

# Borderless education with high speed networks

J. Janitor

Computer Networks Laboratory, Technical University of Kosice  
Jozef.Janitor@tuke.sk

**Abstract**—Information and communication technologies have connected and brought people together in several ways. In the last decades, the way people were able to communicate and exchange information has changed everything. As the Internet started to grow, the IP protocol became the de facto standard in networks, more and more applications have started their journey to bring faster, more reliable and powerful communication and collaboration mechanisms to people all over the world. First it was just an E-mail, then Instant Messaging as a way to quickly discuss things, later real-time and live Voice over IP. Currently a new phenomenon is being seen and it is real-time Video and Voice over IP. By 2014, video is predicted to form 91% of the global Internet traffic. The power of video is in face-to-face communication, emotions, gestures, body language, etc. The paper shows how the e-learning can be transformed from only reading online content into studying online using advanced videoconferencing – TelePresence. It is based on a case study on using Cisco TelePresence at the Technical University of Kosice (TUKE), Slovakia, Europe and at Paradise Valley Unified School District (PVUSD), Phoenix, Arizona, USA to develop and provide a course that is held by an instructor located at TUKE to students located at PVUSD.

## I. INTRODUCTION

The educational process has not been significantly changed in the last 2000 years. The biggest change happened only to books. These books have moved from the form of printed black and white papers to colored textbooks and nowadays to online content. This way the e-learning was born. The online content can contain several multimedia and interactive parts, which make the learning process of students much easier and more effective to understand. While the books have innovated themselves, it was always about a single teacher who has delivered the knowledge to students.

In some geographical areas it might be impossible to hire a local teacher who will be skillful enough to teach complex systems to local students. Rural areas outside of major cities are affected the most by this issue. When this issue is not addressed, rural areas are unable to grow and transform into new, highly prospective areas simply because of the lack of knowledgeable workforce.

Teaching advanced topics might be challenging in any area. Especially topics that are connected with technology. Technologies are changing and more importantly growing so fast, that one cannot be an expert forever in several fields. Schools must seek for the new best experts in those fields, who can deliver the knowledge to students in the best possible way. This is a difficult job, as those experts are many times either already working in different institutions, or are located in different cities. Although many schools nowadays do so, daily transportation of shared staff members or students between schools and/or institutions can be really exhausting and thus ineffective.

People are losing expensive time during traveling and exhaust gases from vehicles are not helping our nature either.

As the speed of the Internet and its penetration is growing faster every year, it affects more and more people. New applications are being developed that make the daily life easier. Like communication through e-mails has totally changed the way business works and transformed formal letters to something that looks more like instant messaging, real-time communication applications are changing absolutely everything. Real-time Voice over IP has enabled families to have long lasting conversations with their friends and brought back people from far to closer. Lately video communication is believed to be the biggest gamechanger in real-time communications. Some predictions say that by the end of 2014 all video content will exceed 91% of the global Internet traffic [1]. The great importance of video is in visible emotions on face-to-face communication, body language, gestures, etc. Researches in the area of human communications show that more than 60% of all communications are derived from nonverbal behavior.

Real-time face-to-face video communications through videoconferencing applications are nowadays available to everyone on the Internet. Many of those applications are not providing any guarantee of quality of service or quality of experience. While for home use, that aspect might be acceptable, for enterprises the demand on the quality of experience is much higher. Therefore, for enterprise video communication the TelePresence technology should be used.

TelePresence is not just a simple videoconferencing solution. TelePresence refers to a set of technologies which allow a person to feel as if they were present in the same room. Video is delivered in Full High Definition 1080p resolution, while every participant has its own place at the table which is captured and displayed at the other end in real life-size. Eye contacts, as well as gestures on faces and emotions are experienced the very same way as in real life. The TelePresence room is equipped with special sound and lighting technique, which is automatically adjusted in a way that people in the room are not perceiving TV screens, but people on the other side of the “virtual” table.

## II. CISCO TELEPRESENCE [2]

Globalization increases the need for communication among colleagues and partners. Business discussions encompass not only multiple people but also multiple locations.

While today’s meeting and collaboration tools provide a significant productivity boost, they are not a substitute for in-person meetings. Videoconferences, in particular, are often difficult to set up, challenging to use, and do not

adequately replicate the benefits of face-to-face interaction.

To improve this situation, Cisco TelePresence creates an “in-person” meeting experience over the converged network. Cisco TelePresence delivers real-time face-to-face interactions between people and places in their work and personal lives using advanced visual, audio, and collaboration technologies. These technologies transmit life-size, high-definition images and spatial discrete audio. Now it's easier than ever to discern facial expressions for crucial business discussions and negotiations across the “virtual table.”



Figure 1. Cisco TelePresence effect – the virtual round table

#### A. Audio/Visual Technology

Cisco TelePresence incorporates the latest standards and technologies to offer the best audio and visual results:

- H.264 video codecs to offer the highest quality and lowest bit rate
- Session Initiation Protocol
- Native 720p and 1080p high-definition cameras
- Native 720p and 1080p high-definition encoding/decoding
- Low-latency architecture and low bandwidth utilization
- Wideband advanced audio coding with low delay (AAC LD)
- Multichannel spatial audio with echo cancellation and interference filters to eliminate feedback from mobile devices
- Optimized environmental conditioning to provide the best audio and video and overall user experience

#### B. Network

Cisco TelePresence uses the standard IP technology deployed in corporations today and runs on an integrated voice, video, and data network. The system supports high-quality, real-time voice and video communications with branch offices using broadband connections.

It offers capabilities for ensuring quality of service (QoS), security, reliability, and high availability for high-bandwidth applications such as video — particularly high-definition video, which can require 1 Mbps to 5 Mbps, depending on the resolution.

#### C. Hardware-Optimized Environment

The system includes purpose-built office furniture that incorporates cameras and displays, lighting, speakers, microphones, and projection capability into a specially designed table for larger rooms, or, in smaller configurations, into existing office furniture.

#### D. Software Applications

Cisco TelePresence applications incorporate a variety of new and existing standards-based software for accommodating converged voice and video transmissions, including:

- IP telephony
- Groupware
- Services

#### E. Cisco TelePresence at the Technical University of Kosice[4]

The Technical University of Kosice (TUKE), one of the key leaders in Slovakia in the field of introducing new, innovative forms of communication into educational processes and work with students, has installed its own Cisco TelePresence CTS-3010 room in May 2010. This was the first installation of Cisco TelePresence CTS-3010 in an educational institution in the region of Central Europe.

The Cisco TelePresence unit at TUKE, as well as at other Slovak universities, is connected to the Slovak Academic Research Network (SANET) which provides a 10Gbps optical backbone network, with interconnections to CESNET and GEANT2 networks. As the backbone is highly over-provisioned, currently it was not necessary to implement QoS mechanisms into the network which simplified the Cisco TelePresence installation processes.

Cisco TelePresence virtual meeting solutions are designed to provide users with the feeling that they are virtually in the same room together. To achieve this level of realism, certain conditions must be met:

- To present a life-like, high-definition image of a person in real-time over the network requires very stringent service level requirements for delay, delay variation (i.e. jitter), and packet loss.
- The meeting room environment also must provide a near perfect replication of lighting, acoustics, and ambiance.

The Cisco TelePresence unit at TUKE has passed all the required conditions and TUKE has received a certificate of the Cisco TelePresence eXperience. CTX is a mark of excellence in a new and growing TelePresence industry.

### III. TELEPRESENCE NETWORKS

Having a TelePresence unit without a possibility to connect to other units would be pointless. Therefore several commercial TelePresence network operators exist

around the world. These networks are private, closed networks, that guarantee QoS service level agreements. For the real experience of TelePresence calls it is always necessary to have enough bandwidth with short delay and jitter between the endpoints. The private operator provided TelePresence networks can provide that requirements. On the other hand, as these networks are closed, not publicly accessible, there is a limitation on interconnection and less possibilities on creating TelePresence calls between different organizations.

While the public Internet does not guarantee any QoS parameters (as the communication might be routed from the source through several different Internet Service Providers towards the destination), interconnections between National Research and Education Networks (NREN) are well distributed and provide enough, usually even over-provisioned bandwidth.

In the USA, the National Lambda Rail (NLR) NREN operates a public Cisco TelePresence exchange that is used to cross-connect TelePresence units in education [3]. Currently there are more than 60 Cisco TelePresence units from the USA connected to that exchange point [9]. It enables all those units to communicate with one another. TUKE is connected to the very same exchange at NLR, thus making TUKE reachable from any USA Cisco TelePresence unit and vice versa. Even though the data communication from the TUKE TelePresence unit is flowing generally through the public Internet (SANET-GEANT2-NLR), with current TelePresence calls there were no QoS related issues detected by the time of writing this paper.

#### IV. CASE STUDY OF TELEPRESENCE USAGE AT SLOVAK UNIVERSITIES

##### A. *The TelePresence portal*

The TelePresence technology is a fairly new way to communicate with people over long distances in very high quality. Many people are not familiar with this technology, which is caused by the lack of information in the local environment. Therefore, a new informational portal has been developed to provide everyone with basic information about the TelePresence technology. The portal not only provides basic information for the general audience, but also provides information for scheduling calls, checking calendars, etc.

##### B. *Connecting Cisco TelePresence sites together*

In bigger TelePresence networks and exchanges [3], the network operators are using a Session Border Controller device which provides a single point of connection for every participating TelePresence site. In the National LambdaRail TelePresence network (NLR) in USA, they were using a Cisco GSR router with an SBC blade in it that can provide such a functionality needed for TelePresence interconnections. Currently, they have moved to Cisco's ASR routers, which are now the preferred platform to be used as an SBC [1]. With a lack of these devices either in SANET, or at TUKE, other methods to interconnect TelePresence systems in Slovakia were researched.

With great experiences from a successful deployment of VoIP networks in a Slovak educational field, it was clear that other solutions can be used as well, at least to

overcome the time until a new enterprise SBC can be obtained. The VoIP network between universities, high schools and other institutions was built using the SIP signaling protocol. Experiences with centralization of the VoIP call processing and call routing using open source SIP proxy servers and protocols like ENUM were utilized to provide a similar functionality as an enterprise SBC can provide.

Cisco TelePresence systems are using the standard SIP signaling protocol [10] to establish, manage and tear down TelePresence calls. Therefore, it is possible to use a standards based SIP proxy server to provide a central point for SIP based signaling routing. From the configuration point of view, for all new TelePresence sites at Slovak universities, it is enough to configure a new SIP trunk to the TelePresence SIP Proxy server from the Cisco Unified Communications Manager (CUCM) interface.

The central TelePresence SIP Proxy server was built at TUKE using a Kamailio open source SIP proxy server on an Ubuntu Linux 10.04 server installation. The configuration was updated to provide the needed functionality – to forward SIP messages to the called TelePresence site (CUCM). In the current setup, each site is manually defined with its TelePresence number in the full E.164 form (e.g. 421556027000) and the corresponding CUCM's address. Future plans are to move these parameters into a relational database, thus making afterward changes easier and less error-prone.

Now, when a user dials a TelePresence number from his room, the initial SIP messages are sent from his CUCM to the TelePresence SIP Proxy server which is then forwarding the signaling messages towards the corresponding CUCM. While all the signaling messages are flowing through the TelePresence SIP proxy server, the media stream is forwarded directly between the TelePresence units. Of course, this setup has both advantages and disadvantages. The advantage is in lower latency which is a crucial QoS parameter for TelePresence calls. The disadvantage is in the fact that in this setup, the TelePresence unit itself must provide non-firewalled connection for the media streams (which can be handled and secured using an application layer firewall with SIP inspection and dynamic port pin-holing).

##### C. *Scheduling*

The great advantage of Cisco TelePresence is its ease of use. In enterprise installations, users can schedule a meeting via TelePresence the very same way they were used to schedule normal meetings. They can use Microsoft Outlook to make a reservation for a single or multiple TelePresence rooms. The Cisco TelePresence Manager (CTM) will enable to use only a single touch on the TelePresence's IP Phone to start the scheduled TelePresence conference. This setup requires having a Microsoft Exchange installation with other supporting systems as well, which was not the case for TUKE.

From the beginning, the TelePresence room at TUKE was scheduled using Google Calendar with Google Apps. Google Calendar with Google Apps provides an easy way to schedule company resources such as rooms, places, etc., with a possibility to federate and delegate user roles on the calendar to anyone who has a valid Google account. That allowed for all new TelePresence sites at Slovak universities can use one unified calendaring

application that is available to everyone through a web browser. With one unified calendaring application, it is now very easy to schedule a conference between institutions. The single touch dialing option, which is available with CTM, is a very popular feature not to implement. The single touch dialing was created as speed dial on the TelePresence’s IP Phone menu. When users press the SCHEDULED CONFERENCE menu, the scheduler’s number is dialed out. The scheduler is an application running inside of an Asterisk VoIP server, which used as a frontend for the scheduler. Asterisk provides voice guidance and assistance for the scheduled conferences. The scheduler application uses Google’s DATA APIs to check for planned conferences in Google Calendar at that time and manually starts the planned conference at the TelePresence system.

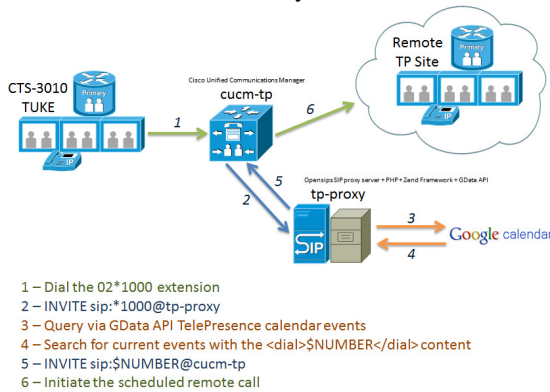


Figure 2. Single touch dialing with Google Calendar

The current version of the scheduler can even work with no touch at all, as it automatically starts the scheduled conference 5 minutes before it is supposed to start. Participants just enter the TelePresence room and the conference starts without the need for any intervention from their side.

*D. Teaching@TelePresence*

The Computer Networks Laboratory (CNL) [5] at TUKE is operating the Cisco TelePresence unit at TUKE, as well as developing new development activities around the technology. One of the first development activities was the interconnection between the TelePresence unit at TUKE and the NLR network in the USA. Based on this interconnection, more than 100 USA TelePresence units, which are distributed over various universities and other edu-institutions, have become reachable for employees and students of TUKE with a simple press of a dial button on an IP phone of the local TelePresence unit at TUKE.

During the summer holidays, representatives of CNL and TUKE have exchanged contacts and started TelePresence discussions with the representatives of Paradise Valley Unified School District (K12), Phoenix, Arizona, USA (PVUSD) [8]. After few e-mail exchanges and settings up a TelePresence call it was clear that both sides have strong enthusiasm and potential to start a common cooperation in both education and research and development. TUKE has presented its faculties, their activities in the field of education and R&D. All those discussions have led to the creation of a first ever global

intercontinental educational program, which is provided and delivered in a form of presentation lectures through Cisco TelePresence!



Figure 3. TelePresence session between Slovakia and USA

The course contents have been developed and realized by the Cisco Academy (CA, ASC, ITC, NRP) [7] at TUKE and it provided the students and staff members of PVUSD with education in an internationally certified course called CCNA Exploration.

The development of the course with methodology, materials, etc. raised up several questions and challenges. It was necessary to deal with and find optimal solutions for the time zone difference, which in this case was even 9 hours, language barriers, but the most important was to find a good methodology and workflow on how to provide such a course over TelePresence. While the Cisco TelePresence solution provides a form of a virtual round table, compared to a class-room or a laboratory it misses, for example a whiteboard. However, whiteboard is essential for education. It enables to effectively present ideas that the teacher is trying to explain to students and thus improve the process of learning.

The summer holidays were full of work at CNL and RCNA at TUKE. Members were working together on the development of appropriate teaching methodologies for a course that is delivered over TelePresence. Within few weeks, all the new challenges that were raised with the innovative Teaching@TelePresence course were successfully solved. A study schedule has been developed based on the experiences from long-term teaching of local students at RCNA at TUKE. Also a methodology to provide lectures and exercises, workflow on how to collaborate and communicate between instructor and students, knowledge evaluation through exams, etc. were introduced. The whiteboard issue has been fixed by a “virtual” whiteboard in the form of a tablet PC with a touch screen that provides the very same ease of drawing diagrams, topologies, notes, etc.

As the first course, that was used as a proof-of-concept and as a verification of the viability of a Teaching@TelePresence course, a course from RCNA’s portfolio was selected - CCNA Exploration - Network Fundamentals.

The CCNA Exploration - Network Fundamentals course is one of the most desirable courses that are available in the Cisco Networking Academy (NETACAD)

and it provides the fundamental basics that are essential for further education in the field of computer networks. The selection of this particular course was highly influenced also by the lack of NETACAD in the near locality of PVUSD, while PVUSD has expressed high interest in such a course to educate their students and staff members in the area of computer networks.

The first Teaching@TelePresence course was attended by staff members of PVUSD from various departments. In total, from PVUSD, 10 people from 5 different physical locations (always a pair of 2 persons), through 5 TelePresence units have joined the course. In order to connect to one TelePresence call all those units at the same time, a “Meet-Me” number at the NLR’s Cisco TelePresence Multipoint Switch was used [2,3].

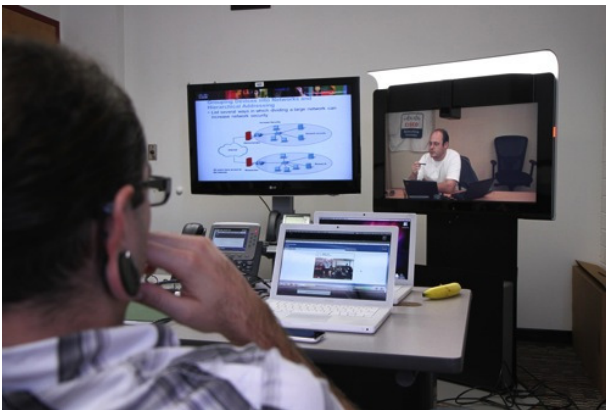


Figure 4. PVUSD Cisco TelePresence unit

Each of the 5 physical locations at PVUSD was equipped with the Cisco TelePresence CTS-500 model, which offers one Full-HD plasma screen to display the teacher, and one LCD screen to display the presentation or the “virtual” whiteboard.



Figure 5. TUKE Cisco TelePresence unit

At TUKE the Cisco TelePresence CTS-3010 offered 3 Full-HD plasma screens to display students from PVUSD and one LCD screen to display the presentation and the “virtual” whiteboard.

The schedule divided the course into 8 days in total, throughout 2 weeks [6]. Classes were held every week from Monday till Thursday. To overcome the issue of time zone differences, both parties have selected the most suitable time to start the course. Every day, the classes started at 4:00PM local time at TUKE and 7:00AM local time at PVUSD, and ended at 8:00PM local time at TUKE and 11:00AM local time at PVUSD. Each session lasted for 4 hours and ended with bon appétit to lunch at PVUSD and bon appétit to dinner at TUKE ☺

## V. FEEDBACK FROM THE TEACHING@TELEPRESENCE

The practical outcomes of the course showed that the Teaching@TelePresence is a very viable way to teach remote distant students and in some ways the students and the instructor evaluated the course as even better than a course in a real classroom.

The lectures and the exercises of the CCNA Exploration Network Fundamentals course via TelePresence differ only a little from a real, normal in-class teaching and learning. The teacher of the Teaching@TelePresence course can see the students in their real life-size, he registers emotions on students’ faces, gestures and general body language of students sitting on the other side of the world! Hence he is able to respond with the same reaction to, for example gestures from students which might indicate difficulties with understanding of the just explained topic, as if really sitting together in one classroom. Students can interactively ask questions or add comments in the very same spontaneous manner as in a real classroom. They can even be polite and raise their hand before asking a question, as in a real situation ;-)

### A. Feedback from Students

TABLE I.  
EVALUATION QUESTIONS

Question	Average Rank (min=1, max=5)
Understanding of an instructor via TelePresence vs. via normal in-class training	4.86
Interactivity of the course via TelePresence vs. via normal in-class training	4.00
"Falling asleep" or feeling tired in course via TelePresence vs. via normal in-class training	2.71
Ease of use of your TelePresence installation (calling in, connecting a PC, sharing a screen, etc.)	4.71
Sound quality in your TelePresence room	4.86
Video quality in your TelePresence room	5.00
Presentation screen quality in your TelePresence room	5.00
Sitting in a TelePresence room vs. in a normal classroom	4.71
What is your over-all satisfaction with the first ever Teaching@TelePresence course?	5

What do you think, what is the biggest difference between a course that is via Teaching@TelePresence and a normal in-class training with local instructor?

- I don't see a big difference at all. It feels as though the instructor is in the room with you and there is no disconnect between the students and teacher. I felt more comfortable in this setting than in a face-to-face setting.
- It's easier to attend! I like that I'm not in a room with a bunch of other students.
- Not consistently seeing other participants in the class.
- the biggest different i felt was trying to answer questions since one doesn't see everyone and doesn't know if you are talking over them or not.
- No difference

- There are a lot less distractions via TelePresence since there are not that many people in the room.
- That more of the students had access to a high quality instructor.

Are there any advantages or disadvantages of a course that is going through TelePresence over normal in-class course? Please express your thoughts.

- I think the advantages far outweigh disadvantages. I have taken many, many classes over my educational career and I got more out of this class than any other class.
- No.
- I like the TelePresence because it gives us more options of training outside our organization. We don't have qualified staff to teach all subjects.
- Some advantages would be the fact you can take courses outside the realm of what the school may have to offer you at their campus.
- No traveling
- The only disadvantage I can see is getting face to face time with the instructor.
- I do not feel there were any disadvantages, at least in a course on this topic.

Would you attend another course over TelePresence?

- 100% YES
- 0% NO

Would you rather attend the next course over TelePresence or in-class?

- 100% TelePresence
- 0% In-class

Why did you choose that answer in the previous question? What is better/worse in that type of training?

- The TelePresence was easy to attend and pay attention to while sitting in class with a face-to-face instructor can be tedious and boring.
- I like being in a small class and not having to deal with other students. Because sometimes other students are unmotivated and distracting in a traditional classroom environment.
- In the TelePresence class there are less distractions from a regular class.
- I feel that the TelePresence was an effective way of learning, and also convenient for my situation.
- Not having to travel
- I am distracted very easily and being in a small room with only one other person helped me focus
- TelePresence was much more convenient.

Have you noticed any cultural differences between the people from the EU/Slovakia/Kosice/Technical University of Kosice/Computer Networks Laboratory+Regional Cisco Networking Academy and the US culture? Anything shocking or interesting?

- Not at all. I came into the TelePresence with an open mind and did not notice any cultural difference in the least.
- Not really... I found both instructors to be very friendly and a pleasure to work with and learn from.
- We differ on what some items are called. Nothing shocking. I like the differences.
- I have done a lot of travels throughout the world so I couldn't really say anything shocking or interesting. I have been impressed on the quality of English over there.
- No
- They need to get Macs.
- Yes. Your sense of humor, voice inflections, accented words and syllables, pauses during speech.

## VI. CONCLUSION

Technologies are changing and transforming the world. Education is part of that change. Education as we have known it is changing and transforming the way teachers do teach students and the way students learn from teachers. Nowadays we can easily deliver knowledge to any distant place in the world. The form of the delivery, speed and quality is dramatically shifting forward for a better tomorrow. We do not have to reinvent education, but we can dramatically improve its delivery.

A good example of this shift is the example of how simple TelePresence solutions can change the way schools will seek new teachers, change the way students will interact with the teacher and in the end change everything – to better.

Together we are more powerful than we ever could be apart! Together we can change everything.

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