the use of open standards, simplifying distribution and reducing the need for conversion between source and receiver, will be important characteristics in connection with the transition to IP-based audio and video distribution.

9.2.1 Audio/Video Bridging (AVB)

The coming IEEE 802.1 standards for Audio/Video Bridging (AVB) represent a very promising solution. The purpose of the standards is to ensure robust transmission of audio and video signals of professional quality within the framework of IEEE 802-based computer networks. The standards are intended to ensure robust and precise handling of clock signals, to ensure that adequate bandwidth for a given media stream is allocated in all network elements in the signal chain and to define queuing and forwarding rules which ensure that the desired media stream reaches the receiver within a given maximum time delay.

AVB shall make it possible to transmit audio and video streams via standard network connections simultaneously with other data. Within a subnet in which all components support the AVB standards it will be possible to achieve robust transmission with predictable quality and delay, independently of other traffic in the same subnet. These characteristics mean that AVB may be the solution many have been awaiting for as regards the distribution of audio and video signals. In the long term this may also become an attractive alternative for signal transmission between different local audio and video units in teaching rooms.

It is too early to say if and when an adequate selection of equipment supporting AVB will be commercially available, but it is a positive sign that many significant commercial operators which have previously not officially collaborated have created a forum for the implementation and promotion of AVB, the AVnu Alliance (see http://www.avnu.org/). The forum includes both network operators and professional audio and AV suppliers. The AVnu web page includes, among other things, some white papers providing relatively easily comprehensible presentations of the technology and areas of use.

For more detailed background on AVB it is recommended to refer to http://en.wikipedia.org/wiki/Audio_Video_Bridging, as well as the IEEE AVB Task Group's web pages at http://www.ieee802.org/1/pages/avbridges.html.

10 Alternative distance learning systems

This chapter contains a description of distance learning configurations for teaching rooms. Section 10.7 also provides a summary of the advantages and disadvantages of the various configurations. The chapter is intended to be a tool in the planning phase with respect to the clarification of needs and user groups.

Infrastructure for centralised distribution of audio and video signals will be an important component of a number of the configurations presented in this chapter. This is described in more detail in Chapter 9.

Note that being able to distribute lectures to external parties places greater demands on both the lecturer and the operational organisation. Particularly with regard to setting up the sessions and in cases where two-way communication with external students is desired, this form of teaching is more demanding for the lecturer than traditional local teaching. Not least is the challenge for the lecturer of avoiding uncertainty regarding the use of the AV equipment, and of succeeding in maintaining focus on the students present in the same room.

The following factors are important for reducing the challenges connected with distance learning:

- Having adequate capacity and expertise in the operational organisation to provide prompt assistance when the need arises. Ideally, the operational staff should also be able to assist in setting up distance learning sessions.
- Putting enough work into the development of user interfaces on control panels so that their configuration and operation is found to be intuitive.
- Placing emphasis on good training, labelling and design of instruction manuals. This applies to the actual operation of the AV systems, how to conduct oneself in relation to local and remote students and how to use the various presentation tools so that the teaching is a positive experience also for those present in the room.
- Establishing configurations which call for the smallest possible amount of moving, connection and physical adaptation of equipment before use.
- Placing emphasis on good integration of cameras, support monitors, and so on, in the room (see the recommended configurations in Chapter 8 of UFS 116).
- Placing particular emphasis on good lighting and room acoustics when designing teaching rooms (see Chapter 8 of UFS 116).

Systems for remote monitoring and assisted presentation as described in Part II Operational support are important components which simplify the role of the lecturer. It is therefore advisable to place considerable emphasis on creating efficient operational support systems if distance learning is to be an important element of the teaching schedule. Specific requirements for remote control are dealt with in the description of each alternative distance learning configuration.

See also Chapter 5 Requirements for network infrastructure.

For each of the alternative configurations a schematic diagram is presented showing the signal flow between the primary components of the system. For the sake of simplicity the diagrams only show the arrangements for video transmission.

10.1 A. Complete distance learning system based on video conferencing codec

This is the traditional distance learning configuration and includes the following components:

- Camera directed at the lecturer
- Camera directed at the audience
- Microphone system for lecturer and if necessary audience
- Video conferencing codec and if necessary an video scaler
- Support monitors and sound reproduction of remote parties for the lecturer's use

See the detailed description in Chapter 8 of UFS 116.

There should be possibilities for complete remote control of all functions of the AV installation, including setting up distance learning sessions, source selection, camera control and adjustment of microphones (sound level and muting).

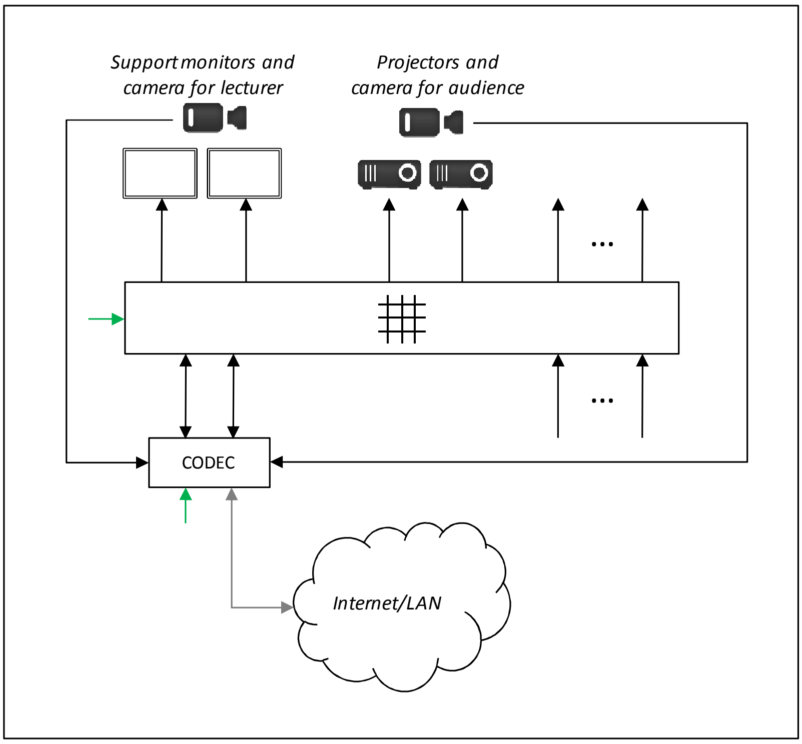

Figure 6. Schematic diagram of video distribution using a complete distance learning system based on video conferencing codec.

A number of institutions have also created their own distance learning studios, equipped with a complete presentation system with whiteboard, lectern with PC, interactive pen display and so on, as well as a distance learning configuration as described above, with the exception of cameras and microphones directed towards the audience. These rooms are used both for distance learning without local students and for holding exams, among other things. In combination with streaming systems as described in Alternative C, the studios are also used extensively in the pre-production of lectures.

A low-cost alternative is based on so-called desktop video conference systems, in which the lecturer uses, for example, his own office instead of a dedicated distance learning studio. A configuration of this type may either be based on stand-alone personal video conferencing systems or on PC-based systems with web cameras and software encoding/decoding. Although the latter alternative has low investment requirements, video encoding of good quality (720p or better) is very processor-intensive and therefore requires a powerful machine which is not used for other demanding applications during the distance learning session.

It is also important to remember that the users' perception of quality depends not only on bandwidth and the quality of the encoding itself, but also on lighting conditions, video background, cameras, microphones, background noise and the acoustic properties of the room. A dedicated distance learning studio will hence provide completely different possibilities for producing distance learning sessions with predictable, high quality, in which the students perceive the presentation as a good alternative or supplement to ordinary lectures.

10.2 B. Simplified distance learning system based on video conferencing codec

As above, but without support for communication from remote parties. This configuration is primarily based on one-way communication from the lecturer to remote students.

The support monitor showing remote parties is dispensed with. A monitoring function for outgoing video can be provided by means of a PC monitor located on the lectern or possibly integrated in the control panel. The camera directed at the audience can also be dispensed with if necessary.

The only way in which remote parties can pose questions is by instant messaging or similar functions. If desired, support for audio and video transmission from a remote party may be included.

The requirements for remote control are the same as for Alternative A, but with reduced complexity as a result of fewer components.

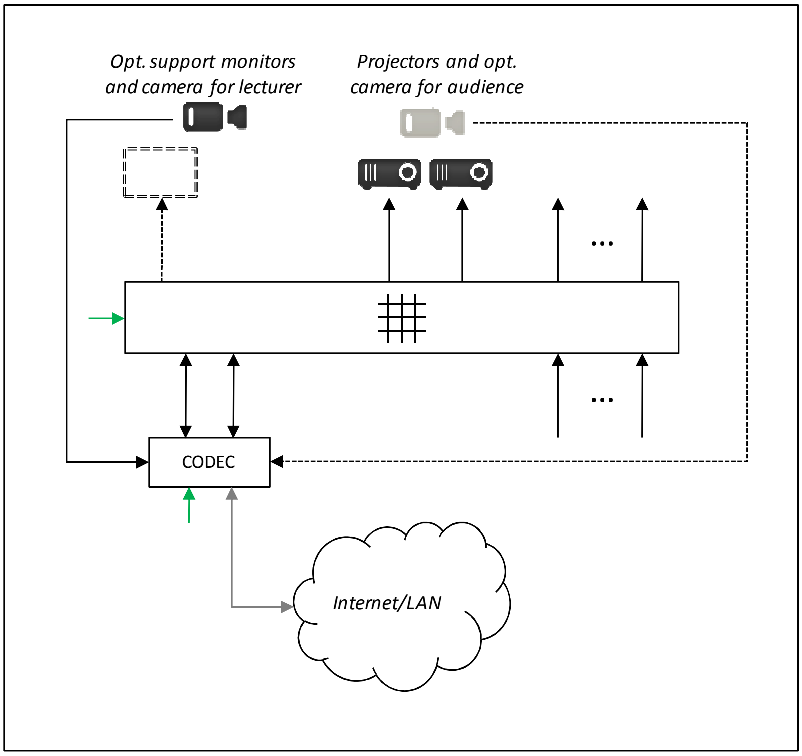

Figure 7. Schematic diagram of video transmission for a simplified distance learning configuration based on video conferencing codec.

Alternative B may also be of interest for distance learning or pre-production studios where seeing the remote party is not important.

10.3 C. Streaming via the Internet and podcasting

Being able to distribute lectures to students' portable PCs, smartphones, web tablets, and so on, is becoming increasingly important and is an important supplement to the traditional distance learning concept in which students follow the lecture from a classroom or meeting room using video conferencing equipment. It is also of interest to post podcasts of lectures for direct downloading or distribution via subscription services.

In connection with streaming to mobile terminals, instant messaging or possibly e-mail are currently the most likely methods for putting questions to the lecturer. In the long term, *ad hoc* video connection from mobile terminals may become possible.

An important criterion for achieving a positive user experience is to be able to distribute media content at various qualities, adapted to the characteristics of the terminal. Ideally, each lecture should be available in a selection of formats and qualities, thereby providing optimal quality on everything from smartphones with small screens and limited bandwidth to PCs and large screens with fast network connection, without the user having to think about which quality is most suitable for his terminal and bandwidth. At present there is unfortunately limited format support, possibilities for parallel coding at different qualities (so-called multi-rate coding) and automatic selection of optimal quality for the most common streaming concepts. In the long term, scalable video coding (SVC), as described in Chapter 6 MCU, will provide substantially more robust and less resource-demanding encoding systems.

Technical and functional system requirements for integrated control systems are provided in Section 4.19 of UFS 119. These are based on the need to transmit audio, video and a presentation (basically static images), with the user having possibilities for flexible configuration of video and presentation. A prerequisite is that it shall be possible both to transmit streaming sessions in real time and to save and index them for later playback. Most streaming systems consist of one or more recorders/encoders and a shared server to handle the storage, indexing and playback of recordings.

If the room also has a traditional distance learning system as described in Alternatives A and B, the video conferencing camera may also be used as a video source for the streaming system. This assumes that the video output from the camera is split, preferably before the video conferencing codec, and that the control system is programmed so that the camera can be remotely controlled independently of whether or not a distance learning session has been set up. Some cameras must be controlled via the video conferencing codec, but most new video conferencing cameras support the VISCA protocol and can therefore be controlled directly from the control system using RS232 connection.

In rooms without a traditional distance learning system, where a dedicated camera must be used for streaming, the same basic requirements are placed on quality, controllability and location as with traditional distance learning systems, but it is advisable to use a camera which can be controlled directly from the control system, preferably by means of VISCA and RS232.

In addition to the above-mentioned, the following characteristics are important for achieving good quality and a user-friendly system in which editing and setup are not unnecessarily time-consuming.

- Good algorithms for detecting changes in images in presentations.
- Intelligent handling of video presentations.
- Good support for handling metadata, preferably also with the help of automatic text recognition in presentations.
- Flexible facilities for pre-programming setup and starting/stopping of streaming sessions.
- Flexible facilities for the organisation, searchability and structuring of recordings of sessions.

There are currently few systems which effectively support all the functions mentioned above and in UFS 119. As a result there is little competition and it is also difficult to find good, robust open systems.

In addition to the actual investment cost, a major challenge is that demand for distribution of lectures is expected to increase dramatically and in time this type of functionality may become an integral part of ordinary lectures. This will call for both considerable operational capacity and effective solutions for handling large volumes of media content. While the latter should be attainable, a greater challenge will be achieving a robust, user-friendly system which is easy for lecturers to set up, requires little administration and editing and at the same time provides a positive user experience to students.

The important challenges are therefore to ensure:

- Good integration with other AV equipment and control systems in individual teaching rooms. Ideally lecturers should only need to press “Start” and “Stop” to record and distribute lectures.
- Favourable camera location and well-planned design of the lecture site and presentation facilities, so that the need for manual adjustment of the camera is kept to a minimum.
- Well thought-out system design with regard to the location and, if necessary, shared use of streaming systems.

Because of the investment costs it will be of interest to share recording and distribution units between two or more rooms. A prerequisite for this is that a system be established for centralised audio and video distribution, as described in Chapter 10, but it will also be crucial to consider potential conflicts and capacity problems as the use of the streaming systems increases. A scalable system which can be expanded by adding recording and distribution units is therefore strongly recommended.

Note also that this sort of shared system places greater demands on automatic audio processing to compensate for variations in sound level, for example, from room to room. In any case it is advisable to set up a dedicated audio processor (DSP) which ensures that the audio signal entering the recording/distribution unit has approximately the same level for any speaker and type of microphone. There may also be a need for dynamic compression of the audio signal. It should also be ensured that the comparative levels of speech and programme sound are natural.

As with Alternative A, there should be possibilities for complete remote control of all functions of the AV installation, including camera control and adjustment of microphones (sound level and muting). In addition there should be a simple way of controlling the routing of audio and video signals to any shared recording and distribution units, cf. the detailed description in Section 10.1. The actual streaming system shall normally be controlled by remote access via a web interface or by connection through an external desk, but if the lecturer is to be able to start and stop recording without the assistance of the system operator, this should be integrated in the control system for each room. This requires that the recording/distribution units support integration with a standard AV control system, typically via an RS232 interface. If one wants to be able to control any shared units locally from each teaching room, a dedicated control unit for the shared units must normally be installed which communicates with the control units in the individual rooms.

In addition to stand-alone systems, several manufacturers also offer their own systems for recording and distributing video conferencing sessions, which are typically connected to an ordinary video conference or distance learning session as an additional party in a multi-party conference. While these can be good alternatives as regards pure functionality, they have the disadvantage that they require the installation of a video conferencing codec in every room that is to support streaming, and that a good multi-party setup is available for every room.

There is also a range of pure streaming units for video with associated audio, which have typically been developed for the broadcasting market. Many of these support high audio and video quality (up to full HD/1080p30), but they often lack much of the other functionality described above. Systems of this type therefore have limited areas of use for the distribution of lectures. See also Section 9.2 IP-based audio and video distribution.

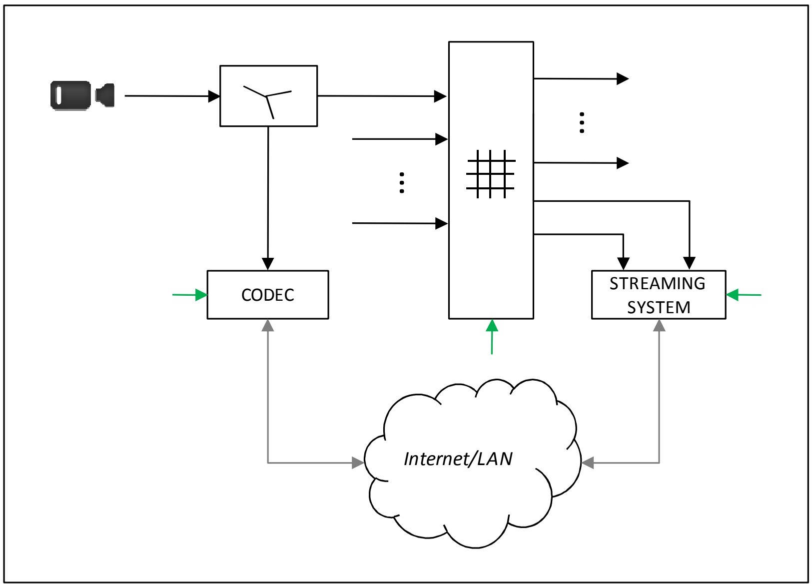

Figure 8. Schematic diagram of video transmission using a streaming system with video conferencing codec and recorder/encoder situated locally in a teaching room.

Web meeting tools are also expected to become an important supplement to distance learning systems based on video conferencing codecs or streaming systems, especially for small groups of students when the degree of interaction is higher than in traditional auditorium-based lectures. They will also provide an easily accessible and inexpensive alternative for network-based teaching, providing high flexibility for both lecturer and students and supporting various forms of interaction and feedback. In connection with the eCampus programme, UNINETT has carried out a thorough analysis of the needs and functional requirements for web meeting systems and has evaluated various available systems. This is a work in progress and is planned eventually to establish a shared system for the entire university and college sector. The use of web meeting systems for traditional meetings, web-based teaching and *ad hoc* collaboration has been evaluated in connection with the eCampus programme. Cf. http://blog.ecampus.no/webmøter/, and in particular the report on web meetings. This work has been carried out in collaboration with a number of universities and colleges.

Norway Opening Universities (NOU) has also published a good podcast handbook which deals with educational, technical, organisational and legal aspects of the broadcasting of lectures. The handbook also focuses on material which includes video, and is available (in Norwegian) at http://norgesuniversitetet.no/podcastboka/.

10.4 D. Internal broadcasting of lectures via IPTV or infosystem

Many institutions want to be able to distribute single lectures, presentations or special events to a large number of rooms throughout a building or campus. If an infosystem or IPTV system is also planned it will be an advantage to use this infrastructure.

10.4.1 IPTV system

Typical commercial systems for IPTV are based on a head-end unit located on the client's premises which decodes a number of commercial channels and distributes these on the campus network by multicasting. Reception is achieved by means of set-top boxes and/or software decoding. The majority of turnkey IPTV systems support the distribution of one or more internal channels. In practice, this means that the IPTV head-end unit has an input board with connections for audio and video sources, typically S-Video or VGA/DVI/HDMI, as well as unbalanced stereo audio.

If infrastructure for centralised distribution of audio and video is established and the IPTV head-end unit is located at the central hub, it is easy to connect the IPTV head-end unit to an available output in the centralised routing and matrix system.

In connection with distribution via an IPTV system it will usually be natural to allocate a separate channel which either shows an information display or a black screen when the IPTV head-end unit is not receiving a signal at the input in question. Hence no integration is necessary with AV control systems apart from the ability to route relevant sources to the IPTV head-end unit, typically by way of a common hub.

In addition UNINETT offers a separate IPTV service which can be used by anybody connected to the research network, cf. http://forskningsnett.uninett.no/tv/. This service is currently under development.

It is also possible to broadcast lectures in the form of a multicast stream with the help of a stand-alone hardware/software encoder, but the challenge here is in integrating this stream as a separate internal channel in the user interface for the set-top boxes. Using software-based encoding, on the other hand, this is not complicated as long as the user knows the address of the multicast stream.

In meeting, group and teaching rooms, reception based on a set-top box controlled via the AV control system will be the most robust and user-friendly alternative.

Any need to restrict who can receive the various channels must also be considered. In the case of multicast streaming this can be done either at VLAN level or at IP address level. Alternatively, encryption and a common shared key for all recipients may be used. UNINETT is planning a separate UFS dealing with multicast, which will be published under https://ow.feide.no/gigacampus:ufs.

10.4.2 Infosystem

Most infosystems available today have facilities for distributing real-time multimedia streaming, typically in the form of MPEG2/MPEG4 video streams with stereo audio. If one wishes to use the infosystem to broadcast lectures, one must ensure that the system supports real-time encoding via physical audio and video input ports. In practice, so-called video grabber cards are used, connected to the central server of the infosystem. In this case, integration with the rest of the AV equipment will be the same as for an IPTV system.

It is also important to remember that many standard monitors used with infosystems in shared rooms are supplied without loudspeakers. To be able to show lectures in all rooms with AV equipment, one must also ascertain whether the infosystem supports the reception of information channels on any PC.

For distribution via an infosystem, the requirements for integration with the AV control system will be the same as for an IPTV system, but external sources must also be selected manually in the infosystem.

Note that there is normally a need for automatic level adjustment and possibly also compression of the audio signal, in the same way as in Alternative C above.

Alternatively one may also make use of a streaming system as described in Alternative C, using local PCs in each room to display the streaming session.

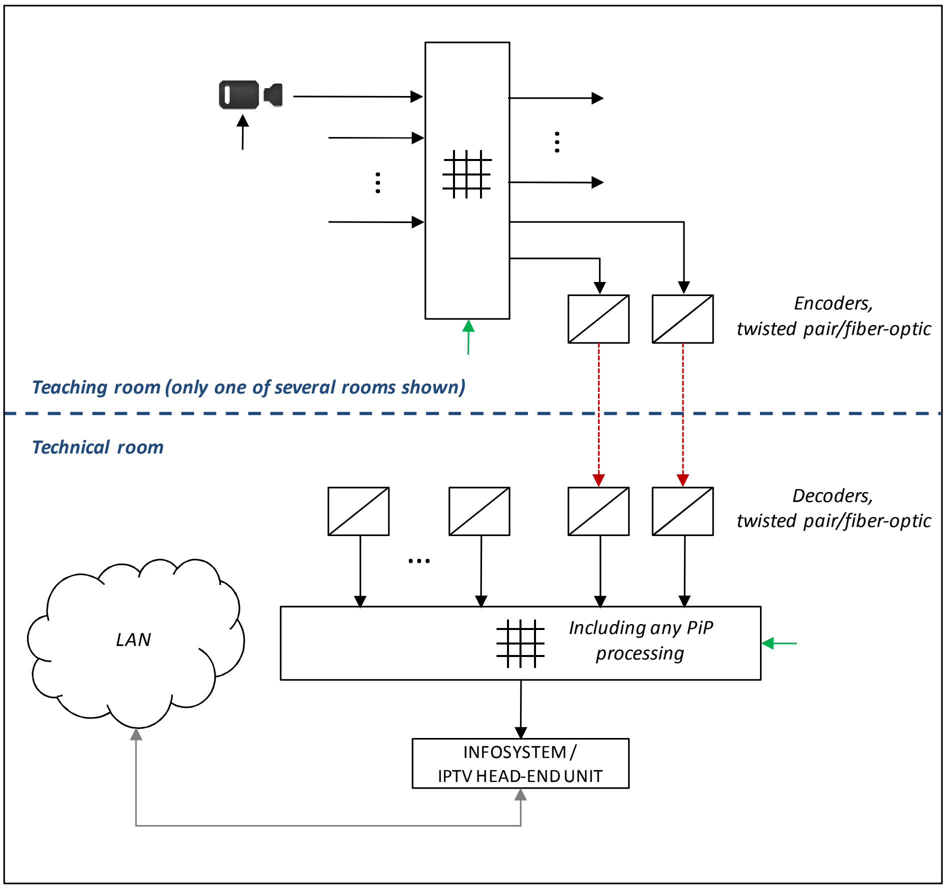

Figure 9. Schematic diagram of video transmission using internal distribution via an infosystem or IPTV based on a centralised distribution system.

10.5 E. Point-to-point transmission via twisted pair or fibre-optic cable

If one only needs to transmit lectures from a small number of dedicated rooms to a small number of other rooms, a system based on point-to-point transmission from room to room may be suitable. For example, this may be of interest where there is a need to bring together individual classes at the beginning of term but one does not wish to prioritise setting up large auditoriums whose capacity is only used for a short period each year.

If one or more reception rooms have separate loudspeaker systems for speech and programme sound, three audio channels should be distributed: mono speech and stereo programme sound, so that the audio can be correctly reproduced in the reception room.

Point-to-point transmission requires no special integration with the control system, with the exception of routing to and from encoders and decoders in individual rooms. Selection of encoder/decoder systems is described in Section 9.1.

For a more flexible system, a centralised distribution system is recommended, as described in Chapter 9.

Note that point-to-point transmission in principle requires dedicated wiring without patch points between the transmission and reception rooms and the wiring structure must therefore be carefully planned. On the other hand, for a centralised distribution system it is easier to build up a general infrastructure which can be adapted to changes in transmission requirements, since all wiring from each individual teaching room is terminated in a common telecommunications room.

10.6 F. Alternative A/B in combination with C/D/E

If full flexibility is desired in connection with the distribution of lectures, it may be of interest to use a combination of several of the above-mentioned alternatives.

One example is HiST's nursing faculty at Øya Health Centre in Trondheim, which uses a combination of Alternatives A, C, D and E, connected by way of a common matrix system located in one of the telecommunications rooms in the building.

Achieving a user-friendly, robust system with so many functions connected together requires a well thought-out infrastructure and a well-developed user interface. At Øya Community Hospital an advanced operational support system has also been established which enables both monitoring and remote control of the individual rooms and remote control of the matrix system for the centralised distribution, MCU and streaming systems. This has been achieved by setting up a flexible monitoring system for audio and video located in the system support department and connected to the central matrix system. This is controlled via a separate control system using touch screens, which also communicates with the control systems in the individual teaching rooms providing source selection and camera control, among other things. In this way, simple, intuitive control of several simultaneous distribution systems can be achieved. In addition, all rooms can be monitored using IP cameras and remotely controlled using standard operational support systems, as described in chapter 3.

Figure 10 shows the basic structure of video distribution in a system corresponding to that installed at Øya Community Hospital.

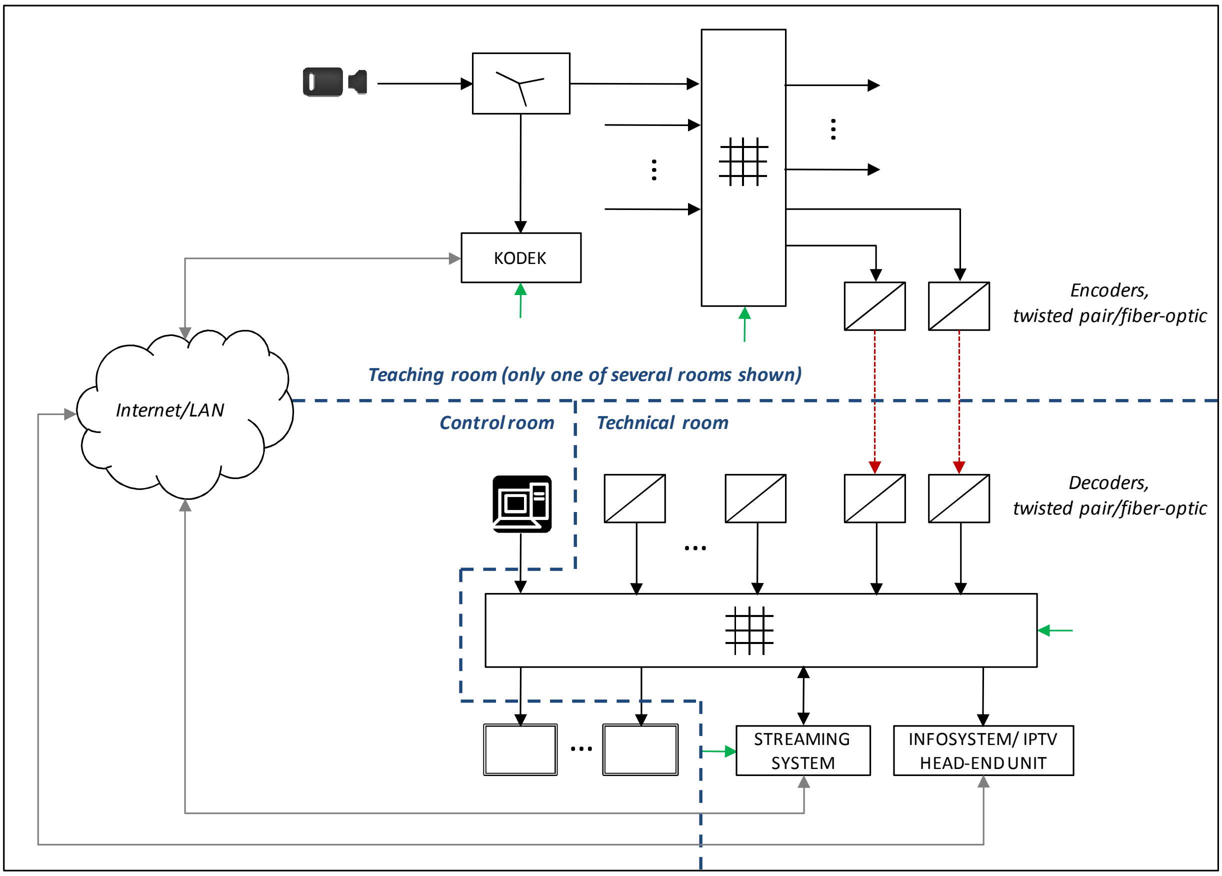

Figure 10. Schematic diagram of video transmission using a centralised distribution system based on Alternatives A/B in combination with C/D/E.

10.7 Comparison between the different systems

To make it easier to decide on the correct system for a particular project, a comparison has been made of the advantages and disadvantages of the systems presented above.

The codes A-F refer to the codes used in the various Section headers 10.1 to 10.6.

A. Complete remote teaching system based on video conferencing codec	
+ Good two-way communication, also with the audience + High video and audio quality + Good control by the lecturer – can be used without technical support staff + Relatively standardised system	÷ Relatively expensive ÷ Receiver must have video conferencing equipment ÷ High user threshold for some lecturers
B. Simplified remote teaching system based on video conferencing codec	
+ Simpler management and control by lecturer + Less need for focus on technical aspects	÷ Primarily one-way communication ÷ Relatively small cost reduction compared with Alternative A
C. Streaming via the Internet and podcasting	
+ Flexibility. Receiver needs only network access and standard PC + Possibility of watching lectures at a later date	÷ Only one-way communication ÷ Requires a dedicated camera and possibly manual camera setup unless Alternative A is also installed in the room ÷ Somewhat lower quality than Alternative A ÷ Requires a centralised distribution system if no recording unit in each room or mobile recording unit which can be moved from room to room
D. Internal broadcasting of lectures via common antenna system/infosystem	
+ Flexibility. Receiver only needs a TV receiver and set-top box or a PC with standard software + Easy to integrate with other infrastructure	÷ Only one-way communication ÷ Requires a dedicated camera and possibly manual camera setup unless Alternative A is also installed in the room ÷ Normally also requires a centralised distribution system ÷ Quality depends on centralised equipment for common antenna and technical configuration of infosystem
E. Point-to-point transmission via twisted pair or fibre-optic cable	
+ High quality + Relatively high investment requirement	÷ Normally only one-way communication ÷ Requires a dedicated camera and possibly manual camera setup unless Alternative A is also installed in the room ÷ Requires the reception room to have equipment for reception (decoder and integration with AV installation) ÷ Requires additional infrastructure for flexible routing and one-to-many transmission
F. Alternative A/B in combination with C/D/E	
+ Flexible for the receiver + Easy to remotely control camera and use infrastructure from Alternative A without major additional costs	÷ High total cost ÷ Relatively complex infrastructure ÷ Places demands on user skills unless a high degree of remote support is available

Table 2. Comparison between different distance learning systems.