Situated Public News and Reminder Displays

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Abstract. In this paper we present concepts for and experiences with a Situated Public Display system deployed in a university setting. We identify the rate with which information is updated as an important property to distinguish different kinds of information. With a first slideshow based prototype it was very difficult for users to predict whether information was updated since they last looked. To solve this problem, we took a broader view and conducted a contextual inquiry to investigate how people deal with paper based posters. We deduced an information flow diagram that identifies roles of people and categories of posters and noticeboards. We identified actionables, that is, posters that offer people to take a specific action, as a special type of information to support. We identified two strategies, planning and opportunism, to deal with actionable information. We present a system using two kinds of displays, News Displays and Reminder Displays, to support both strategies. We show how auctions can be used for Reminder Displays to select those information chunks that are most important in a particular context. Finally, we present an evaluation and lessons from the deployment.

1 Introduction

Due to falling costs of electronic displays and their potential value, we predict electronic displays soon to cover much of public space. Digital displays offer a whole new way of presenting information in public spaces, essentially because the cost of changing information is so low. Public Displays prove especially useful in scenarios where other communication forms like email, mail or the web are infeasible. This is usually the case when the identities of information providers and interested people are unknown to each other or computers are not used by everyone. On most public displays that are installed nowadays, however, information is presented as slideshows or scrolling text. We argue that both presentations are unsuitable for users that pass the displays often, because it is difficult for them to tell whether information was updated. We propose using two different kinds of displays, News Displays and Reminder Displays, instead. Imagine the following scenario. A student passes the digital display installed at the entrance of his department (a News Display) every day. One day, as he has a quick glimpse on it to see whether there is something new, he notices that there is an interesting talk next week, and notes it in his calendar. One week later, just before the start of the talk, a guest researcher who has just arrived passes the lecture hall. He sees the talk announcement on a different display (a Reminder Display) in front of the lecture hall and decides to attend spontaneously.

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News Displays show new information chunks as soon as they are created. These displays support the process of planning well ahead, for example for regular visitors to a place who see the displays often. Reminder Displays show chunks which are considered important at the current time and location by the system. They support the process of acting opportunistically, for example for one-time visitors to a place. Note that the same information chunks are shown on News Displays when they are new and again on Reminder Displays when they are considered important. Thus many people will see chunks first on News Displays and then be reminded by Reminder Displays just in time.
Main contributions of this paper are:

- The identification of the update rate of information as an important criterion informing the design of public displays.
- A consolidated information flow model, that categorizes information chunks, noticeboards and roles of users as found in a university scenario.
- The identification of actionables as a major kind of information chunks to support, together with planning and opportunism as strategies to deal with them.
- A workflow of how people deal with actionables that shows tasks and resources that need to be supported.
- A restructured information flow model that drives system design.
- An information system consisting of News and Reminder Displays, which integrates the findings and was successfully deployed and evaluated in a university setting.

2 Related Work

Work on Situated Public Displays has been done in three broad areas. They were used for *continuous support of small groups* (e.g. members of a workgroup), to provide *shared workspaces for small groups*, and for *support of large groups* (e.g. the inhabitants of a building). For continuous support of small groups, systems like CWall [6], Plasma Poster Network [4], Notification Collage [7], MessyBoard [5], Hermes Door Displays [3], and Semi-Public Displays [10] provide public displays where members of a workgroup can post content, mostly via a web form or email. In these systems, all workgroup members can post content, because peer control works well in small groups. Some of these systems also generate content automatically, like Semi-Public Displays, that show who is currently in the lab from keyboard activity. Most of these systems are interactive and evaluated by expert users in the respective research groups. For these users, many of these systems proved valuable over a long time period from a few months up to several years. The BlueBoard [16] and MERBoard [19] systems provided shared workspaces for small, co-located groups, and a log-on was required to use them. For many tasks, however, people preferred to gather around laptops, and the systems were most successful for specialized tasks, like the SOLtree application of MERBoard. For support of large groups, however, less work has been done. The GroupCast [12] and BlueScreen [14] systems were evaluated only by smaller

Fig. 1. Some News Displays (1,2) and Reminder Displays (3,4) installed at the department building

groups, although their design can well be applied to very large groups. In GroupCast sensors were used to determine which people are nearby, and information regarded to be of mutual interest was displayed to spark informal conversations. BlueScreen also sensed nearby people, and used auctions to show ads to people who have not yet seen them. ECampus [18] is an effort to deploy displays throughout a whole university campus. It supports a large user population. Currently, eCampus does not focus on the utility of information shown, but more on soft values. For example, in an underpass bus station, content created by artists is shown on large displays. In most systems for a large user population, content creation is limited to authorized users, because peer control is too weak to suppress inappropriate content. [11] provides a good survey for systems that support small groups together with the advice to carefully integrate systems into users' workflow.

3 Requirements Analysis

From the systems reviewed in related work, only the eCampus system focuses on support of large groups, but less on the utility for the users. The goal of our system was to provide useful information for large user groups. To understand the values of our users towards a Situated Public Display system, we conducted

a laddering analysis [15] interviewing 24 students. The study revealed that the most important values students want to support are *success, fun* and *social interaction*. We decided to focus on the value of *success* first, and build a system that would provide useful information for students on a daily basis. The system should complement, but not replace the paper based noticeboards that are in use in our building. In order to gain first experiences, we deployed a first prototype early. Since the prototype seemed not to work as we expected with the user population, we decided to conduct a Contextual Inquiry to understand more thoroughly the needs of our users.

Fig. 2. The layout of the first prototype

3.1 First Prototype

Design. Since it was too difficult to dynamically update information with PowerPoint and we had flexibility problems with HTML, we decided to deploy the system as a Java application running full screen. The bigger part of the displays showed information chunks similar to paper based posters. Information chunks from different institutes were shown in slides, where display duration depended on the number of letters on the slide and was about 20 seconds on average. Each institute was assigned a number of slides, and two information chunks announcing information like news or seminars could be displayed on each slide. On average 5 slides were shown, resulting in a cycling time of approximately 100 seconds until all items were shown. Peak utilization was 12 slides, resulting in a cycling time of approximately 4 minutes. In addition to the information chunks, different information modules with information that was updated more often were shown on the right. We implemented modules like a clock, rain radar, bus departures, cafeteria menu, flight departures, video streams, and building facility opening times, which could easily be replaced to fit the context of the display.

In contrast to the poster like information chunks, this information is not edited manually but extracted automatically from diverse sensors in the building (e.g. information on how many public computers are available), and sources derived from the web. We tried to design the presentation of modules so that users can tell very fast whether something was updated, and then extract the information as fast as possible. For bus departure times for example, we used a presentation very similar to that used at real bus stations.

Results. The system was running for 8 months. After an initial hype, the system began to suffer from disusage. An observation of our users suggested that the problem might be that most users do not stay in front of the display but only have a short glimpse instead. We observed 20 random users who happened to pass by the display installed in the secondary entrance within half an hour. Only one user watched the display for about one minute. 10 others glimpsed at the display for about two seconds, and 9 users did not look at all.

Discussion. The most important benefit of digital displays over paper based displays is that information can be updated at any time. Obviously, not for all information it is useful to always update it. The weather data for example usually doesn't change significantly within 15 minutes, the cafeteria menu changes once a day, and for information chunks it is not predictable when new chunks arrive. We call the rate with which significant changes are expected the *update rate* of information. Note that update rate doesn't refer to the technical refresh rate, but rather to the rate by which users can expect significant changes. Users looking at the displays are usually interested in new information. Thus they should be enabled to either predict whether anything has changed or to decide this very quickly by looking at the display. We concluded that the main problem with our first prototype is that slideshows don't support this behaviour. In order to tell whether anything has changed, users have to wait for a whole cycle to see all the slides. This is especially annoying for people who pass the displays regularly. Our hypothesis was that people try to estimate the cost of waiting against the expected benefit of information gained. This is difficult if no cue is available whether anything is new. Thus, because people can't estimate the benefit of waiting, they mostly don't wait but walk away instead.

3.2 Contextual Inquiry

Inspired by the problems from the first prototype, we decided to do a Contextual Inquiry [2] to determine the real needs of our users. The goal of the study was to understand how people in our department use posters and noticeboards to spread and gather information.

Method. For the interviews we tried to cover all relevant stakeholder groups for the system. We interviewed 21 users from four different institutes, which were three undergraduates, six graduate students, seven secretaries and five faculty members. The interviews took place after the first prototype was deployed. The

interviews took place within a period of three weeks and interview duration was between 30 and 90 minutes. We started with a short conventional interview of 10 to 15 minutes to determine the responsibilities and typical tasks of users regarding posters. We then went with the user to the place where they would normally carry out these tasks and had them explain to us how they do this. Thus, for users who created posters, we went to their workplaces, and for users who put up or read posters, we went to the noticeboards they normally use. This process can be described as apprenticeship compressed in time, where we acted as apprentices, analyzing and understanding the typical tasks of the users. This approach is important because users usually have no explicit understanding of their own work, so it is important to observe them in context. In addition to the interviews, we collected examples of posters and took photos of all noticeboards used in our department in order to find categories of posters and boards. After the interviews we created information flow models, work sequence models and artifact models. We consolidated the data over all interviewees into an affinity diagram and a consolidated information flow model.

Results. In the consolidated information flow model (figure 3) we focused on how information chunks are created, distributed and consumed. Users are categorized into sources, filter/forwarders and sinks of information. *Sources* in our case are mostly faculty and secretaries, for whom it is important that their information reaches all interested sinks. Therefore, they distribute posters over multiple noticeboards, highlight important facts and use a corporate identity to increase the probability that interested sinks read the poster. Then they send the information to filter/forwarders (who can be themselves). *Filter/forwarders* are mostly secretaries and decide whether a poster is worth posting and where to post it. Sometimes it is important that people can rely on information they filtered, so they put stamps on filtered posters or post them on locked noticeboards. They put down old and non-approved posters and maintain an archive of those. Everyone could act as an information *sink*, consuming information that was created by sources. Since there are many students, they form the most important subgroup. Sinks like to quickly evaluate the expected benefit of looking at posters against the opportunity costs of used time. Therefore they often only have a quick look and a longer one only if they have enough time or are really interested. They like to quickly identify the source and key points of a poster, and like to have pictures on it to quickly identify if they have already read it. Most sinks like to have important information centralized in certain places, so they know where to find it. Many look for new information in the morning, are interested in cafeteria menu around noon and in weather data when they leave the building. Students had different information needs at the beginning than at the end of the semester, and needs differed between first and higher semesters. Some sinks keep a well maintained calendar and note all actions they want to take in calendars and to-do lists. We refer to this strategy as *planning*. Other sinks prefer to attend events for which they see posters spontaneously. We refer

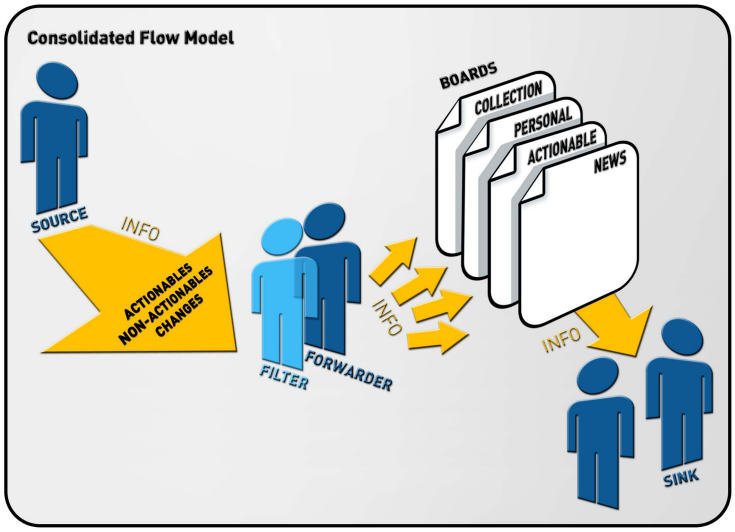

Fig. 3. The consolidated information flow model. Actionable, change, and non-actionable information chunks are created by sources and put onto noticeboards by filter/forwarders. Sinks read these chunks on news boards, dedicated actionable boards, personal boards and collection boards.

to this behaviour as *opportunism*. For important events, these sinks rely on being reminded by friends. Most sinks however use both strategies depending on the context.

We studied more than 60 posters and categorized them into actionables, changes and non-actionable information chunks. *Actionables* offer people to take a clearly defined action within a certain window of space and time. These are for example deadlines for exam registrations or talk announcements. Actionables have deadlines, so it is important to see them on time, while the time until the deadline can vary from one day to several months. *Changes* to actionables were mostly cancellations or changes of the date. They often came as colorful posters, but sometimes the original poster was just changed with a thick pen or post-it. *Non-actionables* are all chunks that are neither actionable nor changes to actionables, for example new project or publication announcements or snippets from newspapers, which serve mainly representation purposes. Other examples are lists of exam grades or operating instructions for machines. We extracted the parts that were shared by most information chunks, which were a title, a clearly visible notion of the source of the chunk, for example the institute logo and contact address, the date of creation, a text and a picture, and for actionables the time and location of the action opportunity. All posters were only hung at locations where sources believed the sinks would see them. Posters for students of Geoinformatics for example were placed in the respective area of the department.

We studied more than 30 noticeboards and observed four different categories, which we called news boards, dedicated actionable boards, personal boards and collections. *News Boards* are installed at the entrances and are intended for highly urgent chunks. Sometimes even the doors of the building were used as news boards. News boards are glanced at by most people while passing them. As it is very hard to keep the boards up to date, most of them degenerate to collections. *Dedicated actionable boards* hold only actionables of a specific kind, and are guaranteed to be complete and reliable. In our department, a dedicated board that holds all available excursions is locked behind glass and has a single board maintainer. These boards can be placed anywhere, as long as everyone knows where they are. People go there specifically to have a look at this board. *Personal Boards* belong to a person or group and hold all kind of chunks that are related to these. In our department, most professors and workgroups have one that is located next to their workplace, and sometimes the office door is used as a personal board. They often hold representative chunks, and people go there explicitly if they look for something related to this person, but also have a glimpse as they pass by. *Collections* are mostly large boards where anything is put that does not fit anywhere else. Each institute of our department has one, and most of the posters there are diverse actionables.

Discussion. From the contextual inquiry we gained models and categories for posters, noticeboards, stakeholders and the respective information flow. For the redesign of the displays we decided to focus on the distinction between actionable and non-actionable information chunks. Whether a specific chunk is really actionable for someone depends of course on the context, like the time, location or role of that person. A seminar announcement for example can be actionable for a student, but not for faculty. Of course, actionable information can also be useful to people who do not want to take the action. Seeing the talks given in a certain institute gives a feeling of what is going on in that institute even if one does not attend the talks. For dealing with actionables, we identified the strategies of planning and opportunism. The choice of strategy also depends on the context: A one-time visitor to a place would need to rely on opportunism, while for someone who visits a location every day it would be entirely possible to plan ahead. We also saw that information need of interviewees depends heavily on context, specifically time, location, interests and intent.

4 Design

In consequence of the insights we gained in the requirements analysis we redesigned the information system for information chunks.

Because the major part of the posters we studied were actionables and changes, we decided to focus our redesign to support these, while also supporting non-actionables as a side effect. To enable users to decide whether something is important to them we color code chunks in the colors of the institute that created it. We also show an image, the creation date, the name of the institute, the author, a prominent title and a textual description. For actionables, we also show the time and location of the action opportunity.

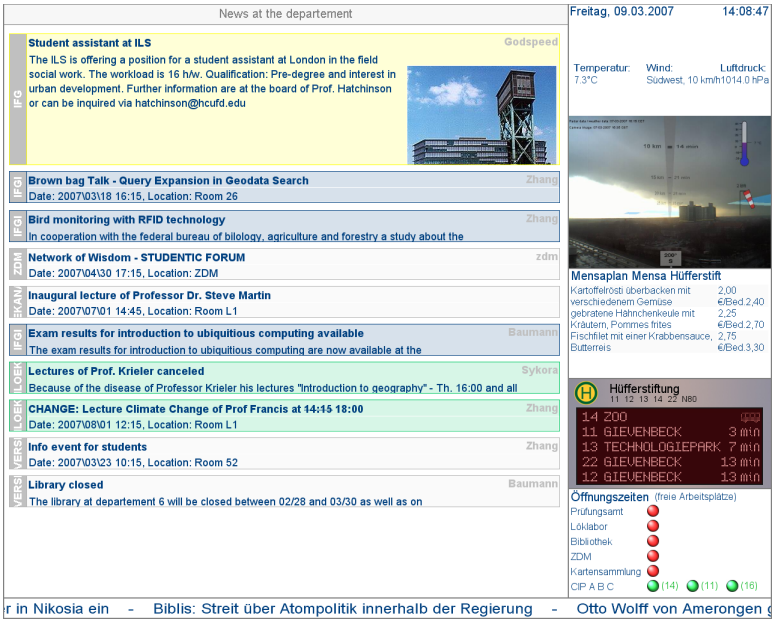

Fig. 4. The layout of the News Display. A list with new information chunks is at the left, while other information modules are shown at the right (e.g. time, weather, cafeteria menu, bus departures, building facility opening times and a news feed). For chunks, details are shown in turn (chunks translated from German).

For actionables, the main question is whether to act or not. We adapted the workflow of how to deal with actionables presented in [1] for the case of public displays (figure 5). We propose to use two kinds of displays, News Displays and Reminder Displays, to support the whole spectrum of strategies between pure planning and pure opportunism.

News Displays (see figure 4) are intended to support planning. They don't adapt to the context and simply show all actionables in the order they were created by sources. They enable users to answer the question "What is here and now *new*?". We adapted the metaphor of an email inbox, so new chunks are shown on top of a list, and gradually move downwards as new chunks are added. Users can glance at the first chunk and see whether they know it, and if they don't, read chunks from the list until they get to the first one they already know. With this strategy, users are guaranteed never to miss a chunk as long as they pass News Displays regularly, like once or twice a day. On the other hand, it doesn't help much if users pass News Displays more often. Thus, News Displays should be installed in spaces where the number of different people who see them is maximized. Good places for News Displays would be at the entrances, where all users in the building are guaranteed to see them twice a day.

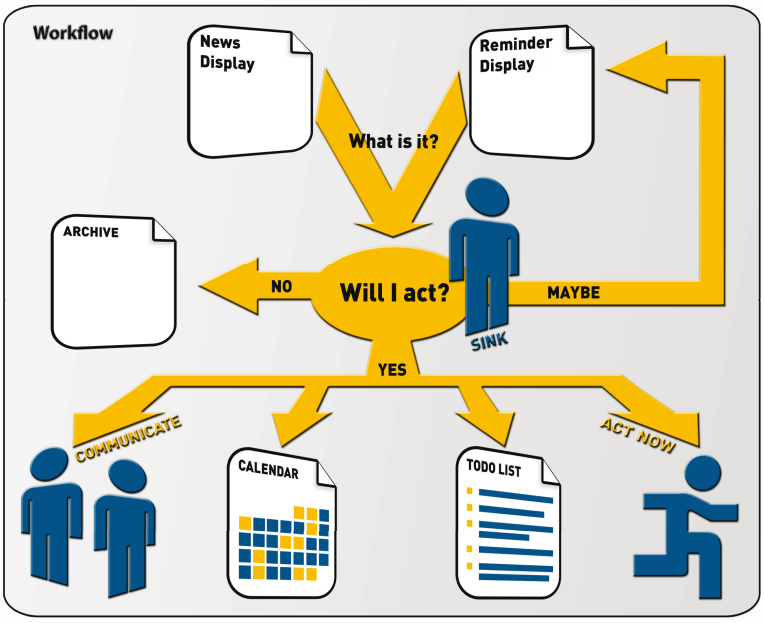

Fig. 5. The workflow of how to deal with actionables. People see actionables on News or Reminder Displays. They have to determine what the actionables are about and then decide whether they want to act. If they decide not to act, the actionables are available for later reference in the archive. If they cannot decide yet whether to act, for example because of missing information, they will be reminded later that the decision is still due. If they decide to act, they can act immediately, communicate or delegate the actionable to someone else, or copy the actionable to their calendar or to-do list.

Reminder Displays (see figure 6) are intended to support opportunism. They show actionables next to the time and location where they take place. Users are enabled to answer the question "What is here and now *important*?". We adapted the layout of newspapers, so readers can start reading the headlines of the biggest and most important chunks and then also read the small ones if they have time. Because many users will already have seen the chunks on News Displays, we use images to facilitate recognition and remind people of the actionables. Reminder Displays adapt to time and location, trying to always show those chunks with maximum utility for the user in a specific context. For Reminder Displays, the more often users see them, the better, because the probability is higher that they are reminded of an important event. Thus, Reminder Displays should be placed in locations where the total viewing time for all users is maximized. That would be for example in places where many users hang out, or main hallways where many users pass often.

All information chunks are also accessible through an archive online. We try to have all important actionables on the displays, so that there is no need for people to regularly search the paper based noticeboards anymore. Because paper

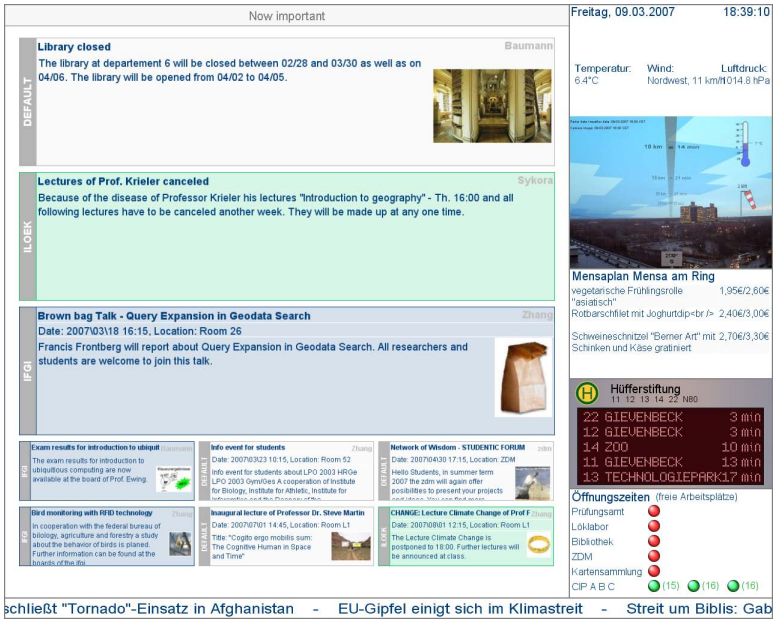

Fig. 6. The layout of the Reminder Display. The most important information chunks, depending on the current time and location, are shown on the left (chunks translated from German).

based noticeboards are much cheaper, provide higher resolution and more space, we still support them for reference information. Users do not need to search them for important actionables, but details to actionables that were presented on the displays can be looked up there. Because such reference information needs a low update rate anyway, paper is ideally suited for this task.

Note how the process of planning a user's time is now distributed over the displays and the user himself. Instead of copying all actionables that are assumed to be of interest to the user's calendar, he is only provided suggestions. From the set of all actionables available, the newest are shown on News Displays and those the system believes the user could be interested in are shown on Reminder Displays. A lot of screen space is useful to present the user many possibilities. From this subset the user finally decides which really to attend, going there directly, or copying them to his calendar or to-do list.

The submission tool should fit into the sources workflow. We restructured the information flow as depicted in figure 7. We decided to provide one interface to submit information chunks for sources, filters and forwarders alike. We argue that communication between those can take place via telephone, direct communication, email or paper as usual and need not to be changed. For the submission tool to fit into the users workflow we considered it crucial that the tool is fast and easy to use as well as reliable. We started by providing each user

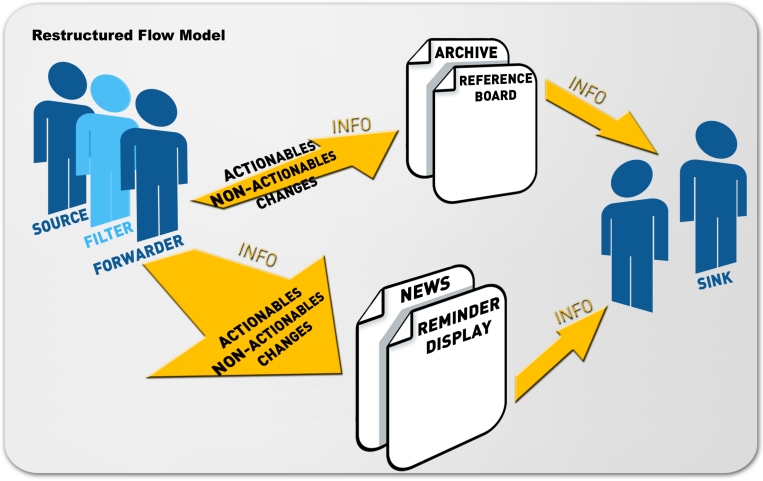

Fig. 7. The redesigned information flow model. Sources, filters and forwarders are supported with the same interface for chunk submission. Communication between these roles takes place in oral form, by email, paper or telephone. The sources create chunks in the categories actionable, change, and non-actionable, and submit these chunks simultaneously to News and Reminder Displays and paper-based reference boards. Sinks can be planners who pass News Displays regularly and read all new chunks to decide whether to copy them to their calendar or to-do list. Sinks can also act opportunistically, see chunks on Reminder Displays and decide to act immediately. In case sinks want to see details for chunks they saw on the News & Reminder Displays, they can see extended versions of chunks on paper-based reference boards or online archives.

a local Java client, but changed to a web application by March 2007 for easier access, higher reliability and easier administration. A chunk can be created in two simple steps, filling out the necessary fields and approving the generated previews. We decided to support the most important features paper has, so users can use all important fields we identified for posters, highlight important facts and use their institute's corporate identity. Sources can also change chunks by crossing words out or adding yellow post-its to them. They can see, edit and remove all chunks that were created by colleagues from the same institute, and reliability is guaranteed because only people with the password can submit chunks with a certain institute's corporate identity. We consciously decided not to make the submission tool available for anyone. Because inappropriate content could lead to a negative appearance of the university to users, we decided only to give access to the submission tool to sources that can be held responsible for the content they posted. To provide additional benefit for sources, new chunks are available on the institute's web page, as an RSS feed, and a paper version resembling the posters we studied can be generated with a single click.

Reminder Displays adapt to context using auctions. Obviously screen space on public displays is limited, so when the number of available chunks exceeds the available space, it must be decided which chunks to show. This is especially important when the number of sources scales up, for example when the system is deployed for a whole university or as an advertising platform for a city. On Reminder Displays we want to provide the chunks with highest utility for a certain context. [14] introduced the use of auctions for allocating scarce screen space to information chunks. In our system, auctions are used to allocate space on Reminder Displays. Each month sources are given a certain budget in a virtual currency to assign to information chunks. They are assumed to assign a budget to information chunks in proportion to how important they consider a certain chunk to be. By default a fixed budget is assigned to each chunk.

On Reminder Displays, every 10 seconds all slots available are sold in an auction. Each chunk is represented by an software agent which makes a bid in the virtual currency depending on the current context of the display. The highest bidders are displayed on top, and the lower bidders below. Non-actionables bid a high amount when they are created and a smaller amount when they become old. The bid of actionables depends on the context, which currently is only the location and time until deadline, and is highest just before the event. A detailed bidding strategy for actionables is presented in [13].

5 Experiences

We evaluated the deployment by analyzing the submitted chunks and by conducting paper based as well as web-based questionnaires. The system has been deployed in a university department building with more than 2000 students and 70 faculty members. We installed two 42" News Displays at the entrances and five Reminder Displays of various sizes from 19" to 42" throughout the building. The displays were wall-mounted and attached to hidden PCs for flexibility. The first slideshow based prototype (section 3) was running for 8 months from 10-2005 until 4-2006 before being replaced by the News & Reminder system in 5-2006. To this date, the News & Reminder system is running for 12 months, making for a total of 20 months. The new web-based submission tool was introduced in 03-2007. Maintenance effort to keep the system running is about 4 hours a week for 7 displays.

Usage statistics. In 17 months, 23 sources created 236 actionables, like talk announcements, 21 changes, like the cancellation of a lecture, and only 15 non-actionables, like the announcement of a new project. Unfortunately, the data for the first 3 months was not recorded. The overall number of 272 created chunks is not very high, but submission is stable over a long period of time (see figure 8). 9 groups submitted 132, 36, 32, 19, 16, 16, 14, 5 and 5 chunks, respectively. The most active sources submitted 78, 32, 26, 24 and 22 chunks, respectively, the least active four sources only created one chunk. 154 of the 272 chunks created contained an image.

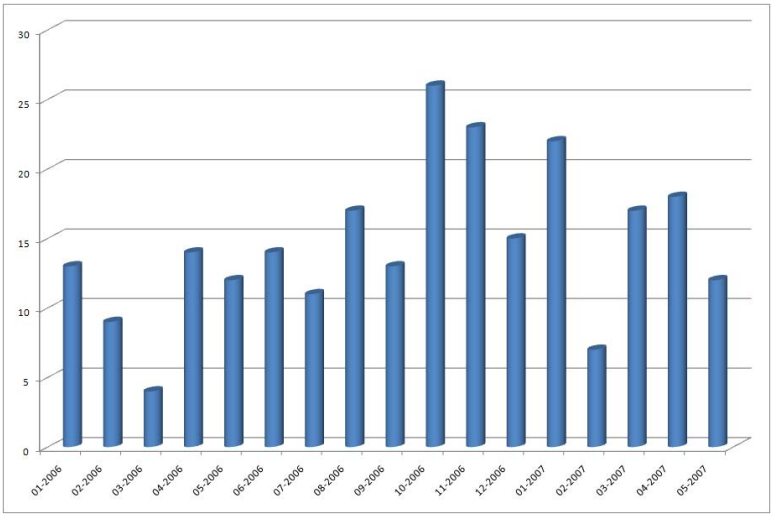

Fig. 8. The number of chunks submitted to our system. In total 272 chunks were submitted. The first prototype was used from 10-2005 until 4-2006. The News & Reminder system was used from 05-2006 on. The data for 2005 was lost. Usage was approximately one post per work day and periodically dropped in term breaks (e.g. 02-2007).

Sources Questionnaire. To further investigate the utility of the system, we interviewed 7 sources regarding their usage of the system. We used a questionnaire to establish how often and for what users they believed to use the system.

Sources reported that they posted between 0.5 and 2 digital chunks ($\mu = 1.6$) and between 1 and 10 paper posters ($\mu = 4.3$) a month. 5 said to post mostly events to the displays, again 5 said to post mostly job offers as posters. For both chunks and posters, only one ever received feedback that anyone has read the item. Most sources said they would prefer getting more feedback. 6 out of 7 sources said they feel they should post more chunks to the display. Four said they submit less because it costs too much time to make a submission, one forgot the password and for another the submission tool didn't work. Asked for additional features, only one wanted to be able to update existing chunks and highlight this.

Sinks Questionnaire. During one day, we interviewed 28 randomly selected students who were sitting in the computer pools regarding their usage of the system. All sinks we interviewed said they know and use the displays. Three sinks reported not to glance shortly at the displays when in the building, the remaining 25 stated to glance between twice a week and 30 times per day ($\mu = 3.9$). A short glance was estimated to be between 1 and 60 seconds ($\mu = 10.2$). In addition, 21 sinks reported to sometimes stop in front of the displays. They reported to do so between twice a week and 5 times a day, for a duration between 20 and 300 seconds ($\mu = 86$). 14 of 28 sinks even reported to look to the display for a mean

of less than 5 seconds. 23 of 28 sinks reported to regularly use the information chunks, 14 to use cafeteria menu, 10 to use rain radar, and 3 to use bus, time, and news ticker information, respectively. All sinks liked the locations where the displays are installed. 21 sinks used the News Display in the secondary entrance, and 18 used the News Display in the first entrance. 11 users reported to use a Reminder Display in a main hallway. Only one sink reported to use the other Reminder Displays. On a scale from 1 (very good) to 6 (very bad), users graded the system between 1.3 and 3.3 ($\mu = 2.2$). 23 out of 28 said they would object to have the displays removed.

Utility/Attractivity Questionnaire. We asked 15 students from a course in geoinformatics to rate our system in terms of utility and beauty [9]. According to the answers, both factors are well balanced but can be improved. People described our system with the terms 'technical', 'presentable', 'innovative', 'good', 'easy', 'useful' and 'enjoyable'.

Discussion. The submission seems to have plateaued at approximately one chunk per work day. Although the computer science institute had by far most submissions (132) all groups regularly use the system. One student was often called by various groups to submit items on their behalf and submitted 78 chunks, but having 23 sources from 9 groups and with various levels of computer expertise suggests that the system is attractive for different people. The change to the web based submission tool didn't change the amount of submissions significantly, and number of submissions varies widely between sources. We believe that the main problem is that chunk submission is not yet fully integrated in many users' workflows. For many older sources, the workflows have evolved over many years, and despite our efforts it seems quite difficult to change them. Also, many sources hesitate to submit many chunks because they don't want to congest the system. The time requirement to submit chunks was considered crucial by sources, and we took effort to minimize this. Only 50% of the chunks contained images, probably because it takes more time to find an adequate image.

We found it very promising that all of the 28 randomly selected sinks knew the displays and reported to use them at least twice a week. This is probably because to enter the building, users have to pass the displays. Because the digital displays are eye-catching, we experience it natural to at least have a quick glimpse on them. It is striking that the News Displays are used much more than the context adaptive Reminder Displays. The main reason is probably that News Displays are installed in places where much more people pass by. It is also possible that in a university environment more people rely on planning instead of opportunism. Additionally, some information modules like cafeteria menu are used much more than others, like building facility opening times. It is possible that some kind of information is simply more interesting, or that some modules are easier to understand than others. Concluding, it is interesting to see that a large population has integrated the technology into their everyday life.

6 Conclusions and Future Work

Known issues that proved important for Situated Public Displays From the experience of 1.5 years of deployment, we found many well-known lessons approved in the context of Situated Public Displays:

Deploy or Die. We agree with the 'Deploy or Die' argument of Sharp [17], that ubicomp is at the point where it must make its way out of the lab to really weave itself into everyday life of ordinary users. Many of our experiences, like that people won't wait in front of slideshows, would have been much more difficult to observe in a closed lab.

Do Requirements Analysis. We want to emphasize that it is important to make a thorough *Requirements Analysis* to really understand how technology can fit into users' workflows [2]. If one does not do this, one risks making false assumptions, for example that most users will stay in front of displays for a longer time.

Provide immediate benefit for all stakeholders. We also want to underline that it is very important to provide *immediate benefit for all stakeholders* [8]. If only one group has a benefit (for example students) while another group must do more work (for example secretaries) the system will suffer from disusage. Thus we aimed at improving the cost/benefit ratio for sources by making the systems easy to use and fit into the workflow, and also by providing side effects, like automatic poster generation.

Provide 24/7 reliability by using standard hard and software. To gain the trust of ordinary users, it is urgently important to provide 24/7 reliability [18,3]. From the beginning we tried to minimize risk. Some displays with WiFi network connection (although standard) proved too unreliable, so we had to put network cables to all display locations. For production deployments, centralized systems where servers control multiple displays are suitable, while for research purposes where you may want to install a Bluetooth stick at each display one PC per display is useful. To avoid the perception of a broken system, we implemented various levels of caching and fall-back modes that show locally stored content and images.

New lessons learned. In addition to these well known lessons, we learned some new lessons more specific to Situated Public Displays that we hope will help other ubicomp researches and practitioners.

The update rate of information is especially important. Different kinds of information have different update rates. People should be enabled to make a quick cost/benefit estimation of the effort of system usage and the payoff. The first question users have when they approach a display is whether there is something new. The design should enable users either to predict or to determine this very quickly. With slideshows, for example, people do not know whether there is something new until they waited for a whole cycle.

Identify sources, filters and forwarders and win their support. Because content is king, it is important to have sources constantly deliver new

chunks. Sinks will only rely on the system if the majority of all actionables is posted on the displays. We identified content creators and won their support early during the contextual interviews, which also significantly increased the sources trust in our system.

Identify actionables, changes and non-actionable information chunks. From the posters we studied, the vast majority was actionables, with a smaller number of changes and only some non-actionables. The same structure was reflected in the chunks that were created for our system. In a company, presumably much more non-actionable information would be posted. In a city center however, many advertisements would be actionable, pointing directly to the shop. The specific mixture however depends on the environment of the deployment.

Support planning with News and opportunism with Reminder Displays. Some environments are closed and have only regular visitors, like certain companies where employee information would be shown on the displays. Most of the users there will plan well ahead and thus News Displays are very suitable. Other environments are open and have many one-time visitors, like city centers and shopping malls where advertisements would be shown on the displays. In these setting more users will act opportunistically and thus Reminder Displays are more suitable. Most environments, like our university, are however somewhere on a continuum between these extremes, such that a mixture of News and Reminder Displays is best.

Place Displays in entrances and waiting areas. We provide News Displays at the entrances to the building, so users are guaranteed to see them twice a day. Reminder Displays on the other hand are installed in working and waiting areas, such that the total viewing time is maximized.

We proposed the notion of update rate as well as the distinction between actionable and non-actionable information to categorize different kinds of information. We developed the concepts of News and Reminder Displays as ways to present actionable information to planners and opportunists alike. In the future, we want to generalize these concepts to other areas beyond universities, where Situated Public Displays can be deployed. In particular, actionable advertisements can offer users diverse action opportunities like discounts, shows or special events. Thus, News and Reminder Displays could be deployed in shopping malls, city centers, airports or amusement parks to enable people to participate in more action opportunities and make better use of their time.

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