# VIDEO STREAMING: REMOTE PARTICIPATION AND ENGAGEMENT IN THE CONFERENCE ENVIRONMENT

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**ABSTRACT**

Video streaming and videoconferencing technology is now attainable using inexpensive and widely available equipment. This paper uses of a set of case studies conducted at a recent conference in the UK to investigate the technical and organizational issues related to differing approaches to the technology. Two approaches, videoconferencing over the Access Grid with VRVS and a simple mono-directional video stream, were used back-to-back. Effectiveness, scalability and applicability of each approach are compared in various applications. In each case, a synchronous but asymmetric feedback channel was made available, making use of a modality of lower bandwidth; a simple, moderated IRC chat system. Asynchronous feedback was also collected post factum using blogs and content distribution services such as Flickr. Feedback from users of each channel is analysed, and recommendations are given for future use of video streaming in conferences, workshops and interactive events. Relevant current research and opportunities for future work are identified.

**KEYWORDS**

Video streaming, asynchronous, interactive video, videoconferencing, presence, computer-mediated communication


## 1. INTRODUCTION

Video streaming is an increasingly common method of providing remote access to events such as conferences, workshops and in education. It may be used both synchronously – that is, the video is made available remotely as the event occurs – or asynchronously when the video captured during the event is streamed at a later date. Alternatively, access may be provided both synchronously and asynchronously. Synchronous access to the stream has several advantages. It may confer an increased sense of *presence* – that is, the extent to which a participant feels that they are 'there with others'. This is separately defined elsewhere as 'the perceptual illusion of non-mediation' (Hauber et al, 2005) and may be markedly higher where video streaming is used than in situations where other modalities are used, such as audio streaming only.

A wealth of work exists on the opportunities and difficulties offered by teleconferencing, particularly as applied to videoconferencing. The technology is mature and has been available for several decades. In early years much was expected of it. Videoconferencing was often described as a relatively cheap alternative to the travel required to enable face-to-face interaction for teleworkers or computer-supported collaborative work (CSCW). However, in practice videoconferencing may suffer from several significant flaws, both technical and social, discussed in Section 2.2. We assert that both video streaming and videoconferencing may be successfully used in appropriate applications within events since the formalized nature of a conference presentation – for example – may be expected to limit the severity of these issues. We refer to this as the pragmatic or discount approach to remote participation; it is formed in part by the availability of appropriate technologies, and tailored to mitigate the limitations of each mode of communication.

The use of technologies such as instant messaging, IRC, blogging and wiki for the purpose of supporting discourse during a conference has been discussed in some depth. The inclusion of fully remote participants

into this discourse by means of audio streaming was investigated previously (Kelly et al, 2005). One issue was that of insufficient quality, caused by low bitrate or lossy compression of audio information. Furthermore, an audio channel alone provides sufficient information to follow talks, but can be frustrating to remote participants since many utterances result from or are prompted by visual cues or interjections from the audience that are not caught by a microphone. The sense of presence, though greatly improved by a real-time audio connection as compared with access to a slideshow alone, is fragile and easily lost. Missing a significant visual cue is sufficient to damage the listener's perception of presence.

The use of video streaming adds an additional channel for this data and reduces the frequency of these occurrences. We suggest that low-bandwidth synchronous feedback via IRC may provide a potential recovery mechanism. Remote participants are able to make use of feedback channels in real-time, meaning that they are offered an opportunity to participate synchronously in discussion, analysis and interpretation. This provides a further channel for repair and recovery. Asynchronous channels are additionally made available for use during the event or at a later date.

This paper briefly summarises existing research in the area. We describe our experiences in organizing and running an event geared to optimize the remote user experience. This was investigated at a recent event coordinated by UKOLN, the International Web Manager's Workshop (IWMW). The performance of two videoconferencing technologies, the Access Grid and a video streaming solution based around the IceCast streaming media server with the FFmpeg/Theora libraries are evaluated and contrasted in terms of technical effectiveness and user experience. We underline several key issues, technical, organizational and social, for event organizers wishing to support remote participation Finally, we identify areas for future work.

## 2. VIDEOCONFERENCING AND VIDEO STREAMING

### 2.1 Related work

Pre-existing strategies have been identified, for example in (Augar et al, 2003) and (Kelly et al, 2005), that aim to provide 'discount' channels for communication shared by local and remote users. For example, IRC and IM (Jabber) have been used for the purpose of permitting conference delegates to carry out side conversations during events. Wikis have been used in similar contexts, such as (Jacobs & McFarlane, 2005), to enable discussion following the event. The successful use of these features leads us to consider video as an additional channel designed principally to reinforce the sensation of presence for remote users. In this we are advised by research results, suggesting that incorporation of visual media with text narratives and synchronous/asynchronous discussions, allows the use of media to extend beyond information dissemination thereby producing a more immersive and learner-managed resource (Dawson et al, 2003). We aim to promote engagement with communities of practice beyond the duration of the event.

### 2.2 Videoconferencing and video streaming

The two technologies in use during the event, videoconferencing and video streaming, represent differing approaches to the use of video transmission in events. Videoconferencing applications contain a feature set typically optimized toward supporting interactive conversation; that is, designed to support and emulate those features of face-to-face conversation that typically lack in computer-mediated communication, such as turn-taking and gaze (see Table 1, below).

The conference setting limits the impact of certain of these characteristics. For example, turn-taking in this setting is typically very formalized, whether in a question-and-answer session or feedback to a presentation. Non-verbal information such as gesture and expression remain of interest; even so, a lecture theatre or conference hall provides little opportunity for close observation of detail. For broadcast of a conference event, we may therefore speculate that the *primary* requirement is that the audio information is clear and of good quality. The video is primarily an accompaniment. It is of value only as long as the following points are met:

The video stream must not result in audio delay; degradation of the audio signal resultant from addition of a video channel is unacceptable (Whittaker and O'Conaill, 1997). It must be correctly synchronized with the audio stream, since the capacity for repair depends upon the relevance of the video information. The effects of subtle video distortion have been studied; a delayed response due to transmission may cause speakers to be

viewed as slow (Kitawaki et al, 1991), and lip movements not synchronized with speech due to video compression may cause the speaker to be viewed as less credible (Reeves and Nass, 1996) in (Chen, 2003). However, frame rate may be as low as 5 fps. Understanding of the content of the video does not depend on a high frame rate (Ghinea and Thomas, 1998)but a lower frame rate leads to the perception that audio and video are not correctly synchronized, with an effect of perceived lag (Watson and Sasse, 1996).

Organisers must avoid excessively negative affective reactions to the speaker or to participants. Videoconferencing has been demonstrated to cause stress to participants, particularly those inclined toward anxiety, particularly under certain conditions such as when participants are able to see their own image (Wegge, 2006). Thus a further prerequisite for remote streaming is that it is as unobtrusive as possible to participants.

Data protection law, expectation of privacy and good practice require that participants are made aware of, and consent to, the use of these technologies before the event. Video streaming has wider implications for privacy than videoconferencing; unless video streams are secured behind an authentication system remote participants may elect to remain invisible and anonymous. The reactions of remote participants are hidden to speakers, as are their identities. A speakers may feel surveillance, and mediate his or her spoken and body language accordingly (Carter & Lederer, 2006). Furthermore, any participant may record both videoconferences and video streaming sessions. This is particularly an issue with video streaming, where an anonymous participant may record and redistribute the session.

Table 1. Comparison of the features of video streaming and videoconferencing

| Video Streaming | Videoconferencing |
|---|---|
| Monodirectional (asymmetric) | Bidirectional (symmetric) |
| Feedback provided through alternative channels | Turn-taking mediated using audiovisual channel, such as speech, gaze or gesture |
| The viewer may not participate | Viewer is typically an active participant |
| There may be no indication to the speaker that remote participants are taking part. | Remote participants are visibly indicated, either symbolically or via video |

## 2.2 Defining a pragmatic approach to remote participation

Video streaming provides an excellent analogue to the experience of attending a pre-prepared presentation, although feedback and question-and-answer mechanisms must be handled according to another communication channel.

Videoconferencing, however, provides symmetric two-way communication. It is therefore suited to environments or tasks in which this is desirable, such as discussion with remote participants. In the context of an event such as this one, a suitable task might be a presentation given by both remote and local presenters. A panel session with local and remote participants offers a similar opportunity. This is complicated by the fact that an increased number of participants and a developing dialogue increase the requirement for clear and accurate turn-taking between speakers. The former scenario is both formalized and simplified by the fact that, in general, presentations are prepared before the event; the requirement for the channel to support ad hoc turn-taking is kept to a minimum in this scenario.

## 2.3 Technical infrastructure

The Access Grid is an advanced videoconferencing system operating on the Grid. It is designed with many more features than a basic videoconferencing system, such as shared display. The Access Grid is used as a collaborative education tool as well as a remote conferencing and CSCW tool (Kim et al, 2006). During the IWMW event, however, only a small subset of these features, required to provide remote participation, was used. The installation used was not a permanent Access Grid Node, but a temporary node. This meant that video quality was limited to that given by a webcam with the node software running on a laptop customized for the purpose. Due to limited Wi-Fi bandwidth the decision was made to connect the node to the wired network infrastructure as network glitching is generally a primary source of difficulty with videoconferencing.

Various options were considered for video streaming. Primary design requirements included the use of off-the-shelf hardware, such as a Firewire (IEEE1394) DV camera, and a basic desktop PC for encoding. Secondary factors included free availability of encoder and decoder software, an installed base of appropriate codecs, and intellectual property claims such as patent royalties relating to the solution chosen. The practical compromise chosen was an inexpensive DV camera connected via Firewire to a desktop PC running Linux with the video compressed and encoded using the Ogg Theora codec. The resulting stream was wrapped in an Ogg envelope and redirected to an IceCast server running on a separate machine. This served the multimedia stream that could then be embedded within web pages and accessed using a suitable plug-in.

Two symmetric feedback mechanisms were considered. The first was the use of IRC. Since IRC is often unavailable from the workplace, due to firewall issues, a web-based interface to the channel (using the CGI::IRC script) was provided to aid accessibility. This solution had been previously tested during a related study (Kelly et al, 2005). The second mechanism was the SMS short messaging service. This was interfaced directly to an IRC announcement service via an eggdrop IRC bot. Hence, incoming SMSs were announced directly to a channel moderator and could be redirected to the channel itself. All events on the public IRC channel were recorded by the eggdrop for later reference.

Asymmetric feedback mechanisms chosen were those tested previously but with the addition of a shared tag, to be used for tagging photographs from the event on Flickr, and related bookmarks on del.icio.us, blog entries on Technorati, etc. The consensus tag approach to relating content from social tagging services is relatively novel, but effective (Guy & Tonkin, 2006). Social tagging is simple, quick and incurs a low cognitive cost.

## 3. CASE STUDIES

During the event three studies were completed, to allow comparison of remote and local participant experiences within videoconferencing, video streaming and 'narrated' video streaming. Symmetric and asymmetric feedback channels were available in each case. The first was a plenary session that included remote participants taking part across the Access Grid – that is, via videoconferencing. The bulk of the conference was streamed using video streaming, generally from an unattended video camera. During one session, however, the video camera was manually directed to follow the viewer's gaze throughout. For example, where the viewer's attention was directed at an element on a PowerPoint slide, the camera view was zoomed to follow.

### 3.1 A Distributed Access Grid session

Several remote participants took part in this session. The setup was as follows; two locally present speakers took part in a plenary session, to a distributed audience. The majority of the audience was locally present, and remote participants were themselves visible to the audience, projected on a large screen on one side of the stage. The remote participants were at a perceived disadvantage in that they were a major focus of the audience's gaze, but were not provided with any indicator that this surveillance was taking place. Their view of the event was recorded from a laptop placed on the front of the stage. The remote audience therefore had a close-up view of the speaker throughout the event, whilst the local audience was not visible to them.

Combining this view with the static video stream described in 3.2, however, meant that the remote audience could gain an appreciation of the audience's perspective. Feedback was generally positive, although it was felt that the limited use of video-conferencing did not demonstrate the capabilities of the technology. Some felt that displaying footage of remote participants to the audience was distracting. Remote participants did not perceive themselves as under surveillance but only as audience members. This was misleading, indicating a mismatch between local participants' perceptions and those of the speaker and remote audience. This, for more interactive sessions, may lead to difficulties in turn-taking due to mismatch of existing social strategies caused by the limited cues available. A possible solution is the addition of a mediator or moderator, an individual tasked with overseeing the various feeds and ensuring that all communities are fairly represented.

### 3.2 Static video streaming

The video camera was sited at the back of the room, from a height slightly above that of participants. This 'participant's eye view' was realistic, in that it was essentially the same view that a local delegate saw, and permitted the speaker's actions to be observed as well as the screen behind them. However, the resolution was insufficient for most slides to be read remotely. In practice combining a static video stream with a method of paging through slides may address this issue – for example we considered SMIL (Synchronized Multimedia Integration Language) could be used for this purpose although we found no mechanism for this purpose suitable for use in real-time. One major issue mentioned in feedback from remote participants was the fact that no indicator was provided on the video stream of the theme or name of the current session. The addition of subtitles or an indicator bar would solve this problem.

Whilst speakers could not gauge the effects of their words on remote participants, a dialogue was enabled between delegates present in the room and remote participants. Perhaps because there were over a hundred delegates present in the room, and because the talks did not require a high level of user participation, speakers did not express discomfort. It was expected that, as in other studies (Chen 2001), feedback would include the finding that the inability to see remote participants impoverishes interaction between speaker and delegates.

## 3.3 Video streaming and shifting focus

Remote participants reported that the strategy of tracking participants by shifting camera focus made a large difference to the quality of the result. One participant stated that 'the video stream came alive during that session'. It became easier to watch and follow, and complemented the audio more closely. However, a corresponding fragility was also reported since occasionally events occurred that transferred gaze too quickly to be followed in real-time by a camera operator. These events would have been picked up on a panoramic view of the stage. Furthermore, the cost of a full-time camera operator adds significantly to the costs of running an event. This approach is nonetheless practical on a limited scale, and should be considered for specific events or sessions.

One objection to this relates to the interpretive nature of the task. By directing the remote viewer's attention, the camera operator is in effect assisting in the creation of a narrative presentation. This requires a skilled camera operator. The technique could be counter-productive in some instances, particularly if poorly executed.

## 3.4 Use of asynchronous forums

Over 325 photographs were deposited post-event on Flickr marked with the recommended tag (iwmw2006). Over 20 blog posts were similarly tagged according to Technorati, all of which were relevant to the event. Many blogs discussed a specific session; most of these could be correlated to the event program (and to corresponding audio and IRC log sessions) by speaker name. Around half of these represent a formalized application of blog software – blogging as substitute for emailed trip reports or as logbook for an event - rather than as a community activity or contribution to discourse within an active social network. By contrast, the use of Flickr was less formalized and concentrated mainly on documentation of social events within the duration of the conference.

The wiki forum was designed to permit longer-term community-building and reinforcement of the themes covered during the event. Most sessions made little use of the wiki; conversation tended to occur on the IRC channel. Wiki edits continued for around a month after the event as a series of disconnected edits. An interesting problem for the future is the real-time interfacing of dissimilar channels into a single resource. Where an excess of channels are available attention is split over both resources to mutual disadvantage. Extending the use of tagging may provide a partial solution to the development of information 'trails'. A simple, standardized, scheme could be applied across the various media. For example, wiki keywords could be synchronized with tags chosen to identify resources, and reused as an identifying metadata tag provided as an overlay to each video segment.

## 4. DEPLOYMENT CONCERNS

## 4.1 Technical concerns

The issue of primary concern was that of bandwidth. This event was held at the University of Bath, at which UKOLN is sited. Fortunately this meant that excellent links with the Computing Services were available and it was possible to plan network usage far in advance. This averted the possibility of inconvenient network maintenance or other planned outage, leaving only the possibility of equipment failure. Since the technologies used for video streaming were relatively experimental, particularly the use of Ogg Theora, there was some expectation that remote participants would have difficulty installing the codec and viewing the stream. In practice, however, very few issues of this nature were reported. Where events are not held locally, an equivalent level of service would require contact to be made with the host institution at an early stage. A wired network is essential for ensuring that the quality of video is adequate. Wireless networks at events oriented toward technology are often under heavy load, especially if delegates are permitted access.

## 4.2 Social concerns

Permission was asked of each speaker before the event to record and stream the session. In most cases, speakers agreed to be recorded. One speaker declined. Feedback received during the event included the perception that discomfort with videoconferencing correlates to gender. Research has previously indicated this outcome, with women reacting less favourably to videoconferencing in certain contexts (Armstrong-Sassen et al, 1998). It is possible that careful camera setup may reduce anxiety – e.g. by neutral choice of camera location.

Care was taken to indicate that each session was recorded, and that all feedback channels were recorded and logged. Delegates showed no discomfort with the simultaneous recording of sessions. Several incidents occurred on the IRC channel that led to subsequent requests for voluntary deletion of comments from the centrally held permanent log. Remote participants' log files could not, however, be edited.. One issue of relevance for future events of this nature is the development of appropriate policies and procedures for voluntary deletion and editing of records. Another is the development of effective methods of making conference delegates aware of the potential audience of such records.

Implementers of video streaming in education have observed that, with the rise in availability of distance learning technologies, fewer students attend the event in person. Whilst in the case of conferences and workshop events there are many draws to attend in person, this is nonetheless a question that must be considered prior to publicizing the existence of video streams and remote attendance facilities. The cost of attending an event is significant enough that delegates may find it difficult to justify the cost where information is available by other means.

## 4.3 Expectations management and reliability

The availability of a wired network during the event had a significant positive impact on the reliability of both video streaming and videoconferencing services. However, participants making use of video streaming reported several occasions in which the video 'froze' and required the stream to be reloaded to continue. This may be attributed in most cases to broken frames resulting from an interrupted video stream.

Other technologies used suffer from related failure modes. SMS networks, for example, frequently suffer from delays that precludes the use of the technology as a sole solution where time is short, such as in a question and answer session. However, it does not preclude its use across longer time scales or where asynchronous communication would be appropriate, for example annotation and delayed feedback services. Furthermore, SMS is an appropriate technology for several situations where the use of a laptop may not be possible. For example, even in a technology-biased event, many users will have brought a mobile telephone but the use of laptops is limited by battery life.

As with any experimental system, there is a reluctance to advertise widely before the event. However, the choices of technology made for video streaming proved to be appropriate for the purpose and scalable to a far larger number of participants than were attracted on the day (around fifteen).

## 4.4 Retention and contributor's remorse

Speakers and delegates alike may find themselves making unguarded or regrettable statements, either online or on a recorded medium. Several policy issues arise with relation to this. Consent for recording must have been sought before the event; however, this does not preclude the possibility of editing or censoring the

resulting records. This becomes more difficult where a larger number of technologies or channels are in use. If one delegate makes an unguarded remark, itself picked up by a microphone and streamed to remote participants, each participant may have recorded the remark. Furthermore, other delegates may have recorded it either aurally or in terms of an IRC message or a note on an online collaborative environment. It is difficult or impossible to edit a video without leaving an obvious transition; this gap can quickly be filled by examination of other records of the event. Under these circumstances, it is difficult to set an appropriate policy.

## 4.5 Archiving and preservation issues

Several strategies exist for the effective preservation of digital video and multimedia objects (Hunter & Choudhury, 2003); most centre around migration, emulation and metadata. Best practice in the area of preserving complex multimedia objects begins with the choice of an appropriate data format – 'as high quality, standardised and platform-independent as possible'. The object should be 'stored in a simple structural markup such as SMIL or HTML+TIME'. Of particular relevance to video data are IP and patent issues. These may adversely affect the continued availability of compatible software at a later date due to legal restrictions. This was a significant factor in the decision to make use of the Ogg Theora codec.

## 4.6 Accessibility

Accessibility issues are a significant concern in deployment of multimedia technology. Whilst an archived broadcast can be annotated using an accessible solution such as SMIL, real-time captioning is both expensive and difficult. Simultaneous note-taking offers a partial solution, although this provides only a summary of what is being said. Automated speech recognition may improve matters; although the captions provided by this method are inaccurate, a human editor can correct them adequately fast for near real-time captioning to become possible (Wald, 2006).

During the event, the synchronous chat system was used both for interjections/annotations, commentary on the topic under discussion, and for repair ('what does the speaker mean by –?'). Making use of simultaneous note-taking on a public text-based channel provides opportunities for real-time annotation and discussion of these notes and their context– a community-based annotation may be richer than simple note-taking, and is less technically and computationally expensive than the use of speech recognition. However, if speech recognition is used, a collaborative approach to correction of data may be appropriate.

## 5. CONCLUSION

A speaker taking part remotely in a conference event might benefit directly from the 'face-to-face' bandwidth of communication that a two-way videoconferencing system provides. However, remote participants in general gain little from the additional functionality provided by videoconferencing over an asymmetric approach. A simple video stream, set up to emulate the typical viewpoint shared by local conference participants, constitutes a useful accompaniment to a good-quality audio stream captured using high-quality microphones and encoded to a good standard. Of most interest is the demonstration that, in 'asymmetric' settings such as a conference presentation (that is, one speaker is directing the event, whilst any incidental discussion between delegates is brief and fragmentary), extremely asymmetric feedback channels suffice. A low-bandwidth modality such as text-based chat or SMS messaging is sufficient for many purposes. For the purposes of supporting local and remote users, and for effective reinforcement of the learning experience, a little relevant and timely information is more effective than a great deal of irrelevant information. The choice of technology must be tailored to suffice, and not to exceed, that required for a given event or modality, rather than by the available options.

Retrieval of information post factum from services such as Flickr, where a memorable tag is defined before the event for use on event-related material, reveals itself to be the most popular of the various asynchronous services available during and following the event. The increasing popularity of 'Web 2.0' community-based web sites underlines the problem of how to integrate and aggregate information from a variety of sources into a single, coherent narrative for the community and for the learner. Similar problems

have been identified and explored elsewhere, such as the IUGO project (Shabajee, 2006). however, real-time aggregation of several related data sources into a coherent narrative remains an unresolved problem.

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