

Time Travel Proxy: Using Lightweight Video Recordings to Create Asynchronous, Interactive Meetings

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ABSTRACT

Time Travel Proxy (TTP) enables participating in meetings that you cannot attend in real time, either because of time conflicts or global time zone differences. TTP uses lightweight video recordings to pre-record your contributions to a meeting, which are played on a tablet that serves as a proxy for you during the meeting. Reactions and responses in the meeting are also captured in video to give you feedback of what happened at the meeting. A working prototype of TTP was deployed and studied within four developer teams in their daily stand-up meetings. The study found that the affordances of video helped integrate the time traveler into the social context of the meeting, although the current prototype was better at enabling the time traveler to contribute to the meeting than it was in conveying the meeting experience back to the time traveler.

Author Keywords

Telepresence; asynchronous collaboration; video; meetings.

ACM Classification Keywords

H.4.3. [Information systems applications]: Communication applications---Computer conferencing, teleconferencing, and videoconferencing.

General Terms

Human Factors, Design.

KEEPING UP WITH MEETINGS

A growing concern in modern work life is keeping up with the number of requests to attend meetings. A survey of research on meetings [13] found that managers spent almost 70% of their time in meetings, which they expected to increase in the near future. This increasing demand for meeting time often makes it difficult to find times when all the participants can attend, resulting in challenges in resolving time conflicts among overbooked calendars. The increasing dispersion of work to other sites and time zones

[3] adds to the temporal pressures. Working in global teams that span across time zone difference of eight hours or more adds to the challenge of scheduling meetings since there is no overlap in the typical workday [15].

Taken together, these trends in meeting pressure suggest an opportunity for “time-shifting” collaboration. Can we enable people to participate in meetings that they cannot attend in real time? Can we mitigate temporal distance by enabling asynchronous participation in meetings? While meetings have become a popular (perhaps even overused) mechanism for transferring information, they also provide a social context of creating a sense of belonging and working for the group [7]. Any tool to support meetings needs to support this social work as well as the communication functions of meetings.

We present the Time Travel Proxy (TTP) prototype which explores using lightweight video recordings to enable asynchronous meetings (see Figure 1). After reviewing related work, we describe the design of TTP and a field study of four developer teams using TTP in their daily stand-up meetings.

RELATED WORK

TTP builds on the work of Venolia et al. [17] in using a physical proxy to represent a geographically remote participant in hub-and-satellite teams. While their work



Figure 1. Time Travel Proxy prototype

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showed the social and longitudinal benefits of physical proxies for spatially remote colleagues, we extend the proxy concept to include temporally remote colleagues.

In light of the maturing infrastructure for sharing video messages (e.g., YouTube), recent work has explored using lightweight, asynchronous video messaging to collaborate and communicate. VideoPal [5] enabled students between Greece and the U.S. to share “penpal-like” video messages to get to know each other in a conversational manner. We wanted to explore how recorded video messages could accomplish the work of business meetings.

There have been a few prior attempts at enabling time travel around meetings. Tucker et al. [16] developed Catchup, which allowed late-joiners to a meeting to get up to speed by reviewing condensed audio summaries of the meeting. Banerjee et al. [1] used mechanisms for annotating and indexing recorded meetings to enable quickly browsing and reviewing the meeting later. While this helped people who missed meetings quickly find the information they sought, it did not enable them to participate in the meeting.

The Time Independent Collaboration System [12] enabled students to complete a class project by exchanging asynchronous video messages. They used this prototype to study the effect of synchrony and high fidelity cues (e.g., video) on measures of social processes such as involvement, credibility, conversational effectiveness, etc. They found that synchrony, more than high fidelity, correlated with favorable social processes, emphasizing the challenge of creating an effective asynchronous conference experience. However, in their prototype, all participants viewed the video messages individually, as if they were never in the same place at the same time. In TTP, we designed for the case where most people met together with only one or two people who could not attend. We believe this “temporal hub-and-satellite” is a more common case where individuals may miss a meeting due to time conflict or global time zone differences.

Given the diverse activities that can occur in group meetings, ranging from decision-making to bargaining to discussing routine matters [11], we looked for an accessible meeting type to initially focus TTP’s design. We thought that the relatively structured and short individual status reports presented at daily stand-up or scrum meetings used in the agile software development process [9] would be a good place to start exploring the concepts of TTP.

A case study of agile development in an industrial context [2] found that the prevalence of daily meetings led to a challenge of too many scrum meetings. A study of globally distributed scrum meetings [4] found that unsuccessful agile teams forced everyone to meet at very inconvenient times, leading to a resentment of scrum. Since these studies documented how these concerns arise in daily scrum meetings, we used those meetings as an initial focal point for the design concepts of TTP.

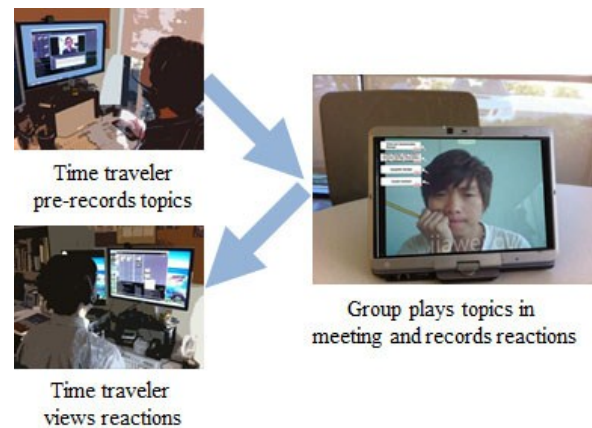


Figure 2. Using Time Travel Proxy

TIME TRAVEL PROXY PROTOTYPE

TTP is designed to enable a temporally distant person (*time traveler*) to participate in a meeting. Our design goals were to enable the time traveler to contribute to a meeting by pre-recording comments, to provide a physical proxy to represent the time traveler in a meeting that played those comments, and to capture the meeting’s reactions and other comments to the time traveler and convey them back to the time traveler. This basic usage flow is depicted in Figure 2.

Asynchronously recorded video messages are used to enable a time traveler to contribute to a meeting. A time traveler selects an upcoming meeting scheduled in his online calendar and uses his computer to record video messages on topics that he would like to contribute to the meeting. These *topic* videos provide progress updates on his work or comments on issues that he anticipates will arise in the meeting. Pre-recording topics is easier if there is an agenda published in advance or a recurring structure to the meeting. Each topic has a subject line which describes the topic. Email notifications of his recordings are sent to all participants in the meeting, so they are aware of TTP topics to be presented at the meeting. In addition to the topic videos, the time traveler records about one minute of a video loop which serves as his *avatar* during the meeting.

During the meeting, a group member brings TTP running on a touch tablet, which serves as a physical proxy for the time traveler. After using the TTP software to select the recordings prepared for this meeting, the time traveler’s avatar plays full screen on TTP, along with “thought bubbles” that contain the subject line of each recorded topic (Figure 3a). This avatar video loop provides an ongoing, dynamic representation of the time traveler’s presence in the meeting to provide a proxy sense of actively participating in the meeting. TTP is set on the table such that the other meeting participants can see the TTP screen.

As a pre-recorded topic from the time traveler arises in the discussion, or whenever people in the meeting decide to play a topic, they can touch a thought bubble on TTP. The avatar changes to the full-screen replay of the recorded



a. Time lapse of playing avatar video loop with topic “thought bubbles”



b. Playing topic while recording reaction video

Figure 3. Interacting with TTP

topic (Figure 3b). While the topic video is replaying, TTP also captures a *reaction* video of the meeting, to record the meeting participants’ reactions to the time traveler’s topic. The preview window in the bottom right corner of Figure 3b indicates that a reaction video is being recorded. By default, the reaction video extends for 60 seconds after replaying the topic to naturally capture the discussion presumed to immediately follow its replay. The reaction video recording can be ended before the 60 second timeout by touching an “X” close control. Our design rationale for the reaction videos was to capture a sense of the meeting members’ verbal and non-verbal reactions, such as whether they understood the comment, agreed or disagreed, or any immediate responses to the pre-recorded topics.

Meeting members can also *reply* to a specific topic by touching a button embedded in its thought bubble. They can also record a *new message* to the time traveler, not related to any specific topic (Figure 4). In both cases, an interface for recording a video message (similar to that used by the time traveler to record topics) appears on TTP. The time traveler is notified via email when a reply or new message is recorded. Reactions, replies, and new messages provide ways for the meeting members to asynchronously interact with the time traveler through recorded videos.

When the time traveler has time, he can view the reaction, reply, and new message recordings directed toward him during the meeting. These recordings convey the group’s reactions to his topics, responses, further questions, or other issues that arose in the meeting. He can then follow through on the collaboration using whatever means he chooses (email, groupware tool, or even another video message). He does not need to review the entire meeting, but can focus on just the interactions most directly relevant to him.

A working prototype of the TTP system was built using a standard three-tier architecture: a rich client, a web service, and a server back-end. The rich client (built using Microsoft Windows Presentation Framework) provided the interface for recording and playing back videos. Video operations were handled using Microsoft’s Expression Encoder library. The video data were stored on a web server and metadata for the videos were stored in an SQL back-end. This architecture enabled videos to be recorded and played back by the meeting participants using clients that interfaced directly with the video web service. The TTP viewer client was designed specifically for touch-based tablets for portability and ease of operation in a meeting.

TTP FIELD STUDY

Using an iterative design approach to system development, we deployed an initial working prototype into actual use to get early experience and feedback on the concept. This approach enables studying how the technology interacts with the actual social context of the work activity being supported. To maximize the input we could get on TTP at this early stage, we focused on co-located agile development teams that have people who often miss meetings due to time conflicts. Studying co-located teams enabled members to experience both the time traveler and in-meeting experience of TTP. The daily frequency of the agile teams’ stand-up meetings maximized the opportunity for using TTP for a member who could not attend.

Using an exploratory survey sent to randomly selected developers at a local U.S. site of our large global software company, we recruited four software development teams to participate in the TTP field study. Each team had between six and fifteen members involved in software or web



Figure 4. Recording a new message in TTP

feature development work. The teams followed an agile software development process, which included a daily stand-up meeting where everyone provided a status update on their completed tasks, discussed planned future work, and identified any issues that blocked their progress.

We deployed TTP in each team for about three weeks. Each team volunteered three or four members to serve as time travelers who participated in the meeting asynchronously three times each (one person scheduled per meeting). This repeated usage enabled gaining familiarity with using the system over time, allowing us to observe how usage evolved. Wherever possible, we identified volunteers who had naturally occurring time conflicts that caused them to miss meetings. We had 15 participants (13 male, 2 female) across four teams using TTP as a time traveler. Throughout the paper, time travelers will be referred to by number (P1-P15) and their teams by group number (G1-G4).

At the end of G2's field study, they wanted to try TTP with some contractors located in China working with their team. Previously, one U.S. team member served as a liaison with the team lead in China. G2 wanted to involve the Chinese colleagues more directly in their daily workflow and afford more interaction with the whole team. The 15-hour time zone difference between the U.S. West Coast and China made it very difficult to find a convenient time for everyone to meet during the workday. We extended the study with G2 to enable them to try using TTP to connect across global time zone differences to increase interaction with their Chinese colleagues. G2's Shanghai-based team lead used TTP to record and participate in the U.S. team's daily stand-up meeting twice a week for a total of five times.

Data collection

We collected a variety of quantitative and qualitative data about the teams' use of and reactions to TTP. For each group, we video-recorded two daily meetings prior to introducing the system to observe how they were normally conducted. We then continued to video record the meetings when using TTP one to two times per time traveler to capture the group's interaction with the system. These recordings captured the physical and behavioral interactions with the system and associated comments and conversations made by the group in reference to the proxy.

We also conducted two interviews each with all 15 time travelers: once prior to using the proxy system, to learn about current practices in their meetings and attitudes towards missing them, and a second interview after they had used TTP to asynchronously participate in two meetings. The second interview focused on their attitudes and reactions towards making recordings and viewing the reactions. Interviews were first open-coded for recurring themes, then analyzed by comparing specific instances of those themes across groups and participants. [14]

Additionally, all team members (time travelers and group members) were given a survey both prior to the team's use

of TTP and at the conclusion of the study. The pre- and post- surveys both used Likert scale questions that measured attitudes towards the value, convenience, and importance of attending the daily stand-up meeting, and the post-survey also featured specific questions pertaining specifically to the experience with TTP.

For the extension to the team in China, we also sent before and after surveys to members in both the U.S. and China, and observed and video recorded four of their meetings using TTP. Finally, we interviewed the project leads in both geographical locations at the end of the team's usage to understand their perspectives on the experience.

Furthermore, we collected log data from TTP as a record of the participants' use of the system. This data helped us characterize the team's usage of TTP, such as the duration of topic and reaction videos and whether and when topic messages and reactions were viewed.

FIELD STUDY OBSERVATIONS

From the log data, we observed that the 15 time travelers made 51 sets of recordings for 48 unique meetings using TTP. Some time travelers elected to use TTP beyond the three times we had asked of them to participate in meetings when unexpected time conflicts arose. Three different teams also found a way to share TTP among two time travelers within the same meeting when an additional time conflict arose beyond the person scheduled to use TTP. They did this by using the tablet to play one time traveler's comments, then switching to the second time traveler. Table 1 summarizes the usage statistics of the number and duration of recordings made and viewed in TTP.

Time Traveler	Median avatar duration	29.5 secs
	Topics per meeting: mdn./avg.	1 / 1.9
	Median topic duration	38.5 secs
Meeting	Topics viewed	89%
	Median additional reaction duration	35.5 secs
	Median reply+new message duration	32.5 secs
Time Traveler Review	Reaction videos viewed	54%
	Replies+new messages viewed	57%

Table 1. Usage data from TTP log files

With a few exceptions, recordings made in TTP of any kind (topics, reactions, replies, and new messages) were short, with a median of less than 40 seconds. We use medians as a more representative way to describe the data due to some outlier long messages that skew the averages. Short messages worked well with people's expected attention span for TTP, and the teams quickly learned from observing TTP in use to keep the recordings clear and concise. One time traveler commented, "Now when I do it I pre-think in my head 'OK I need to make these points, and try to be

succinct about it, because people are going to listen to it, they don't want to hear me chatter'" (P4).

Just over half (26) of the TTP recordings only had one topic, which is consistent with a status report meeting structure of going around the room and having each person give their status update. The other recording sessions had two (11) or three (also 11) topics, which corresponded to a meeting structure that separated input into different categories (e.g., what I did today, what I plan for tomorrow, what I am blocked on). The order of playing TTP comments in the meeting varied among the teams. A couple teams often played it first so as not to forget about it or to "get it out of the way". But others progressed in an alphabetic order or according to the category of topic, so TTP topics were played in an appropriate order.

For reaction videos recorded during the meeting, we looked at the length of the *additional* reaction beyond replaying the topic video (i.e., the total length of the reaction video minus the length of the topic video to which it was reacting). Besides the few cases where the topic video was stopped before completely playing it, the median additional reaction duration was 35.5 seconds (which is shorter than the default 60 second extension). There were only ten new messages recorded in meetings (and most of those were made by one team that did not notice the "Reply" mechanism for replying to a specific topic). Thus, we grouped reply and new message usage statistics together.

In scheduling participants' use of the TTP system, natural time conflicts were leveraged as much as possible to provide a realistic context for using TTP. Where there were no time conflicts, participants were scheduled at random to serve as time travelers. Out of the 51 recordings made, 16 of them reflected genuine time conflicts. Common reasons that participants cited for missing the meeting included working from home or other site (7), doctor/dentist appointments or illness (3), or a concurrently scheduled meeting (3). If there was no conflict, participants generally continued to work in their offices while the regularly scheduled meeting occurred. Thus, recordings were made under a mix of both realistic and artificial conditions.

Avatars

TTP's avatar loop was intended to give a dynamic presence for the time traveler in the meeting, encouraging a sense of participation and ensuring that they were not forgotten. In response to a survey question "I liked having a constant video representation of the person", team members rated an average of 4.8 (SD=.9) on a 7-point scale (7=strongly agree). This rating was supported by comments that it "*adds a bit more life*" (P8) and "*I'm actually somewhat pleased by the effect of it, it's a little bit of a hokey thing, but when the avatar is playing on the laptop in the meeting, it actually kinda looks like the person's there*" (P6)

We asked participants for a roughly 1-minute long avatar to give a long enough interval before looping back. This

duration typically decreased over a time traveler's repeated use, as evidenced by the 29.5 second median avatar video duration. When asked about the avatar video recording experience, nearly half of the time travelers disliked having to record a new avatar for each meeting. A few considered it a "waste of time" (especially if the topic video was short) and others found it "forced" and awkward to sit in front of the camera for up to a minute. Some even "re-used" their avatar for subsequent meetings (even though that meant that their clothing changed between playing their avatar and topic videos in the meeting).

Four participants expressed some degree of being self-conscious about their appearance, whatever appeared in the background, or "tics" recorded as part of the avatar. Two participants mentioned that they noticed distracting or annoying behaviors in others' avatars in previous meetings that they avoided in their avatar recordings. Thus, time travelers expressed several concerns about the effort involved in recording the avatar loop.

Regarding viewing the avatars in the meetings, video recordings of the meeting showed that initial reactions to the avatar often exhibited some confusion as to whether the video loop was in fact a live video feed. Some participants greeted the time traveler's avatar as if they were under that impression, or explicitly asked "Is it live?" In three of the four groups, upon learning that it was a constantly playing loop, people mentioned that it was "creepy," "disturbing," or were uncertain of the purpose of the avatar video: "*So we just watch him fidget?*" These initial reactions quickly subsided as they gained familiarity with TTP, but the widespread initial reactions suggest that the avatar's rich sense of "presence" of the time traveler perhaps led to some tensions in expectations of interactivity.

The potentially distracting factor of the avatar was also noted, particularly in cases where actions in the recording occurred at random times in the meeting (e.g., head nodding or a "hmmm" grimace). A few people suggested that a still image would suffice (or that no avatar was needed). Nevertheless, there was evidence that the avatar succeeded in including and remembering the time traveler in the meeting. For example, participants frequently directly addressed the TTP as if the person was actually there: ("*[P3], do you have anything to say? We'll come back to you.*") And the avatar provided an opportunity to express some social playfulness with the team: "*I can clearly see how the creative minds of my team would from time to time do something incredibly silly on the screen just to see if we're paying attention. I'm not sure if that is intended, but it's certainly fun and enjoyable.*" (P4).

Topic videos

The topic videos enabled the time traveler to contribute information to the meeting. A total of 94 topic videos were recorded over the field study. Once they were familiar with the software and had addressed any technical issues with their computers and sound levels, time travelers generally

reported that recording messages was fairly easy, often taking only a few minutes. No one reported any difficulty thinking of what to say in the messages, largely due to the well-known, standardized format and structure of the stand-up meetings: “[it’s] pretty practiced in terms of we do these every day, do these meetings so much that I know what I need to bring with me” (P7). Thus, participants felt prepared and qualified to record their messages via TTP.

Nine participants re-recorded at least one of their messages, for various reasons, mostly because they reviewed their recording and decided they were either rambling, unclear, or otherwise not polished enough: “Just wanted to say a quick message and realize I’m rambling on here and what I wanted to say was this...that wasn’t clear, either not verbally clear or you could’ve said it in 2 sentences” (P1). Others who did not re-record any messages deemed it unnecessary to worry about. One person mentioned that “it wasn’t a show,” (P2) and another was unconcerned with appearances: “If it looks funny, it looks funny” (P14).

Although the content of the status updates were often intentionally “short and sweet”, as one group member said, several time travelers interjected elements in their recordings to engage or otherwise add some level of interactivity with their recordings. Time travelers tried techniques such as: referring to individuals in the meeting by name and directing a comment specifically to them (either joking or serious), asking questions to a specific team member or the group as a whole, inviting discussion among the present group members (“So, talk about that”), or asking hypothetical questions and pausing to simulate a normal conversational flow (“Guess what I did today? [pause] That’s right, had a bunch of meetings.” (P8)).

Reaction videos

We expected that time travelers would be curious to see how the meeting reacted to their recordings, both while they viewed the topics and in the discussion immediately following. However, the log data show that only 54% of reaction videos made during the meetings were viewed by the time travelers. In the interviews, time travelers commented that unless they had intentionally embedded an attempt at interaction in the recording, they did not expect much reaction from the status updates that they were contributing. Furthermore, there were other feedback mechanisms shared among the team, such as emailed minutes, updating the bug-tracking spreadsheet in a shared repository, or even hallway conversations, that could confirm the team’s receipt of the time traveler’s contributions without having to watch the reaction videos.

Efforts to engage the audience in the topic video often yielded some sort of relevant response in the reaction video. For example, jokes were met with laughter and questions or invitations for discussion resulted in replies back to the time traveler in the reaction video (either with specific information or a request for later follow up). Time travelers commented that they were more likely to watch the reaction

video when they had recorded something to elicit a response: “If I do something goofy you want to see people’s reactions to it” (P6). Participants also reported receiving valuable information in the reaction videos that they would not have received in any other context: “I guess historically I probably would not have gotten that bit of feedback from an email status I sent out” (P6).

In most cases, participants generally felt that the message they were trying to convey in their recordings was understood by the group. However, in the case of G4, at least two participants found that their topic videos were misinterpreted, as evidenced by confusion and added discussion in the reaction videos and how they were documented in the team’s official record. For both these members, watching the reaction videos provided “some feedback that I should make my status update more clear” (P14), which they consciously tried to do in the future.

Since these interesting reactions while viewing the topic videos in the meeting were relatively rare, time travelers expressed wanting some way to highlight any notable reactions that did occur so they could just watch those. Otherwise, they wanted to skip or scan toward the end of the topic video replay to hear when the group started to explicitly respond to the topic.

Reply and new message videos

Only 18 replies and 10 new messages were recorded for time travelers in the meetings. We expect that most of the meeting’s feedback was captured in the reaction videos during the time (up to 60 seconds) automatically recorded after replaying the topic videos. Most of the new messages were recorded by one group that did not notice the reply mechanism for replying to a specific topic, so we grouped reply and new message usage data together. The median duration of these messages was short at 32.5 seconds.

It was disappointing to see that only 57% of the reply and new message videos created in the meeting were ever viewed by the time traveler afterwards. Given the explicit effort of creating replies and new messages (unlike the automatically captured reaction videos), and the email notification to the time traveler that they had been recorded, we would have expected that the time travelers would have viewed those recordings. It seems likely that since the groups were co-located, there were easier, more immediate ways of following up on the issues raised in the meeting, making it unnecessary to actually view the recorded videos.

Comparison to email

When we asked how teams typically dealt with absences at the stand-up meeting (without TTP), usually the absent member sent an email status update to the team as a whole or just to their manager. This led to exploring the question of whether participating via video through TTP was more effective than sending email. In the interviews, time travelers saw added benefit in using TTP over email, as one time traveler reflected:

“For the person who’s playing it... maybe it’s hard for them, but for the person doing it I think it’s better than sending an email. It’s a live perspective, because it feels to me more ‘in’ the meeting than with an email” (P12)

By contrast, email updates were often seen as ineffective because they were frequently either ignored by group members, or if they were only sent to the manager, they were not necessarily shared with the rest of the group. Furthermore, email may be subject to more mediation or interpretation by a spokesperson sharing the message to the group who *“may just highlight or paraphrase, may or may not get the whole context of what’s going on” (P19)*.

In commenting on listening to the time traveler’s recordings in a meeting, many people mentioned the benefits of receiving the information in a richer medium. Often the richness came from cues including facial expressions and tone of voice. Two participants also noted that information was easier to process when delivered verbally as opposed to in written form. The usefulness of video was also more beneficial for more substantial messages than for status updates that were only one or two sentences long.

An additional benefit of TTP over email was related to the visible presence of the time traveler. TTP increased the visibility of absent team members, especially in the case of recurring absences. Prior to using TTP, one participant explained feeling annoyed when group members regularly missed the stand-up *“because I think they’re valuable, and 80% of the team made the effort to be there... A lot of times it’ll be like ‘Oh where’s that guy? He’s missing. Did he tell anyone? No. I don’t know what he did today’” (P15)*. One such group member, who frequently missed daily stand-ups, mentioned the potential positive impact of TTP on teammates’ perceptions of him: *“it’s a more live thing that shows to the team that I am caring more” (P12)*.

Two time travelers even cited the advantage of not having to worry about writing a formal, grammatically correct email: *“It’s a lot easier to record, it’s easier to talk to someone directly” (P10)*. In summary, TTP was viewed as better than email due to the increased visibility of the sender and message, the fact that the message was not mediated and easy to process by listeners, and the relatively lightweight and low-effort process of recording video.

Extension with Chinese colleagues

While the team using TTP to connect with their Chinese colleagues used the system in the same way as the other groups, they also experienced some unique issues related to their geographic distribution. In the co-located teams, time travelers also had the experience of watching others’ messages played back when they attended the meeting. Some mentioned that experiencing TTP from both sides informed the way they made recordings (e.g., avoiding distracting avatar behaviors). The Chinese time travelers, on the other hand, never experienced using TTP in a meeting, and this lack of feedback affected their behavior.

For example, at first the Chinese time travelers recorded messages that were several minutes in duration, at a level that was too specific to be relevant to the entire U.S. team. As a result, the U.S. team liaison sent an email to the Chinese team lead suggesting ways to adapt their use of TTP to be more beneficial to the audience (e.g., breaking up recordings into smaller chunks, tips on avatar creation).

The international use of TTP also added some asymmetries in the communication. The Chinese team lead found TTP and video to be useful to share a large amount of information (particularly relating to software bug testing) in a way that was better than exchanging emails and pictures. However, he acknowledged that in terms of the U.S. team’s response, *“they haven’t done too many messages in the videos to share to us” (P16)*. Rather, most follow up communication occurred via email. The U.S. team liaison felt that, from their perspective, it was not always clear how or if the Chinese team received any video responses that the U.S. team sent: *“If we give feedback or questions, don’t have the real time ‘I get that’... That’s been a little uncertain in my mind, if everything kinda gets back” (P8)*. This concern was compounded by the fact that the teams had different native languages, making comprehension more uncertain. Thus, TTP did not serve as a replacement for written communication, but rather a supplement: *“there are some things that don’t quite get across so you have to follow up in email to make it clear” (P8)*.

In terms of social presence, TTP enabled the two groups of people, who had never met in person, a richer means to communicate and interact via video. Aside from the detailed information being shared, TTP provided a higher-level, general awareness of the Chinese group that was viewed as beneficial from the U.S. side: *“There’s an awareness of the teams... It’s easy to forget about teammates that you don’t see every day... This is the opportunity to get together with them that we wouldn’t otherwise have, or make it feel that way I guess” (P8)*. The advantages of video over written communication in this regard were echoed: *“TTP has been kinda a chance to bump up to a high level, share the important parts with the team who otherwise would not be interested in reading a 5 page document on what’s going on” (P8)*. The Chinese team lead also spoke to the reciprocal nature of awareness: both being able to *“share my face with the other team, that’s cool...”* and to know what the other teammates were like allowed the two sites to get to know each other better.

REFLECTING ON THE FIELD STUDY

As an initial prototype in attempting “time travel” in meetings, we were encouraged that all the teams used TTP over the course of about three weeks each, and even found uses for TTP beyond what we had asked of them. Using TTP to include more than one person who could not attend the meeting and to include Chinese contractors who were time zone shifted from the team demonstrated needs that the teams recognized could be addressed by TTP. The field

study also identified several issues to guide the iterative design of TTP and future work.

Role of video

A central feature of TTP is using video to represent the time traveler in the meeting and to communicate information into and back from the meeting. In deploying TTP into usage, we examined the role of video in its effectiveness, especially given the added effort needed to record and view video. While the design of TTP was intended to convey the more rich and nuanced interactions that video is good at supporting [6], limited opportunities for those kinds of complex interactions arose during daily stand-up meetings.

The TTP meetings we recorded did show some examples of rich reactions through TTP, especially in response to explicit attempts by time travelers to elicit interaction. Laughing at jokes, non-verbal expressions of agreement or confusion to what was being said, and responses to direct questions were all captured in the reaction videos. Video also enabled many of the playful interactions through TTP, largely through avatar recordings. Playful avatars included animating a stuffed animal across the screen, using an action figure as an avatar, and pretending not to be able to hear. These avatars used the richness of video to add some personality and social camaraderie to the meeting.

Perhaps the most practical use of video was to ensure attention to the time traveler's comments in the meeting. Interviewees mentioned that the time travelers felt like their recordings were heard in the meeting, unlike email messages that they could have sent about their progress. While email may have effectively communicated the content of their updates, they had no confidence that people would actually read them, whereas the video recordings projected their participation into the social context of the meeting where they did expect they would be viewed.

In summary, we see a few different ways that video provided a *social context* for the time traveler's contributions. The playful uses of video in TTP evoked more social connection across the asynchronous interactions. The social act of viewing a video as part of the meeting was more likely attended to than reading an email outside the context of a meeting.

Avatar video loops

One of the novel uses of video in TTP is the avatar video loop that gave the time traveler a dynamic, physical presence in the meeting. While the avatar contributed toward getting a high percentage of the time traveler's recorded topics played during the meeting, it also generated some negative reactions from both the meeting participants and the time traveler.

The common initial reaction of mistaking the avatar for a live video feed of the remote person evoked a "telepresence uncanny valley" reaction [10], where the avatar's lifelike representation of the time traveler misled viewers into trying to interact with it in real time. While understanding

the purpose of the avatar was easily learned, it can be a confusing (if not embarrassing) first impression. This misperception probably contributed to several people's comments on the avatar as being "creepy" or "disturbing".

Furthermore, time travelers did not like having to re-record an avatar for each new meeting. We designed TTP to require a new avatar for each meeting to provide continuity from the avatar to replaying the topic videos. That is, the time traveler would be wearing the same clothes and recorded in the same lighting conditions for a smooth transition from playing the avatar loop to the topic videos. But many time travelers complained about the inefficiency of re-recording the avatar which, except for occasions when people used the avatars playfully, was a tedious effort.

One design implication of these reactions is to capture and represent the avatar in a different way. Rather than recording a minute-long video loop, the avatar could be created by individual frames abstracted out of the topic video recordings. Video analysis algorithms could be used to judiciously select individual frames from the topic videos and create a slow animation loop as an avatar. This approach would obviate having to explicitly record an avatar and would generate a dynamic, but animated, avatar that would not look like a live video conferencing feed but still maintain continuity with the topic video recordings.

Asymmetry of benefit

Looking across all of our data, our experiences indicate that we were more successful in integrating the time traveler's contributions into the meeting than we were in conveying the meeting back to the time traveler. The usage logs show that most topic videos (89%) were played in meetings, whereas much lower percentages of messages generated in the meeting (54% of reaction videos, 57% of replies and new messages) were reviewed by time travelers. While most of the survey responses did not show significant differences comparing before and after using TTP or between time travelers and meeting participants, one question that showed a significant difference according to a t-test was, "With TTP, our daily group meetings were helpful to me". On a 7-point scale with 7=strongly agree, time travelers rated the usefulness of the meeting when participating via TTP an average of 4.69 (SD=.33), while the average for other group members participating in the meeting was 5.64 (SD=.30) ($t=2.06$, $p=.05$).

Time travelers appreciated being able to share their information with the group, and receive directed comments in response to their items. However, despite being able to convey their information, time travelers almost unanimously agreed that they missed hearing their teammates' updates and wanted to be aware of what occurred in the rest of the meeting beyond what was recorded in the reaction videos. While acknowledging that sometimes they would find out relevant information one way or another if it was truly important, there was a general feeling of potentially losing something: "*I'm basically blind*

to what others are doing...I felt like I could be missing something or not, there is some uncertainty” (P10).

Team members benefited from the TTP in that they were able to receive information from an absent member. One team manager even mentioned that TTP “obliged” members to record an update that they might normally forget to send to the group. However, many group members also commented that the inability to receive real-time replies to questions and responses was disappointing. According to G4’s manager, *“If we hear their voice we feel they are more involved, but only for the 30 seconds [that they speak.] After that it’s all one-way...We’re talking TO them and there’s no response, we don’t feel that they’re involved. We’re sending messages to them and that’s it.”*

Even though the time travelers received email notification of recordings made for them in the meeting, just over half of those recordings were viewed by the time traveler. This pattern underscores the point that email notifications do not engender the recipient’s attention, in part because email by itself lacks the social context for focusing attention. Despite the effort invested in recording video messages from the meeting, there were not enough social cues to prompt the time travelers to view them.

Furthermore, while the time traveler could tell that the team had played their message by viewing reaction videos, the team had no such mechanism for determining if the time traveler had ever viewed the reaction videos (and, thus, may or may not have received their input and comments). The main reasons cited for not viewing the reactions included the fact that time travelers did not expect the group to provide feedback to their status, or the fact that there was little urgency to do so, as they expected colleagues would follow up with them later if important. G3’s team manager described the effects of this break in the communication loop: *“The clarification questions we’d have to wait, and would not necessarily always get answered...[We] maybe didn’t get a response to that, just get the next status. So the ball would get dropped.”*

Therefore, an imbalance in effort and benefit existed between the time travelers and group members. Time travelers were able to convey their messages but in return lacked information on what others had done. Group members received the recorded update but did not sense an illusion of further interaction, as any reactions from the group could not be responded to in real time (and were sometimes completely lost). Time travelers had to expend effort in pre-recording their topics, the meeting had to invest work in setting up and operating TTP in the meeting and time travelers had to invest additional work in reviewing the recordings from the meeting (although this often was not done). This imbalance between the relatively higher effort needed of the time travelers compared to the higher benefit received by the meeting leads to a classic CSCW obstacle to adoption [8].

We want to explore stronger, more socially visible feedback cues about whether recordings made are actually viewed as a way of creating more social context and sense of interaction through TTP. For example, while we could tell from analyzing the usage logs whether the recordings were actually played by the intended recipient, providing that viewing feedback within TTP itself might increase the social encouragement for playing back the videos. Future designs of TTP need to provide more interaction and feedback from the meeting to the time travelers.

Asymmetry of experience

Another dimension of asymmetry emerged in the group that included the Chinese contractors using TTP. Before adding time travelers that were geographically remote in China, all the time travelers were also able to experience how TTP was used in a meeting, which helped them tailor their recordings to be more effective (e.g., short videos, avatars that were not too distracting). However, the Chinese colleagues never had the opportunity to see TTP from the perspective of participating in a meeting, and relied on getting specific feedback on their recordings.

This asymmetry points to another issue that could benefit from richer feedback. Whereas meetings are mutual experiences where there is more shared sense of what is appropriate to say and do in a meeting, the asynchronous time travel in TTP creates a split between the experience for the time traveler and the meeting. Richer feedback between those experiences is needed to regain a sense of shared awareness. For example, if TTP provided implicit feedback to the Chinese contractors that their recordings were stopped before they were completely played, it might have given them a cue about needing to shorten their recordings.

Limitations of our field study

While we learned a lot from our field study, there are some limitations from how much we can generalize from the teams we studied. First of all, they were all developer groups within our software company that were comfortable with technology and using new software as early adopters. Furthermore, their daily stand-up status meeting had a pre-defined structure and short duration, which might be more conducive to TTP use than other types of meetings (e.g. those that involve discussions or brainstorming). Usage of TTP in different contexts may yield different findings that vary based on both the work and the group dynamics.

Another frequently-raised question was how TTP use would scale if several people could not personally attend the same meeting. Although the original design of TTP was intended to support just one remote user at a time, it could be possible that in larger teams, multiple tablets could be used to represent different people. Alternatively, if the avatar is modified to represent several people, then recordings from multiple time travelers could be played in a meeting. In fact, in at least three meetings during our study, two people sent in recordings. They “shared” the TTP tablet by switching it to represent each person in sequence during

the meeting. While coordinating the playing of multiple comments could become an issue, groups were able to navigate shared use of TTP with little difficulty.

Additionally, the size of groups and the physical space in which their meetings occur could have an impact on the utility of TTP. The group that was least interactive with TTP (in terms of sending replies and curtailing reaction videos) was a larger team operating in a big space, so that TTP was both located farther away from the group and less able to capture the context of the audience.

We also observed that TTP relies on a certain amount of local overhead to bring in a touch tablet to a meeting, log on, and get the avatar running for the meeting. While the teams in our study seemed to master playing the time traveler's recordings at appropriate times in the meeting, some teams struggled more with the overhead effort of getting TTP started in the meeting. The least interactive group with TTP also had the most problems with starting TTP at the beginning of the meeting (perhaps related to setting it up in a big, public space rather than being able to keep TTP running in an office or more private space).

Future work

We plan to continue iterating on the design of TTP, incorporating the design implications that have arisen in our field study. We also want to deploy TTP in a broader range of contexts to exercise how it can work. Beyond the status update meetings where TTP showed some potential in including time travelers, we would like to see what benefits TTP could enable in other kinds of meetings or social chats.

While our field study focused primarily on missed meetings among a co-located team due to time conflicts, we got a preview of the potential and challenges of using TTP in supporting meetings among members in globally offset time zones. We would like to conduct further deployments in globally distributed teams to study their experiences.

While time travel still remains a physical impossibility, we believe that TTP shows potential for enabling "virtual" time travel to participate in work meetings. We hope that an iterative design process will continue to refine the proxy for time travel concept into one that can be practically used in meetings in the future... or perhaps even in the past.

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