Socio-Technical Aspects of Video Phones

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Abstract— **The widespread use of voice over Internet protocol has paved the way for video over Internet protocol. In the past, certain technical shortcomings have prevented the popularity of videophones in the market. With present-day technology, videophones have just about everything required for day-to-day functions. Under such circumstances, certain socio-technical aspects require attention so that videophones can become as widespread and as technically streamlined as a plain old telephone system (POTS) with its additional benefits. A frequently brushed-upon topic is optimum features in the video phone for day-to-day social interactions. We carried out several experiments on different kinds of codecs and video formats to address two issues: i) the size of a video screen and ii) perception of motion and distance. From the measurements, we observed that a small frame rate with low bandwidth is adequate and can result in satisfactory video quality. We also observed that H263 performs well for all the day-to-day social networking activities. Standing 4 feet from the camera can still give reasonably good video quality in the currently available codecs. We believe that socio-technical issues will emerge more clearly over the next several years and they are germane to deployment of PC-based soft phones as well as hard phones.**

Keywords- social factors; social issues; technical issues; videophones; videophone quality

I. INTRODUCTION

When the telephone and e-mail are juxtaposed against each other, the telephone emerges as the leader of connectivity, supplying a real-time audible link between two people as opposed to a merely literal connection offered by e-mail. The video phone, however, is superior to both of these two forms of communication. Not only does the video phone allow an audible connection between two users like a telephone, but it also provides a live visual feed of both parties, bringing the conversation to a level, that rivals that of face-to-face communication. The conversation as virtual as this one between parties stationed as far away from each other as Japan and Munich, for example, signals a major breakthrough in the communication industry.

Despite its advantages, the video phone has not achieved widespread use. The delay for a massive deployment of such a technique is due not only to technical issues but also to social problems. The goal of this paper is to describe some of the existing social issues and bring some quantification to technical issues. Section 2 describes the state of currently deployed video phones and their broader impacts on society. It is clear from the examples presented that video phones can drastically change/improve the current status of electronic communication. Section 3 describes the vulnerabilities; privacy issues related to the use of video phone technology and compares the threats relevant to those associated with e-mail and voice technologies. Section 4 presents an analysis of the relation between the perceived quality of video with respect to quantization, frame rate, and social factors like the environment of the user. Section 5 presents concluding remarks and discusses future work.

II. SOCIAL IMPACTS

The ability to read facial reaction, body language, has proven to be a much more important medium for communication between persons compared to solely audio correspondence [1]. Point-to-point video communications are deemed useful by a myriad of people. From chief executive officers to laypersons, point-to-point video phones can give the closeness and reality of an actual face-to-face conversation needed for everyday life. For an attorney, to see clients or potential witnesses face to face and to observe their facial expressions and body language may be crucial for a case's outcome. This capability is similarly useful in conversations between doctor and patients because it allows visual analysis of the patient. Frequently, crucial business meetings taking only a matter of hours may require executives to travel thousands of miles. With video phones, virtual meetings can be held with ease thousands of miles away, thus saving both time and money.

Video phone conferencing is one of the technologies that allow people to talk face to face to clients sitting in another part of the globe. This technology is not only used for businesses but also for interviews, lectures, and so on. In broader terms, we can divide video phone conferencing into two types: point-to-point conferencing and multipoint conferencing [2]. Point-to-point conferencing refers to communication directly linking two sites, whereas multipoint conferencing is communicating with three or more sites at the same time. In this section, we describe a few of the many studies showing how the use of video phones has had a huge impact on people's lives.

Studies in rural Missouri analyzed the effectiveness of using point-to-point videophone conferencing for a 3-day professional development workshop of elementary school science teachers. The results suggest that the teachers perceived video conferencing to be as effective as traditional onsite professional development workshops [3]. With conversations

being much more personal and involved, the possibilities for communication are virtually endless.

Washington State uses video phones to reduce the need for public health nurses to travel to patients' homes. In Japan, medical staff uses video phones to make direct observations of inhaler use and assist with exacerbation management in Japanese patients with severe asthma. There is also a study proving the usefulness of video phones in the treatment of patients with dementia and in reminiscence therapy [4]. This use of video phones allows staff to improve asthma control and reduce hospital admissions. In Tokyo, a video phone system has been used to provide respiratory-care specialists' resources to primary-care physicians and to pediatric patients requiring home ventilator support. This use resulted in large reductions in unscheduled visits by patients, home visits by physicians, and hospital admission days [5].

Elderly deaf people cannot communicate effectively, can't listen to the radio or television like normal people, and have limited access to a major part of the world. Their isolation from others is enormous. Even worse, they have to depend on others for making a telephone call, even to get to a doctor. With a video phone, a hearing-impaired person can communicate by lip reading or by using sign language either directly with the other party or with an interpreter who then translates to the other party. Those in the deaf community who use the videophone depend on it as not only a means to sign to persons fluent in sign language but also to communicate with the non-fluent [6]. One study describes Bristol City Council's joint venture with British Telecom to supply 40 houses with video phones in which 30% of the houses have elderly people with hearing impairments. This study used an interpreter service and tested its usability. An 82-year-old person said, "When they told me about the video phone, I wasn't really very sure about it. I said I would have a look. They brought it over and put it down. You know, it's really good. It keeps me 'up.' It means bodily, physically, mentally, it keeps me alive and up. It helps me stay in touch with my family and friends." [7].

(a)

Figure 1. (a) Inspection of symptoms via videophone

It is a commonly addressed problem that some of the needs of the elderly people who are discharged from a hospital are not satisfied. They suffer drug non-cooperation, isolation, and limitations to access specialist from their very home. In these situations, elderly people can be managed from their homes by using video phones. A medical staff can watch patients and access their records from their offices without being in a hospital ward for rehabilitation. [8]

"A study was made to examine the effects of telemedicine technology on communication by comparing the style and content of communication between actual (i.e., face to face) and virtual (i.e., non-face to face, videophone) dermatology visits. The hypothesis was that there is no difference in the content and style of communication between actual and virtual visits in dermatology."[9]

It's commonly seen that remote places on a map don't have hospitals, but it doesn't mean that people do not live there or that they don't get sick. Remote places do not have hospitals because it's too expensive to get all the required medical facilities to the rural areas. Hence, the term "virtual clinic" was coined. Virtual clinics use low-cost video phones [Fig. 1(b)], together with some of the clinical equipment mediated by a trained local volunteer to provide remote consultation and monitoring of patient records. This system potentially saves long trips into town by patients since the traditional 'home visit' is not feasible in these regions. A virtual clinic was set up in the rural region of Victoria, Australia by the Department of Rural Health to avoid some of the chronic fatalities due to lack of basic medical services and difficulty for elderly people to reach the medical facilities in time. [10]

Video phones may also be deployed in houses for personal use, where each person can talk as well as see the other person, however remotely located they may be in the actual world. A grandmother could be talking from her home in London, while her son and family could be responding from their home in New York. She could actually see her newborn grandson from across the Atlantic without travelling thousands of miles (Fig. 2). You can have the peace of mind to check your baby and babysitter from anywhere in the world when you are away. Seeing the person with our own eyes and talking to them gives immense satisfaction and creates the trust that you are talking to the right person and that everything is under control.

(b)

Figure 1. (b) View of a patient under diagnosis in videophone.

Video phones can allow people to record video, images of their loved ones, family members, and special occasions. They can also be used by soldiers in the battlefield to talk face to face with their families in the United States, allowing them to voice their emotions. With all this huge impact on human lives, it's not that hard to use a video phone. All that is needed is an Internet connection with a voice over Internet protocol (VoIP)

service to connect with almost anyone in the world at the lowest cost.

Figure 2. Video conferencing with grandchildren

III. SOCIAL ISSUES

The degree to which the problems caused by video phones affect society may seem less serious than those of other misused technologies. Nevertheless, we cannot ignore issues concerning video phones before they may become a part of our daily life. Currently, video phone screens require both speakers to be looking at the person they are talking with as well as seeing them on the screen. Even though it may seem so, the screen's focal point is not the same as the camera's focal point; hence, eye-to-eye contact is not possible. Nevertheless, inflections, expressions, and other non-verbal features lost in cyberspace can be preserved in video telephony, helping to reconnect people during life's special moments [1]. However, certain social issues still prevent wide-scale deployments. Thus, as video phones poise to take off, there is a need for a closer look at the possible problems of using video phones on a daily basis.

A. Display of Mood and Emotions

Video phones can cause additional loss of privacy due to awkward situations while answering a video call. When using a videophone, however, both parties may become uncomfortable if the person they see has not dressed in a manner they consider appropriate or professional (Fig. 3). Video phone calls, like phone calls, intrude on a person's privacy. Therefore, any video phone system of the future must balance retaining privacy to responding to emergency communications before wide-scale deployment of video phones will be successful.

Figure 3. The called person may or may not be presentable to the caller.

B. Trustworthiness

Video phones cannot develop similar trust as much as in face-to-face conversations. Just as phishing occurs in e-mail, we expect it will soon find a way into video phones. As with Internet phishing, criminals may use the pretext of verification of trivial details or transactions. With a look-alike backdrop and realistic acting, these criminals may convince users that they are authorized to request confidential details, such as code/PIN numbers. Currently, video phone users have no definite way to distinguish among the people purportedly calling from a bank or to authenticate whether callers are really associated with the firm they claim to represent.

C. Unexpected Video Clips

Unlike e-mail spam, video spam may not wait for users to open it. As the client of a large insurance company waits to be answered by a secretary, he or she may encounter a number of unwanted advertisements opting him for a lower priced car; at a minimum, such pop-ups disrupt a conversation and sometimes may place the user in an awkward or embarrassing situation.

Video mail, an application similar to voice mail, might come into use as video phone technology expands. However, video spammers can exploit video mail by flooding video-mail inboxes with unwanted videos. These video mails could be important messages and family issues. They also could be video spam; furthermore, unwanted video clips or messages that may be distributed over the network may be inappropriate to view.

D. No Control over Surroundings

Within certain situations, a mobile video phone can make communication easier, but in other situations, it can become a nuisance. Foremost among such nuisances is loss of privacy. As with standard cell phones, the user could be anywhere when the mobile video phone rings. Attending a call on a mobile phone does not make the caller worry about his visual appearance or his current activity [11], [12]. A mobile video would give the user little choice whether he would like to be seen or avoid being seen and disclose him to outsiders [11], [12].

IV. TECHNICAL ISSUES

In addition to the social issues described in section 3, there are a number of technical and security-related issues that demand fast and secure solution before the widespread use of video phones. Some of these issues are identified and described in the next section.

A. PC-Based Video Conferencing

Currently, the most popular form of video conferencing is via the PC in which the user needs a computer, the camera, and optionally headphones in order to communicate via video with the receiver. Video conferencing has assisted communication in both the corporate and the civilian world with moderately user-friendly software structurally comparable to instant messaging. Video conferencing has also shown potential in the medical world, making the formerly defunct idea traditional house-calls feasible again. Although PC-based video conferencing and video phones both support point-to-point and point-to-multipoint video communications, considerable technical differences separate these two devices, as described in Table 1.

TABLE I. PC Video Conferencing vs Video Phone

PC-Based Video Conference	Video Phones
Requires a centralized video server	VoIP infrastructure can be reused
Requires complex configuration, lacks continuous availability, and requires maintenance	Plug-and-play device
Inherits all the PC-based security issues	Dedicated operating system and hardware; hence, comparatively fewer vulnerabilities
High-performance hardware; hence, scalable to a large number of participants in a multi-point video conference. In addition, can hold large amount of video mail	Low cost hardware; hence cannot support large size multi-point video conference; small number of video mails due to limited storage space
Lacks interoperability between different conferencing systems	Proven interoperability due to already existing VoIP equipment
Complex user interfaces; can be an issue for wide-scale deployment across the masses	Easy to use and operate by residential users

B. *Comparison of Social Issues in Three Electronic Communication Systems*

Any kind of communication system has some vulnerabilities and privacy issues with respect to user context. Table 2 compares some the common privacy and social issues for the most popular means of communication.

TABLE II. Social Issues of Electronic Communications

Issue	E-Mail	Voice	Video
Unwanted Calls	Annoying	Annoying, possibly embarrassing	Annoying, embarrassing, and potentially harmful
Phishing	People generally ignore e-mail from unknown source	People follow up on voice calls with other reality checks	High chances of impersonation and easy spoofing
Privacy	Bystanders cannot access without permission	Bystanders overhear conversations without permission; but callers can hide mood and emotions	Physical surroundings, mood, emotions, and all the details of the callee are disclosed
Junk Mail	Impacts productivity	Nuisance	Embarrassing; viewer discretion required
Presence	Difficult to find the location	Special location services required	Location and mood automatically disclosed

C. *Size of the Video Screen*

Video conferencing requires adequate video quality to be able to simulate a face-to-face conversation. In many situations, only a limited bandwidth is available (wide-area network), so maximizing its efficiency is crucial. Several video codecs are available now to satisfy the needs for quality. Among all the services, "teledata" [13] requires the most precise details, which means that communication actively involves video rather than audio. Some of the services require higher frame rates to provide a harmonious and synchronous conversation. For example, there can be visual content during the course of a lecture where the frame rate of about 15 to 25 per second will be considered adequate to meet the need. In some applications [14], even 2 frames per second is enough. In another context, consider hearing-impaired people who are trying to have a conversation. A frame rate of a minimum of 25 frames per second will allow lip reading, and audio does not have any influence in this case. So a specific level of requirement is needed for a particular group of users. Choosing the optimal requirement is another significant measure to keep the network distant from congestion.

Some of the most popularly used codecs in video conferencing are H.263, H.264, H.261, and MPEG standards, in which the bit rate is typically n × 64 kbps. One frequently asked question is what image resolution (and subsequently, screen size) is best for social interactions, emotions, and expressions. We carried out experiments to find the factors that could considerably affect video quality. In Fig. 4, a measure of the quality of the video transmitted using real-time transport protocol (RTP) is made against the bit rate; under a common intermediate format (352 × 288) video using H.261 (ITU-T video coding standard) codec. Fig. 4 gives the quality of the picture, quantized over a metric 'VQ factor' (vector quantization factor) [14] on a scale of 0 to 5, 5 being the best video clarity and 0 being the worst.

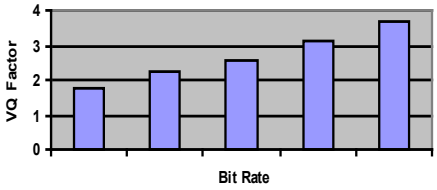

Figure 4. VQ factor vs bit rate (varied from 10% to 100% of the available bandwidth, CIF format)

The VQ factor is calculated by using an algorithm which is proprietary to the software ClearSight [15]. With an increase in the number of bits per second, we can see quality of the received pictures getting better but at the cost of bandwidth.

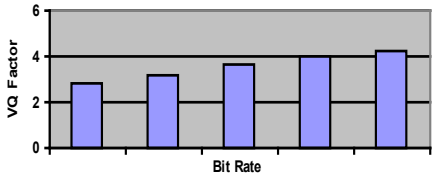

Figure 5.VQ factor vs bit rate (varied from 10% to 100% of the available bandwidth, QCIF format)

In QCIF format, the quality of a video does not suffer much, even with low bandwidth.

In Fig. 5, the quality is measured for a video using QCIF format (176 × 144), with measurements of VQ factor over bit rate. From fig. 5, we can see that the quality of the video does not suffer much with the increase of the video resolution because the image size is directly related to the bandwidth it occupies in the network (e.g., a full-size video conferencing on PC compared to small screen video phone).

D. Perception of Motion and Distance

One of the vital necessities for the video phone is to understand the emotional quotient of the person during a conversation. Video stream can incur a loss in the clarity of the picture due to encoding scheme and the network loss. Furthermore, some of the factors of the surroundings, like the user's distance from the camera and brightness, account for the correct interpretation of actions at the other end. Vendors will frequently update the codec on the video phone and increase the price. So, another frequently asked question is what codec is optimum for social interactions. To address this issue, we made measurements of mean opinion scores (MOSs) based on motion, distance of the subject from the camera, and surroundings of the scene.

1. *Distance from the Camera*: In video phone usage, the user can be too close to the phone or several feet away from the phone. Whenever the user performs an action or makes a movement, it can be identified by the number of pixel changes in the video frame. These changes in the pixels are measured by the brightness flickering metric (BFM) [16], which gives the amplitude of the pixel change from the previous frame.

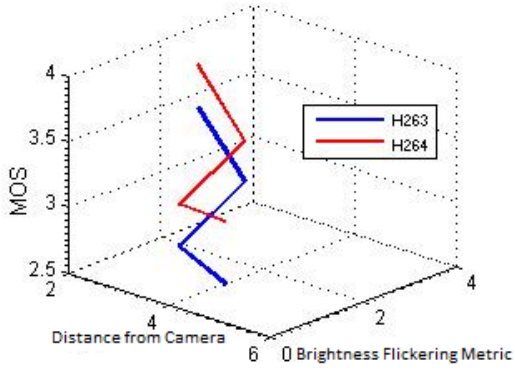

Figure 6. Motion detection with respect to distance from the camera

We have conducted some experiments using two different video encoding schemes, H263 and H264, using the soft phone X-lite. The measurements are made by using the video phone at different distances from a single user (to avoid subject-specific measurement errors). The subject (user) is subjected to a uniform activity for all the measurements taken. We also set the bit rate of 128 kbps for optimum performance.

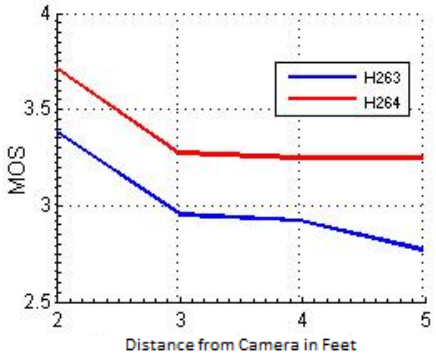

Figure 7. Perceived quality vs distance from the camera.

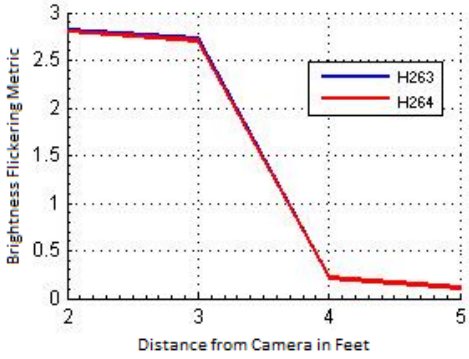

Figure 8. Brightness flickering metric vs distance.

As seen in Figs. 6 and 7, the quality of the video given by the MOS for the video format H264 is better than the quality provided by H263. In addition, the quality of video gradually deteriorates with the increase in the distance between the phone and the subject. Thus, we can infer that the quality of the video can decrease only up to a certain distance and that it will continue to remain the same or increase as the pixel changes of the frame become negligible. From Fig. 8, we infer that the detection of motion from the video decreases with increasing distance from the phone and that the perceived quality of video has the least impact on the perceived quality of the video.

2. *Brightness of the Environment*: With the widespread capabilities and the ability to start a face-to-face conversation from almost anywhere in the world, we expect videophones to be used almost everywhere, from parks and beaches to mines and tunnels. Owing to expanse of its usage, we need to find out whether the videophone can meet its primary objective of delivering facial reactions in different brightness and light sources. A human eye can adapt to the different brightness level with ease, but a phone camera cannot do so as easily. Even with the advent to new technologies for aperture control and image stabilizations in recent video phones, the quality of the captured video greatly differs from that of natural human vision.

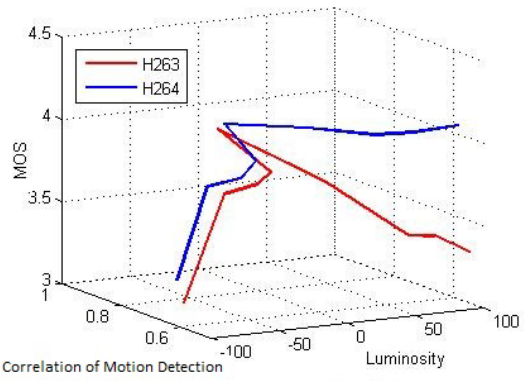

Figure 9. Motion detection with respect to brightness

To identify how the brightness of the surrounding affects the ability to detect motion changes in a video phone, we used real-life scenes with different levels of brightness from very high to too low and made the test subject (user) to replicate the same kind of motion in all the scenarios. Preliminary experiments were made to identify the optimum lighting conditions for motion detection, which is taken as zero luminosity or reference.

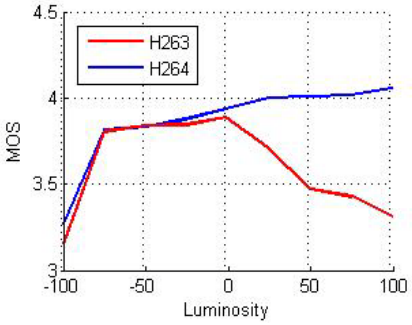

Figure 10. Quality of video vs Brightness.

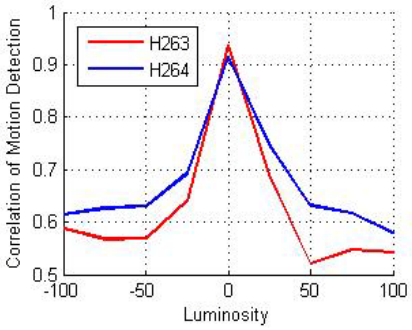

Figure 11. Motion detection vs brightness

From the results in Fig. 9 and 10, we observe that the encoding scheme H264 performs better in brighter lighting conditions and that the perceived quality of both the codecs H263 and H264 are the same in dim or poor lighting conditions. When we consider H263 video codec, the quality observed is greater in normal and medium-low conditions than the other extremities. H264 encoding scheme occupies more bandwidth to retain the frames under higher lighting conditions giving increased quality compared to H263. A measure taken against the luminosity and the motion detection using the brightness flickering metric shows gradual decreases as we move away from the normal in both directions from the results in Fig. 11

The visual quality of the video is mainly considered by the blockiness[16] of the received picture and the amount of pixilation in the frame. The quality of the video drops down drastically with high levels of blockiness in the frame.

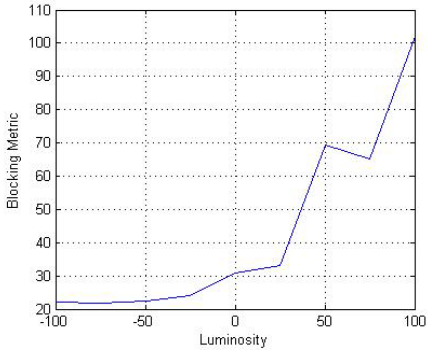

Figure 12. Blocking vs brightness

Based on the test results from Fig. 12, we can infer that the blockiness of the video increases dramatically in the presence of brighter light than the poor ones. It is observed that whenever there is a motion or movement in a region of higher spectral intensity, the video capture results in the production of blocks of pixels around the object in motion. As the light gets darker, we do not observe much differentiation between most pixels; that is, the blocking lowers and eventually gets to zero, tending to complete blankness.

E. Change in Bandwidth Due to Human Activities

The frame rate for the whole experiment was set at 24 FPS (frames per second). We used hard phones as well as soft phones for the measurements. The rates obtained for different resolutions (first three are for hard phone and last two are for soft phone) are tabulated. From the Table 3, we can see that the bit rate increases as the resolution of the captured image increases. We can also infer that every human activity has a direct impact on the bit rate associated with the frame in the video stream. For example, in the absence of a user in the view port indicating a completely static scene, the bit rate maintains a very low value of 4Kbps for every resolution. However, there is a change in bit rate when the scene includes person even he is in complete stand still.

The increase in the bit rate for different activities for the same resolution is due to the movement of exposed body parts involved in the activity. Hence it can be concluded that bit rate increases even with the small amount of motion exerted by the human body without the user's knowledge. These changes are evident when person is breathing normally and heavily.

TABLE III. Bit rate for different human activities in Kbps. First three columns are collected from hard phones whereas last two are from soft phone.

Activity	176x144 (QCIF)	352x288 (CIF)	704x576 (4CIF)	320x240 (QVGA)	640x480 (VGA)
No user	4.023	4.19029	3.99019	5.34221	5.0223
Eye Blink	9.911901818	24.57718188	35.12730746	21.6138	34.17954848
Smile/Scream	8.079086912	20.70645188	33.37620889	15.95332871	32.20755128
No Breathing	7.771264914	19.06039773	20.97370419	11.07658882	19.6834
Normal Breathing	11.54279342	35.1155429	38.08035832	17.43051976	38.90551785
Heavy Breathing	20.12335627	62.39377377	74.60028133	23.92191825	71.39415822

V. CONCLUSION

In this age of e-mail and instant and text messaging, video telephony simulates the personal nuances that come from experiencing face-to-face communications [1]. The rapid growth in broadband networks has contributed to the anticipation of a similar growth in the field of video over Internet protocol; but although the video phone has been available for decades, widespread deployment has not actually happened. We attribute this lack of deployment to the need of technological improvement to support video over Internet. Certain aspects have yet to develop to trigger growth of a video phone market. Apart from the technological needs, interesting social aspects must be analyzed before video phones can become as ubiquitous as the plain old telephone system (POTS). It can be argued that PC-based video conferencing is a cheaper solution, but the issues discussed in this paper are germane to PC-based video communications. As can be seen for Figures 4 and 5, the small frame rate with low bandwidth is good enough and can still result in satisfactory video quality. We also observed that H263 performs well for all the day-to-day social networking activities. Standing 4 feet from the camera can still give reasonably good video quality in the currently available codecs. However, H264 fares better in poor lighting conditions. By addressing social issues and aided by the developments in technology, fully functional video

phones can become a reality and can probably pave way for a better understanding between countries and cultures.

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