Mobile Technology For Awareness Of Time Progression And Its Impact On Meetings.

Flaviu Roman, Himanshu Verma, Nan Li, Patrick Jermann, Pierre Dillenbourg
Centre de Recherche et d'Appui pour la Formation et ses Technologies (CRAFT),
Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland
{firstname.lastname}@epfl.ch

Abstract — **In this paper we present the motivation, design, development, and initial evaluation of a time awareness technology for meetings. As part of improving meetings effectiveness using technology, we focus on the meeting time management, and the method relies on presenting real-time notifications of the progression of the meeting phases to the participants. We then evaluate the utility of the technology, and its impact on the people and their behavior in the meeting, concluding that such a support system brings added value to the meeting outcome in a number of ways.**

Keywords – Frameworks and Methodologies for Collaboration; Collaboration Enabling Technologies; Mobile and Wireless Collaboration Systems; Architectures and Design of Collaboration Systems; Awareness in Collaboration Systems; Interfaces for Collaborative Work.

I. INTRODUCTION

Scientists have historically devoted large efforts to studying meetings and group interactions from various perspectives, including the opportunity and utility of technology mediation and awareness tools in meetings. Nevertheless recent research by Scott, Shancock et al. [1] shows that although it was assumed that the advances in communication technology were expected to diminish face-to-face interactions and replace it with more asynchronous collaboration, the number of meetings in companies and organizations continues to rise.

Romano and Nunamaker [2] have shown that analyzing meetings from perspectives of processes, productivity, expenses and outcomes is essential when many workers spend between one and three quarters of their work time in face-to-face meetings, a figure that increases with hierarchical levels. They find that costs associated with meetings increase every year, and the lack of efficiency leads to large losses for organizations, both in terms of expenditures and in terms of productivity time.

Following our previous efforts in analyzing the effects of balanced participation and designing tools for meeting mediation like the Reflect Table and ReflectWorld [3], we address here the issues of time and agenda management, for which we design and deploy a technology-based solution.

We could think that one of the properties of a successful meeting is that it comes as close as possible to addressing all the issues on the agenda, reaching consensus among the participants on all topics, and finishing within the allocated time. Some flexibility with respect to the agenda may contribute to meeting efficiency, but in most cases the biggest problem is that people are not aware of the progression of time, leading to delays. This comes as a consequence of the cognitive focus in a meeting, normally directed on the task, the discussion, and mutual understanding, which can impair awareness about time progression. Many times this leads to time management breakdowns. Therefore we propose to use technology to mitigate this shortcoming, and to provide the participants with real-time notifications regarding time progression.

II. LITERATURE REVIEW

Munter [4] discusses a series of individual meetings problems among which he identifies poor time management. Mutual understanding and consensus are factors that can impact time efficiency, according to Mackie and Goethals [5], who show that groups are more efficient if there is more agreement on collective agendas and goals. Goodman, Ravlin et al. [6] go deep into analyzing models of productivity and assert that productivity and outcome of the group is influenced positively, among others, by the technology at their disposal. This view is shared by Bran, Malone et al. [7] who state further that besides using technology, the practitioners will need to be able to solve problems in a near real-time manner, adding pressure and challenges to their time management in meetings, and proposes the use of simple and rapid technologies as help.

Macan [8] proposed, in 1994, a process model for time management, and claimed that while positive effects were found on tension and job satisfaction for participants, no significant effects appeared on job performance. We believe that there are two shortcomings in his study which, if adjusted properly, could lead to different results: the complexity of such models can be replaced by simple real-time awareness, and the lack of options and availability of appropriate technology at the time may have proved restrictive in terms of design.

A. Time Management And Awareness

Few meetings are normally equipped with awareness technologies. Research work on awareness has been done by Dourish and Bly [9] who conclude that awareness has a positive impact on content by raising the number of spontaneous contributions or interactions. Even though their conveyed information is very rich, they do not address time progression awareness. Dourish and Bellotti [10] discuss the notion of passive awareness in the context of shared workspaces, which refers to the environmental signals outside the main focus of the task. However they only provide awareness related to activity, and do not mention another passive meeting property: the time progression.

B. *Agenda Management And Time Allocation*

A further aspect of analysis is the appropriate timing of agenda items within a meeting. While an appropriate distribution of time slots across agenda items can be a very important factor to determine the outcome of a meeting, very little research effort has been devoted to this. Simple, intuitive methods widely used are either dividing the total time by the number of agenda items, or starting a meeting without pre-allocated times, methods that carry large risks be suboptimal [4]. Also, very little research has been dedicated to creating technologies to alleviate this aspect; a patent filed by Google for a method of event firing in meeting progress contains small incipient steps in tackling such issues, but the area itself seems underexplored.

C. *Review Of Meeting Assistant Technologies*

We look here both into academic research and commercial solutions, evaluate their state of the art, and capitalize upon their shortcomings in our design.

Since limited research on *face-to-face meetings* is concerned with time progression in meetings, we plan to capitalize on the unexplored territory. The existing research usually integrates time management modules into larger systems to facilitate meetings. Miranda and Bostrom [11] do a review of complex systems through the eyes of content and process facilitation for participants. Process facilitation traditionally includes support for staying on track with the agenda, but they show that this is mostly performed by a human facilitator rather than an automated tool. Studies from Schummer, Tellioglu et al. [12] uncover the necessity of integrated meeting support technologies and propose an initial prototype for such a system, called *LivingAgendas*, which is based on a web technology for building agendas and addressing them throughout the meeting, but with a time management module that is only used when planning the agenda before, and not during the meeting.

Remote meetings assistants were researched more widely, with the advent of streaming technologies, with references of systems spanning from Dennis, George et al. (1988) [13], Cutler, Rui et al. (2002) [14], to Bishop and Danzfuss (2010) [15], all of them employing novel technologies (at their times) to enrich remote meeting environments. Because of the much broader scientific effort, these solutions are better in terms of features and quality than the ones available for face-to-face, and the features could represent an important source of inspiration, should they be appropriate to be present in face-to-face interactions.

We also analyze a number of currently available commercial solutions. We skip the review of older tools, because the rapid increase in the capacity and performance in computing quickly dismisses older technologies as less suitable. The vast majority of the existing software runs on computers only, either as software such as NovusAgenda [16], SuiteAgenda [17], or ZippyMeetings [18], or as an online portal like eScribe [19] or IQM2 [20]. They provide assistance for meetings management, including time keeping, but most are targeted at large organizations with more formal meetings, where using such tools may be part of formalized work protocols. This often means that at least a facilitator, if not all participants, need to be logged in to the system, and interact a lot through it, rather than only through face-to-face conversations.

We believe mobile technologies have some advantages when they function as platforms for displaying short, real-time awareness notifications, while being less intrusive and allowing the interaction and collaboration to focus on the face-to-face conversations. However most existing mobile solutions we found are just former desktop-only software recently equipped with complementary mobile versions, such as MyCommittee [21], iMeeting Planner, iMeeting Client, ASCO Meeting for iPhone. Few to none of these address the time management issue from a minimalist, notification-based awareness perspective, which reinforces our belief that this research and development direction is under-explored.

III. Research Question and Hypothesis

We want to investigate if and how a time management awareness tool for meetings will impact the collaboration and will help the groups address the tasks in a more efficient, less time wasteful manner. We are looking for meeting management effects as a consequence of time awareness.

We hypothesize that upon raising awareness about the meeting progression, using technology, the decisions of groups and progress of discussion are affected in a positive way, will help them stay on track with time and finish in time.

We are further looking into discovering the effects that individual episodes of awareness had on the group, and the impact on the actions of the participants, in various conditions.

Finally we analyze the behaviors and perceptions of individuals with respect to the time progression, including on a private / public display of it. Although the utility of having such a separation is disputed in the literature, especially for collaborative work [22], there is little known about whether such a separation impacts the behavior of individuals in terms of actions related to time progression awareness.

IV. Technology and Method

We designed a minimalist, mobile, notification-based time management awareness module to support face-to-face meetings. The first version, called SwissMeeting, was an iPhone/iPad application. Further, we integrated (ported) this as a satellite module into a content creation and sharing collaborative whiteboard system, also containing an intelligent search and recommendations module (we will refer to this system as MeetingHub).

We envision two strategies for time allocation: to let the users pre-allocate their agenda items, and to use an Eisenhower matrix to rate the importance and urgency of each agenda item, based on which the system will present them with a suggested timeline. The users are able to adjust the durations afterwards at any time. For the current study, the first strategy was employed.

We conducted a user study to evaluate the impact of the time progression awareness.

A. *Participants*

The user study involved 25 university students in 6 groups of who ran 4 meetings in the same composition, as part of a project from a course. Five groups had 4 members, and one group had five. They met in the same formula once a week for 4 weeks, a first week for a trial meeting which did not account for the study, and the subsequent 3 weeks for real meetings, therefore meeting for a total of 18 times for the study. Because the participants could not be preselected, the groups for the studies were not assigned based on a predetermined algorithm, nor were they constructed with purposes of optimizing their success. Also, participants had no prior training in meetings management but had experiences with meetings as students. They were given a different task to solve every time (which shaped the meeting types into *brainstorming*, *decision making*, and *problem solving*). The tasks had to be solved by collaboration, and by self-managing the strategies and the corresponding meeting phases as a group.

B. *Materials, Apparatus And SwissMeeting*

MeetingHub is composed of a whiteboard (shared screen) with two input devices for each user: a keyboard and mouse, and an iPad. All keyboards, mice, and iPads interact with the same whiteboard at the same time, but the iPad application contains several tabs dedicated to specific features (search, settings, and time management with timeline editor). The timeline editor on the iPad functions as a private display of time (Figure 1), while the whiteboard was provided with a similar widget for public awareness (Figure 2).

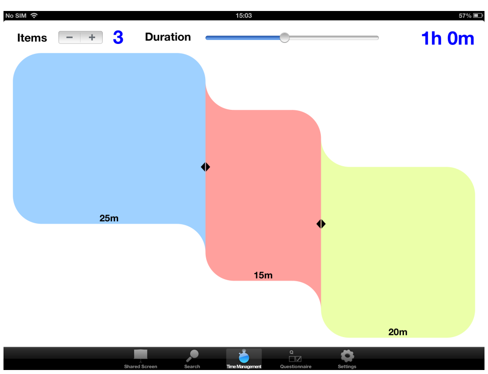

Figure 1. Timeline on private space

The time management related features were adapted from the initial SwissMeeting application. We will describe here the main design and implementation features of the mobile platform. We built the architecture for SwissMeeting based on a set of guidelines, such as simplicity, minimalism, reduced intrusiveness and reduced requirements for user interaction, as well as availability of instant questionnaires, and the Principle of Least Collaborative Effort [23]. These design features also contribute to a longer goal of maximizing potential adoption for future studies in real-world environments. We opted for a server-client architecture and wireless communication because of the need to synchronize information in real-time, including over devices interacting wirelessly.

Figure 2. Public awareness widget

1) *Architecture And Server*

While SwissMeeting's awareness could work just as well as a single application in a meeting, we chose to offer support also for cases when more people bring their mobile devices in their meetings. This enables extra features such as collaborative agenda defining, and meeting invitations. To support synchronizations required by these use cases, we developed a server running on an external workstation / server machine that implements simple server-client architecture. In the case of the port to MeetingHub, the shared computer connected to the whiteboard acts as the server. The server has the role to manage all communication and data, and deployed on a machine that is globally reachable via any internet connection. The server module was built using microsoft.net C# 4.0, and contains an HTTP listener and communication model, data model, and data storage.

2) *Data Model And Operation: Meetings*

Since the use-case model has to accommodate scenarios of both multiple users attending a meeting, and multiple meetings running in parallel, using the same server, the data model has to contain an identity of the user, as well as the identity of the meeting. Then, users can be linked to meetings. In order to relieve the user from having to manage logins, they are identified using a custom scheme which self-generates on their devices. This solution, which relieves the user from having to create login identities, is a representation of a minimalist design.

In SwissMeeting, each meeting has some properties such as the meeting name, location, the scheduled time and its duration. These are filled in when creating a meeting. The meeting identity is also stored but it is transparent to the user. An invitation mechanism allows a creator or participant to invite others by sending a token from within the application by email, and the receiver is added to the meeting participants when he accepts the token. These features were eliminated from the port to MeetingHub, but are required if SwissMeeting would be used independently.

Each meeting can have multiple agenda items. Since all agenda items have to fit in the duration of the meeting, we face the issue of having to distribute this duration to the items. As we discussed in the introduction, the options are to let the participants choose their own durations, or use the matrix mechanism, based on the Eisenhower Matrix method from Time Management, to rank each agenda item's importance and urgency on a Likert scale from 1 to 5. This is easier to quantify, therefore these values have to be chosen by the participants and are part of the item properties. Upon the start of the meeting, the engine suggests a meeting structure where the items are sorted by urgency (more urgent should be addressed first) and their duration suggestions are based on their importance (more important should benefit from a longer discussion allotment). Additionally, each agenda item contains memory for private and public notes.

The server runs a module for feedback management. The questionnaires are stored on the server and transmitted to the device upon requested. As opposed to storing questionnaires on the device only, this mode gives more flexibility over the content of the questionnaires, eliminating the need to update the mobile application every time there's an adjustment to information in the questionnaires. This module was used to replace paper questionnaires for the study, and to greatly speed up the data collection process based on questionnaires.

Since in SwissMeeting the amount of data for storage and manipulation is not very large, we chose not to use a database engine, but a streamlined XML serialization, which integrates very easily with the data model classes, and does not rely on other external engines for management. All the changes in the data stored or received from the application are automatically synchronized to the hard drive, to ensure consistency and reliability. The feedback data is stored similarly, but at the same time is automatically exported to a comma-separated format which can streamline the format conversion for use with statistics software like R or SPSS. Initial tests on SwissMeeting showed that the synchronization experiences no problems or lags, and did scale reasonably well when porting to MeetingHub, however the amount of data required to be transferred increases enough to prevent this model from working outside a local area or peering connection in a large system like MeetingHub.

The communication is performed over the HTTP protocol using POST data attachments, on top of which we defined a protocol that enables coding the various operations. A header field identifies the type of operation, and a general-purpose data field contains a list of objects, that will be interpreted based on the type of message received. Data transferred is serialized using the JSON serialization protocol, and the resulting string is attached as a POST to the HTTP messages.

3) Timeline On iPad

The SwissMeeting application and the iPad application of MeetingHub are applications running on iOS 5.0 or higher. SwissMeeting contains the private timeline and agenda management features, while the iPad module of MeetingHub inherits the private timeline, and implements screen collaboration, search and intelligent suggestions, and feedback collection through questionnaire.

C. Design And Variables

The main independent variable of the study was whether the groups had pre-assigned roles to participants. These roles were assigned to cover related parts of the system: the *time keeper*, the *search organizer*, the *content manager*, and the *leader*. There were three groups with roles (the same role was always assigned to the same person), and three without roles. Another independent variable was the type of meeting they had, according to the task (*brainstorming*, *decision making*, *problem solving*).

We analyze the effect of the blinking notification with respect to the phase of the meeting, and its impact to the conversation of the people. Most of this analysis (including the creation of the appropriate variables) is based on coding on the recorded videos of the sessions, but also on the responses from the questionnaires, and on quantitatively interpreting results from the processed log files.

We used Bangerter and Clark's *activity transition conversation markers* [24] to evaluate transitions in the phases of group conversation. Specifically, using analysis of the recorded videos, we define the Time-To-Transition (***TTT***) as the amount of time (in minutes) it took the teams to move to another phase of the meeting, i.e. the time span between the blinking and the appearance of a conversation transition marker. In parallel, we compute the "state of the topic" and the degree of consensus that existed within the group (***ST***). ST can have the values *done* (coded *blue*), *close* (*red*), *late* (*green*) corresponding to whether the topic was already finished, was about to finish, or clearly required more time to finalize. We assigned the corresponding colors Blue, Red and Green to these values.

Another variable we defined is the dominating activity (***DA***) of a phase, from *read*, *write*, *talk*, and *organize*. From this, the activity transition (***AT***) is defined as the pair of *DA*s before and after a phase transition. We also observed the Boolean values of finished-in-time (***FT***) as a measure of meeting efficiency (from the time management perspective).

Other measures are *number of actions*, *familiarity of group*, *gender*, *and number of utterances*, assessed either by pre or post-test questionnaires, or counted by the system and available in the log files.

D. Procedure

The groups were asked to skim the tasks briefly before the meeting and to setup an ad-hoc meeting agenda together (define a number of phases, and the estimated durations for each phase of the discussion). A phase would correspond to an allotment where some type of action would be carried out as part of the strategy the group creates to address the task. The total duration of the meeting was fixed and depended on the task (30, 45, and 45 minutes). Once they agreed on the phases and time slots, they pre-allocated time slots for each phase, and the experiment started with the time awareness widget hidden. The phases' durations *could still be adjusted* at any time during the experiment. Upon reaching the end of a phase, the widget popped out and started **blinking** for about half a minute, indicating that the time for the phase has passed, and then disappeared.

The system logs all actions, including those related to the widget (e.g. modifying time slots, etc.) We also collected data by having the participants fill in pre-test and post-test questionnaires. The pre-test questionnaire assesses the level of acquaintance of the participants, while the post-test questionnaire is aimed at matching the users' operations and decisions in relation to the awareness of phases ending. The meetings were also recorded with front and back camera, to capture elements of the interaction between the participants, and video coding was used to compute part of the variables.

V. EVALUATION AND RESULTS

MeetingHub is a larger system whose goals are to study collaboration from several angles including through the sharing of information, of search results, through the use of the affordances for specific purposes, through meeting management and conversations. However the results we discuss in this paper are strictly related to the time and agenda management of the meeting, and the collaboration interactions resulting from the awareness of the time progression.

On our track to validate the hypothesis and to obtain exploratory results, we aim to answer the following concrete questions:

A. Did the participants become aware of the blinking?
B. How accurate were their pre-allocated time slots? Did they intervene and adjust them throughout the meeting?
C. What do we learn about the use of private vs. public display of the progression of time?
D. What was the impact of the public blinking on the conversation and meeting organization / management? Is there a relation between TTT and ST? Do transitions happen also before a blinking event?
E. What influenced the perception of utility of a time management tool? (i.e. roles, familiarity, gender, etc.)
F. What was the qualitative assessment of the added value of the time management tool (e.g. pros/cons and adoption)?

The data reveals the experiment contained a number of 30 blinking events (or episodes), which was a consequence of the number of phases designed by the participants before the start of the meeting. Of these, 13 were in groups with roles, and 17 in groups without roles. The results are followed later by discussion and interpretation.

A. Awareness Of The Blinking Notification

A number of 87% of the people reported to become aware of the blinking on the public display, and in 100% of the cases, at least one person observed it within every group and every experiment. In teams with roles, 10 out of 13 times, the person who observed the blink and notified the group about it was the one having the time management role.

B. Accuracy Of Pre-Allocated Slots And Post-Adjustments

The questionnaire shows 63% reported that the pre-suggested times were accurate, while the videos revealed 66% of the groups finished on time. Also, an important observation is that the participants almost never post-adjusted their time distribution after the start of a meeting (only in one case they extended the current phase by 5 minutes).

C. Public Vs. Private Display Of Time

Besides analyzing the effect of the public notification on the group, which will follow, the video analysis shows that there are very few episodes in which participants intentionally looked at the progression, either privately (6 times, out of which 5 times by the person with the time management role), or publicly (by opening the time management widget, 5 times). One interesting episode of consulting the private timeline involved one participant whose intention was to see if they have enough time left for the current phase. He observed that time was about half way through the phase and did not communicate anything to the others, and therefore the group continued the discussion unaffected and unaware of this person's private check of time. The public blinking was the event that everyone noticed.

D. Impact Of The Blinking Notification On The Group

By analyzing the videos, we extracted transition markers such as "*ok so now we're done*", "*so, now we have to…*", "*let's sort all that stuff*", "*now we can just evaluate*", "*we'd better start work[ing]*", "*we have to move on, but there's still an issue*". Figure 3 shows the *TTT* vs. *ST* (blue: done, red: close, green: late).

We also found that the *TTT* was statistically correlated with the *ST*. [ANOVA H(3) = 15.6991, p = .0004] and we found that the task did ***not*** have any impact on it (i.e. the occurrence of Blue, Red, Green episodes had a similar relative frequency across the meeting types) [$\chi^2(1, 4) = 3.5998$, p = .7307]. Groups having at least one green event turned out not to finish the meeting in time (FT) significantly more than groups with no green events [$\chi^2(1, 4) = 4.1885$, p = .0407].

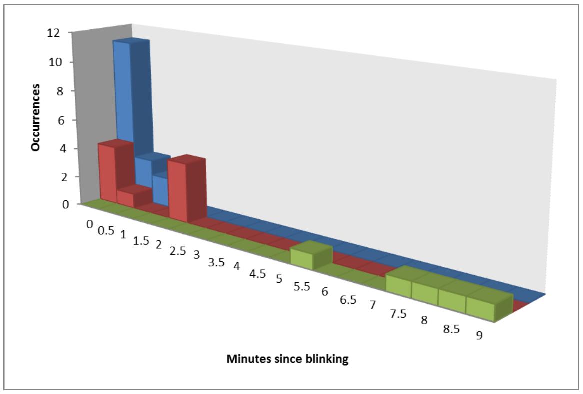

Figure 3. Time gap between blinking and phase change based on content status. Ox Axis: Time (minutes) since blinking. Height shows the number of occurrences at that time.

We took a step further into analyzing the 5 Green events, because their interpretation is not straight-forward. We correlated the episodes within the TTT from the blinking to the logs representing the number of actions. We found out that in one case, the TTT of 5.5 minutes was caused by a system downtime, whereas in 3 of the other 4 cases there seems to be an interesting result of increasing activity, whose local peak is usually close to the transition moment, as shown in Figure 4.

No relation to number of actions, verbal communication evolution or other type of activity has been found in the fourth case, which remains unexplained.

E. *Influence On Perceived Utility Of Time Management*

The rating of perception on utility of having a time management tool in meetings was very high [M = 4.09, SD = 0.81 on a 5-point Likert scale]. Furthermore, groups with roles perceived this utility significantly higher than those with no roles [$F(1,70) = 5.761$, $p = 0.0191$], and this was ***not*** impacted by the meeting / task type (that is, groups with roles rated the importance higher across all types of meetings attended) [$\chi^2(1, 4) = 1.2604$, $p = .8681$].

F. *Qualitative Assessment*

We received text feedback from 7 different participants out of 25 (from across 5 of the 6 groups), all positive. One participant affirmed that *"It's really useful for the time management to activate during the meeting, if you are aware of time, you can end on time"*. Others reported that the visual feedback could be complemented with an audio signal. Finally, two people in groups with roles mentioned that assigning the role of timekeeper to an individual was useful because delegating a role creates more inter-dependability between participants for the management of the meeting. However we reckon that no

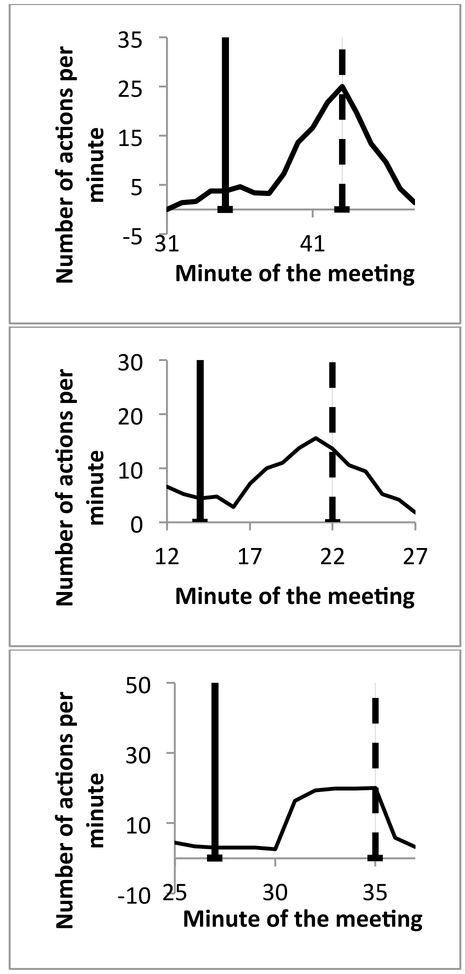

Figure 4. Green cases. Actions per minute from Blinking (full bar) to Transition (dashed bar).

VI. Discussion

A. *Awareness Of The Blinking Notification*

This result is encouraging and proves that the design of the notification was correct, and confirms that the public display should be considered the primary resource for notifications and awareness that concern a whole group.

B. *Accuracy Of Pre-Allocated Slots And Post-Adjustments*

An important finding of our study is that people are good at estimating their required discussion time, with respect to the content they want to cover. This is confirmed by coupling the almost-inexistent time re-adjustments after the meeting start, with the high degree of teams finishing on time, and reporting that they perceived their pre-allocated slots for phases were efficient. Regarding the fact that people did not intervene into modifying their pre-allocated times, this could be related to the preference of moving on soon after blinking (blue + red, 25 / 30) rather than staying on the current topic (green, 5 / 30). But the lack of re-adjustments could also be due to perceiving this action as having little value or be too difficult, if their progress turned out to be far from the intended allocations. We will take the opportunity to analyze this aspect more thoroughly in future iterations or studies of this technology.

C. Public Vs. Private Display Of Time

Because we have seen no immediate action as a result of opportunistic time progress recall (that is, **non-blinking** time awareness events, both from private or public display), it is difficult to evaluate whether the few instances observed had any contribution to the phase changes. We could imagine that people having roles of time managers that looked on their private displays may have been more attentive to the whiteboard "waiting" for the public notification, but since there were no phase changes before a blinking event, we would conclude that the impact on the groups was produced rather by the public blinking notification than by an individual's awareness of the progression of time.

D. Impact Of The Blinking Notification On The Group

The *ST*'s of Blue, Red and Green situations reveal distinct situations of the groups:

1) Blue ST (16 events / 30)

Groups already reaching consensus are using the signal as a semaphore to move on, and they mostly do it immediately. They stick within their allocated time, and avoid any waste. The large number of such situations could be a further indication of the capacity of people to correctly estimate the time required for their phases.

2) Red ST (9 events / 30)

Groups that are about to finish move on after a short time (on average one minute). They seem to use this duration either for recording / saving their ideas, or short interactions for clarifications or for reaching agreement quickly. We believe these groups benefit the most from the awareness, which produces short episodes of convergence that are very useful both for the overall consensus, and for the time management.

3) Green ST (5 events / 30)

We believe these groups that were late or did not reach the consensus chose to prioritize their discussion as opposed to moving on. Our further analysis of these events enables to postulate on the cause of the delay (compared to the Blue and Red). It seems the phase change was performed after an episode of increasing activity over the whiteboard. This can indicate that the end of such an episode of either saving information, re-arranging the whiteboard, or just adding content they felt was missing, could be the cause of the transition to the next phase.

We can further hypothesize that this was either impacted somehow by the blinking in a similar way to the Red ST except with a need for much more time, or that time awareness was not present at all, and the phase transition was content-based. However, the available data is based on activity over minutes rather than seconds, therefore the coinciding points in Figure 4 can be anywhere within a minute spanned.

E. Influence On Perceived Utility Of Time Management

Our interpretation is that people who are assigned roles tend to consciously become more responsible for them, and hence their increased perception on the utility of the time management. However, no significant result on the perception of utility has been found to be impacted by familiarity, gender, or amount of meeting activity (number of actions per user).

F. Qualitative Assessment

We welcome the positive feedback after this incipient study, and we observe that most participants value a time awareness tool in their meetings. Enabling time awareness appears to bring added value, but the type of value seems to be different depending on the situation of the group. Its presence empowers the participants to make a decision about how to continue the meetings. For those already reaching a consensus, or producing a sufficient amount of content, the tool helps reduce the waste of the time resource and move on. Others are helped to speed up a convergence phase, thus entering clarification or coordination episodes while also saving future time. We also found that a minority of the groups prioritizes continuing the discussion as opposed to moving on, and, somewhat unsurprisingly, many of these groups were not able to cover the meeting contents in time.

VII. Future Developments

We plan to extend the availability of SwissMeeting to other widely-used platforms. A port to Android devices is in the final stage of development. We also plan to devise solutions to improve even further the ease of interaction with the application. We are investigating ways to ease text input, where a solution could be to attach Bluetooth keyboards to the mobile devices. Further, in the meeting room, table-mounted holders (cradles) could be installed, to improve manipulation.

Currently there are no plans to adapt the technology to support remote meetings, though the communication infrastructure itself could, in theory, support remote collaboration. MeetingHub itself is completely dedicated to face-to-face interactions, while SwissMeeting could be separately adapted for remote interactions.

A complete validation of the system is difficult without a larger user study. Therefore we plan to enroll groups in organizations to use our tool in meetings, to evaluate its impact, and to contrast the results with the ones presented in this paper, likely with an improved version of the tool, which reflects the feedback of the current study.

VIII. Conclusions

We presented the development of a technology for time management awareness, which participants use in their meetings to get notified about the progression of time. We tested this for the first time by making a port of the designed application to a larger collaborative system for face-to-face meetings.

The design of our technology contrasts with most of the existing tools and research in the domain. We emphasize simplicity; therefore we avoid implementing features that have a low use. We target portable devices, and we relieve the user from having to create accounts by managing identities automatically, and managing participation by simple email invitations. We hope that this design will favor easier adoption of such tools also in corporate organizations, and that by combining the platform and the concepts, the users will report convincing added value for their meetings.

The results of the first evaluation of the concept and tool are promising, showing people become aware of notifications, and these have a positive impact on their meeting management. We also uncover a number of interesting findings related to the behavior of people in meetings with respect to the allocated time, and to the notifications they observe. Further, the idea of having time managed in meetings seems to be adopted and appreciated by the participants.

REFERENCES

[1] C. W. Scott, L. R. Shanock, and S. G. Rogelberg, "Meetings at work: Advancing the theory and practice of meetings," *Small Group Research*, vol. 1, pp. 1–10, 2011.

[2] N. Romano Jr and J. Nunamaker Jr, "Meeting analysis: Findings from research and practice," in *Proceedings of the 34th Annual Hawaii International Conference on System Sciences (HICSS-34)-Volume 1 - Volume 1*, ser. HICSS '01. Washington, DC, USA: IEEE Computer Society, 2001, pp. 1072–. [Online]. Available: http://portal.acm.org/-citation.cfm?id=820557.820581

[3] F. Roman, O. Mubin, and P. Dillenbourg, "Reflectworld: A distributed architecture for meetings and groups evolution analysis," in *Collaboration Technologies and Systems (CTS), 2012 International Conference on*, may 2012, pp. 389 –396.

[4] S. D. Munter, "Meeting resource guide: Common problems and possible solutions," 1985.

[5] D. M. Mackie and G. R. Goethals, "Individual and group goals," *Group processes.Review of personality and social psychology*, vol. 8, pp. 144–166, 1987.

[6] P. S. Goodman, E. C. Ravlin, and L. Argote, "Current thinking about groups: Setting the stage for new ideas," in *Designing Effective Work Groups*, P. S. Goodman and Associates, Eds. San Francisco, CA: Jossey-Bass, 1986, pp. 1–33.

[7] C. A. Bran, T. Malone, D. Lewis, and J. Burton, "The knowledge worker of the future," in *Proceedings of the 24th ACM SIGPLAN conference companion on Object oriented programming systems languages and applications*, ser. OOPSLA '09. New York, NY, USA: ACM, 2009, pp. 851–852. [Online]. Available: http://doi.acm.org/10.1145/-1639950.1640044

[8] T. H. Macan, "Time management: Test of a process model." *Journal of Applied Psychology*, vol. 79(3), pp. 381–391, 1994.

[9] P. Dourish and S. Bly, "Portholes: supporting awareness in a distributed work group," in *Proceedings of the SIGCHI conference on Human factors in computing systems*, ser. CHI '92. New York, NY, USA: ACM, 1992, pp. 541–547. [Online]. Available: http://doi.acm.org/10.1145/-142750.142982

[10] P. Dourish and V. Bellotti, "Awareness and coordination in shared workspaces," in *Proceedings of the 1992 ACM conference on Computer-supported cooperative work*, ser. CSCW '92. New York, NY, USA: ACM, 1992, pp. 107–114. [Online]. Available: http://doi.acm.org/-10.1145/143457.143468

[11] S. Miranda and R. Bostrom, "Meeting facilitation: process versus content interventions," in *System Sciences, 1997, Proceedings of the Thirtieth Hawaii International Conference on*, vol. 2, jan 1997, pp. 124 –133 vol.2.

[12] T. Schummer, H. Tellioglu, and J. M. Haake, "Towards living agendas - shaping the next generation of business meetings," in *ECSCW 2009*, I. Wagner, H. TellioÄŸlu, E. Balka, C. Simone, and L. Ciolfi, Eds. Springer London, 2009, pp. 263–282. [Online]. Available: http://-dx.doi.org/10.1007/978-1-84882-854-4_16

[13] A. R. Dennis, J. F. George, L. M. Jessup, J. Nunamaker, Jay F., and D. R. Vogel, "EnglishInformation technology to support electronic meetings," *EnglishMIS Quarterly*, vol. 12, no. 4, pp. pp. 591–624, 1988. [Online]. Available: http://www.jstor.org/stable/249135

[14] R. Cutler, Y. Rui, A. Gupta, J. Cadiz, I. Tashev, L.-w. He, A. Colburn, Z. Zhang, Z. Liu, and S. Silverberg, "Distributed meetings: a meeting capture and broadcasting system," in *Proceedings of the tenth ACM international conference on Multimedia*, ser. MULTIMEDIA '02. New York, NY, USA: ACM, 2002, pp. 503–512. [Online]. Available: http://-doi.acm.org/10.1145/641007.641112

[15] J. Bishop and T. Danzfuss, "Editorial: Computer supported cooperative work and "software architectures and mobility: A roadmap"," *J. Syst. Softw.*, vol. 83, pp. 902–905, June 2010. [Online]. Available: http://-dx.doi.org/10.1016/j.jss.2010.02.036

[16] "Novusagenda." [Online]. Available: http://www.novusolutions.com/-novusagenda.aspx

[17] "Suiteagenda." [Online]. Available: http://www.suiteonemedia.com/-suiteagenda-overview/

[18] "Zippymeetings." [Online]. Available: http://www.zippymeetings.com/

[19] "escribe." [Online]. Available: http://www.escribecorporate.com

[20] "Iqm2." [Online]. Available: http://www.iqm2.com/

[21] "Mycommittee." [Online]. Available: https://www.mycommittee.com/

[22] J. Rekimoto, "Pick-and-drop: a direct manipulation technique for multiple computer environments," in *Proceedings of the 10th annual ACM symposium on User interface software and technology*, ser. UIST '97. New York, NY, USA: ACM, 1997, pp. 31–39. [Online]. Available: http://doi.acm.org/10.1145/263407.263505

[23] G. K. Zipf, "Human behavior and the principle of least effort." *American Anthropologist*, vol. 52, no. 2, pp. 268–270, 1950. [Online]. Available: http://dx.doi.org/10.1525/aa.1950.52.2.02a00290

[24] A. Bangerter, H. H. Clark, and A. R. Katz, "Navigating joint projects in telephone conversations," in *Discourse Processes*, 2004, pp. 1–23