

# SPALEDAR: Visualizing a Group's Calendar Events over a Geographic Space on a Public Display

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## ABSTRACT

Portable paper calendars (i.e., day planners and organizers) have greatly influenced the design of group electronic calendars. Both use time units (hours/days/weeks/etc.) to organize visuals, with useful information (e.g., event types, locations, attendees) usually presented as - perhaps abbreviated or even hidden - text fields within those time units. The problem is that, for a group, this visual sorting of individual events into time buckets conveys only limited information about the social network of people. For example, people's whereabouts cannot be read 'at a glance' but require examining the text. Our goal is to explore an alternate visualization that can reflect and illustrate group members' calendar events. Our main idea is to display the group's calendar events as spatiotemporal activities occurring over a geographic space animated over time, all presented on a highly interactive public display. In particular, our SPALEDAR (SPAtial CALENDAR) design animates peoples' past, present and forthcoming movements between event locations as well as their static locations. Details of people's events, their movements and their locations are progressively revealed and controlled by the viewer's proximity to the display, their identity, and their gestural interactions with it, all of which are tracked by the public display.

## Categories and Subject Descriptors

H.5.2 [User Interfaces]: Interaction Styles; H.5.3 [Group and Organization Interfaces]: Asynchronous interaction

## General Terms

Design, Human Factors.

## Keywords

Calendar, visualization, location, ambient display, situated interaction, personal, ubiquitous computing.

## 1. INTRODUCTION

Calendars have been around in human societies for aeons, evolving through various materials (stone, paper, electronic) and forms (e.g., a single page, a flip book, a pocket organizer). Today's electronic calendars are not only popular, but are increasingly powerful, especially for coordinating group activities. For example, events from others' calendars might be directly incorporated into one's calendar, or a group calendar can be created that is owned and populated by a social network of people.

However, group calendar design still borrows heavily from their paper equivalents. Foremost, their visuals follow the same time-

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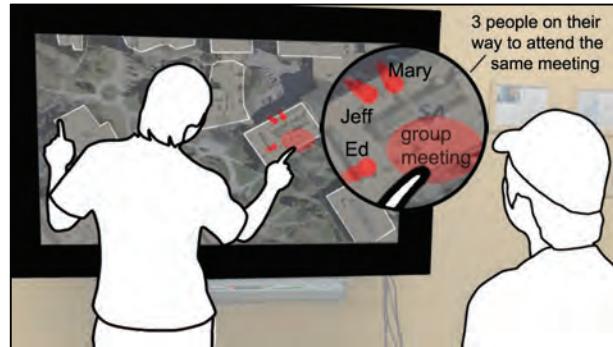


Figure 1. SPALEDAR animates peoples' past, present and forthcoming scheduled movements between event locations on a map. People see and interact with it on a public display.

oriented structure: sequential representations of time units as boxes or time lines, where time flows (depending on granularity) from fractions of an hour to hours to days to weeks to months and even to years. Calendar events are typically packaged and sorted by time. This time-based visualization is highly useful, as it immediately reveals *if* and *when* events are occurring. Yet details are harder to discern because they are abstracted, abbreviated, shown at a small size, or even completely hidden. Event details may not even be visible until one opens or drills down into a detailed view of the event. For example, as text about a one-hour meeting will likely not be shown in the limited space in a month view, one may have to drill down to a day view and even to the hour view to actually see the details.

There are many times when it is exactly these details that are important to acquire at a glance, e.g., to know *who* is moving *where* over a larger *period of time*, including how people are *meeting together*. There are also various situations when an *individual* wants to see what is happening in the broader *group* context, and how their own events fit within that. Consider as one example a person who wants to informally 'catch up' briefly with several other colleagues who normally work in different nearby buildings. Calendar information could potentially help her find an opportune time, either immediately or over the next few days, where one or more of those others are free and happen to be near each other. This encourages casual interaction [9], and minimizes potential interruptions, travel time, and coordination effort. Yet this is tedious with current calendars, as one has to:

- scan each of the colleague's events to see if they are busy,
- either look up or infer where they are located (e.g., from their last known location),
- see if several of them are in nearby locations, ideally at the same time such as in a meeting,
- match the information with one's own events and locations,

- integrate this to form an understanding of the ebb and flow [9] of what others are doing and where they will be over time, and use that to determine time and locations that are the most opportune.

Consequently, our goal is to reconsider how group calendars can be redesigned to reflect this ebb and flow of a small group's whereabouts over time. Our main idea is to display the group's calendar events as spatiotemporal movements and activities occurring over a geographic space animated over time, all presented on a public highly interactive display. In particular, the calendar design – implemented in our SPALENDAR (SPATIAL CALENDAR) prototype (Figure 1) – animates peoples' past, present and forthcoming scheduled movements between event locations as well as peoples' stationary locations. Details of people, their movements and their locations are progressively revealed and controlled by a viewer's proximity to the display, their identity, and their gestural interactions with it, all which are tracked by the public display. We demonstrate our design in a number of interaction scenarios, where we show how people can perform certain tasks that would otherwise be cumbersome and time-consuming to do in conventional calendars.

Our contribution is the visualization and interaction ideas, as well as the design strategies behind them. SPALENDAR itself is prototype – it has design limitations and implementation constraints that preclude any useful testing at this point [7]. Its value is as a proof-of-concept system that realizes particular ideas, and that can be used as an inspiration and spring-board to more mature visualizations and implementations based on the same premises.

## 2. DESIGN STRATEGIES

To set the scene, we present three primary design strategies we employed to create a new type of group calendar. We illustrate these in Figure 1 by showing, at a very high level, how SPALENDAR realizes them.

(1) *Geographic space organizes visuals, in particular where people are.* This strategy makes peoples' location the primary display attribute of the visualization. The visual would represent a geographic space routinely used by the group, such as a building's floor plan, a small cluster of buildings (such as a campus), a split view of several sites (such as a head office and several satellite offices), and so on. Atop this, we visually show peoples' locations (derived from their scheduled events) at particular moments in time. The particular time being displayed can be shifted, for example as a running animation automatically cycling through a time range, or under the explicit direction of the viewer by adjusting a timeline slider.

Our rationale is that this strategy unlocks location data from the 'tyranny' of it being hidden in a text field, where it instead presents location in a highly expressive way. In turn, animating time (and thus people's location) shows an integrated view of how people come and go, how they gather, and how the viewer's own movements fit into this. Figure 1 illustrates this in SPALENDAR. The viewer sees a birds-eye view of a campus. He also sees three people in his group, displayed as labeled animated dots, where they are moving towards a particular location. That location is the site of an upcoming group meeting, displayed as a labeled bubble.

(2) *View reflects group activity.* This strategy integrates people's movements and locations relative to one another into a single view. Our rationale is that this strategy visually reveals the 'group' nature of calendar events. This includes awareness of others who are nearby, co-attendance, activities of colleagues, etc.

As seen in Figure 1, which illustrates co-attendance, much of this can come for free simply by seeing people come together towards a meeting location. Other moments in time – such as seeing the cluster of people remaining in a single location – reveal the co-located nature of some groups even when they are not meeting. Further standard visualization techniques can let people focus on particular groups, e.g., filtering small project groups under the same department so that members can stay aware of each other's whereabouts. A person can also view his or her own location in time and relate them with others', such as seeing who else will be attending the same seminar, or when a colleague will be nearby and thus potentially available for a serendipitous meeting.

(3) *Access is ubiquitous.* This strategy has the calendar act as a ubiquitous information gateway. Admittedly, we expect that the calendar can be accessed on conventional computers (desktops, mobiles). However, we advocate that it should also be accessible ubiquitously, e.g., on situated displays within the various communal spaces frequented by the group – the office hallway, the coffee room, etc. – so that group members see and explore it as they pass-by. The rationale is to mimic real-life practices, where people can infer other's activities by seeing how others come and go. Figure 1 illustrates this strategy, where we see the map on a large display located in a hallway. One person has stopped to explore particular details on it, while a second passer-by – a colleague of the first person – has paused to see what is happening, as it may be of interest to them too.

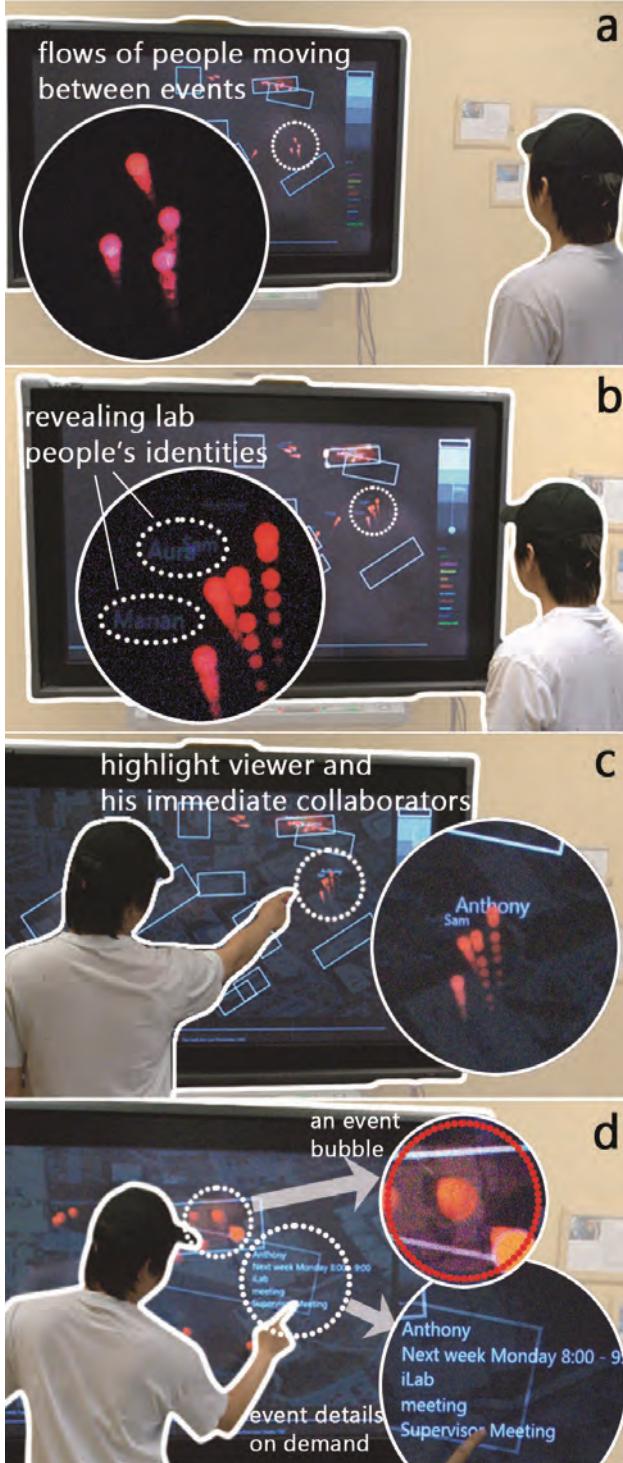
These three aspects are complementary. *Geographic space organizes visuals* is the founding design strategy that defines the subsequent calendar data representations, event visualization techniques, and interaction designs connecting the calendar and its viewers. On top of that, *view reflects group activity* emphasizes the relations between calendar event owners and the social network they belong to, all of whom usually share a number of work or social events. While the first two strategies concern mostly the visualization aspect, *access is ubiquitous* embodies the calendar as an actor in the group space, where, it is deliberately placed in a context so that people can see and use it while on-the-go.

Subsequent sections, as well as the video figure, showcase details and interaction scenarios of how SPALENDAR embodies and builds upon all the above-mentioned design strategies.

## 3. SPALENDAR - BASIC WALKTHROUGH

Figure 2 shows a very basic interaction scenario of SPALENDAR. Anthony, a university researcher, arrives at work and is walking towards his office. As he passes through his laboratory, he glances at a public display situated within it that runs SPALENDAR. From afar (Figure 2-a), he sees his group members' location and movement over the next few days as a simplified visualization. The backdrop is a schematic map – a birds-eye view of the buildings (each shown as a rectangle) that comprise the local campus. Peoples' locations are represented atop this via numerous animated dots. People as dots are rapidly moving between those building blocks, where each day's activities are compressed into less than a minute. This gives Anthony a sense of what had been happening in the last day or two, and what will be happening for the next week or two.

Anthony is particularly interested in what is happening later today. He moves towards the display (Figure 2-b), which automatically detects who he is and his nearing proximity and responds in several ways. The animation slows, and displayed information becomes more concrete: (1) a more detailed satellite map begins to appear as an overlay of the campus map, and (2)



**Figure 2.** Interacting with SPALENDAR: (a) afar, simple flows of people moving between events; (b&c) closer, more information emerges, e.g., (b) people's identify, (c) the viewer and his immediate collaborators; (d) close-up, direct manipulation shows full event details.

the names of people – especially his close colleagues – gradually appear as annotations associated with the moving dots. As the animation cycles back to ‘today’, Anthony moves even closer to the display, whereby these effects become even more apparent (Figure 2-c). Anthony’s own name is now emphasized among all

names, so he can see where he is supposed to be at this particular moment in the animation. His immediate collaborators are similarly emphasized, although to a lesser degree. Anthony notices that a large number of labeled dots (as well as his own) will be going to a particular location later today. Those dots are also turning red, which suggests that they are all moving to an event of the same type. Anthony looks at the legend on the right side of the display, where he is reminded that that ‘red’ denotes a ‘meeting’ event. He also notices that his colleague Sam, who he needs to talk to, is also moving to the same location.

Anthony then steps closer, so he is within reach of the display (Figure 2-d). The animation reacts by coming to a full stop. He now sees that the dots have congregated within a red *bubble* – indicating a scheduled meeting event at a particular location – located in the nearby Computer Science building. Anthony now interacts with the display. He gestures to back-track the time on the timeline to align with that meeting, and he taps his dot for details: a label appears stating ‘Anthony, Next Week Monday, 8am, iLab, supervisor meeting’ (Figure 2-d). Since he and Sam will be in the same location, he touches the display to add an event right after this meeting time, requesting that he and Sam meet for a few moments to catch up (details to how this event is added will be discussed later).

#### 4. DESIGN DETAILS OF SPALENDAR

SPALENDAR embodies the three design strategies in §2 by: (1) visualizing group members’ individual or shared calendar events across locations, which are then animated over time; and (2) enabling implicit and explicit interactions [19] with the calendar on a situated display within the group’s physical environment. These design details are discussed below.

##### 4.1 Visualizing the Group’s Calendar Events

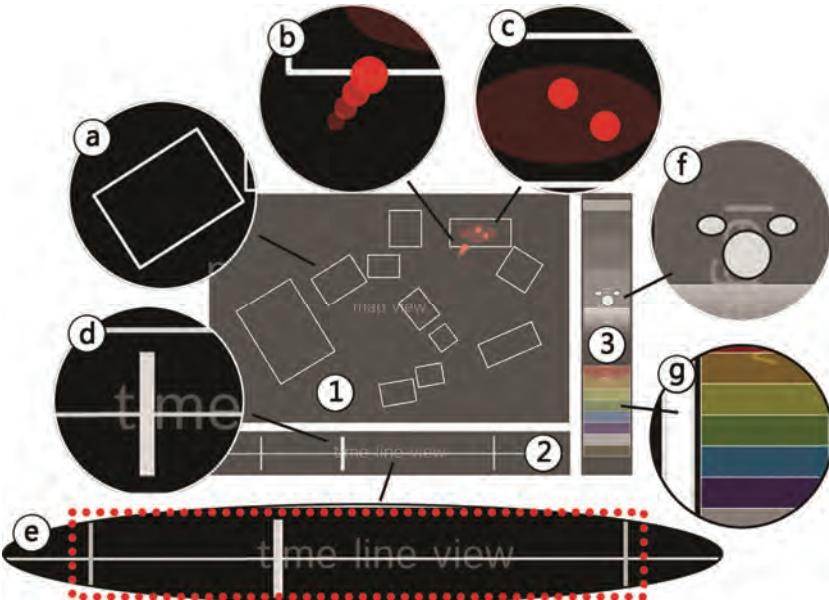
Inspired in part by [8], we base our visualization on two primary interface areas. The *map view* highlights the location attributes of individuals’ calendar events, while also showing scheduled group activities. The *timeline* allows people to control the animation and/or navigate through sequences of events as they appear on the map. We also use our §3 example to show how these views visualize and control the following event attributes and attendee information.

###### 4.1.1 Map View

The *map* (Figure 3-a) defines the typical geographic area used by a group. For Anthony’s group, it contains a drawing of campus buildings, which represents the area typically used by Anthony and his colleagues.

*Event sites* are represented within this map as a schematic of various locations where events typically take place. These event sites are familiar to the group, and serve as references to key event locations (Figure 3-a). For Anthony’s group, this includes buildings where they usually meet for seminars, their several research laboratories, and the various office locations. To help the viewer recognize these locations, a satellite map is overlaid as the background when people move closer to the display. Other groups would likely have different maps, e.g., a group collocated on a single floor may use a floor plan that highlights particular rooms as event sites.

*Group members* are represented by dots (Figure 3-b). These dots are either stationary, or they move between event sites within the map according to their event time and location. These representations inform people of where the others are (or will be in the future) within the geographic space. To reinforce the *moving direction*, we use directional traces to indicate where



**Figure 3.** Visualizing group's calendar events. (1) Map View contains (a) event places on a map, (b) people moving between events, and (c) their presences at ongoing events, etc. (2) Timeline animates the map view within a window (e) and controlled by a time cursor (d). Two legends on the side show viewer's movement (f) and explain the color coding (g).

people are coming from and going to at a given moment in time. This supports directional context even when the animation is paused. Depending on the viewer's proximity to the display, dots may be annotated by people's names, with the viewer's name as well as their close colleagues emphasized to make them stand out. As will be discussed later, a person's current location is assumed to be the same as his last known location, or inferred by their known patterns of activity.

Events are visualized on this map primarily by showing where particular events are located as an event bubble atop an event location. A bubble gradually appears when the event is imminent and fades away when people are leaving to their next event. People (as dots) move into or out of the event bubble. During the event, attendees are contained within the event bubble (Figure 3-c). The bubble's size reflects the number of attendees – a huge bubble will visually capture viewer's attention telling her that many people are gathering for something.

*Event Types* are coded by color (e.g., red – meeting, purple – research talk). The meanings of colors are explained in a legend next to the *Map View* (Figure 3-g). This coding is used to color the visuals of people (dots) as they move to and from events, as well as for the events themselves (bubbles). When people do not have a scheduled event, they are shown in grey to indicate an idle state. In addition, the color's alpha value (i.e., its transparency) varies with that person's temporal proximity to the closest event. For example, as one finishes a meeting (red) and immediately goes to a class (green), the dot's color transitions from red (max. alpha), to grey (min. alpha) to green (max. alpha). In practice, this use of color coding and transparency can result in an interesting and useful visual effect – a colorful map view suggests that people are quite active at that time, while a greyish one says the opposite. At a glance, one can sense the 'hum' of people's activities.

#### 4.1.2 Timeline

As mentioned, the map view is animated over time, with the animation speed and time duration controlled both implicitly (via the viewer's proximity) and explicitly (via gestural and touch interaction). Feedback of time information and explicit control are offered to the viewer via two important visual elements.

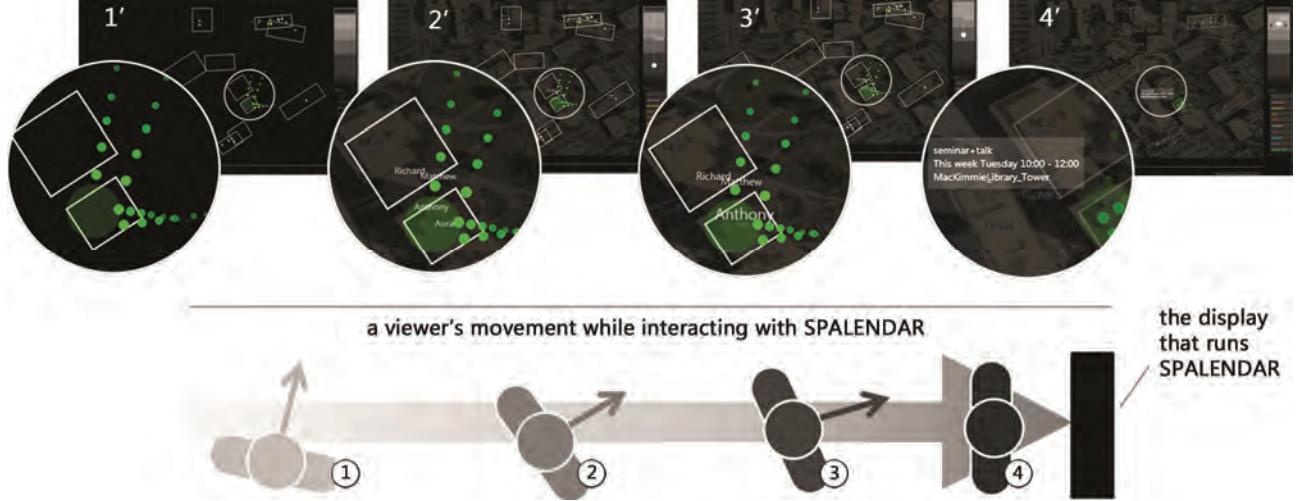
The *timeline* represents the range of time through which the animation cycles (Figure 3-e). Our defaults set the start time as the beginning of the current week (which may include past events) to three weeks from now. Through gestural interaction, a person can quickly scale the range of time to a larger or smaller period, or can shift the range to change the start and end time simultaneously.

The *time cursor* (Figure 3-d) is similar to a video player control. It indicates the current time position of the animation. A person can touch the cursor to (1) move it to a new position to play a particular sequence of calendar events, (2) pause the animation to see exactly what people are doing at a given time, (3) fast-forward or (4) rewind to later and earlier time points.

## 4.2 Interacting with SPALENDAR

In §2, we described why we consider ubiquitous access to the group's calendar to be important. Consequently, we implemented SPALENDAR on an interactive, public display situated within shared group space. Still, we expect that its calendar information can also be accessed from other more conventional devices. The nature of this setting suggests two ways of accessing SPALENDAR. First is via *implicit interaction*, where the display tracks the viewer's proximity (and presumably their attention), i.e., the viewer's physical position, orientation and identity relative to the display [2]. Second is via *explicit interaction*: when the viewer is near the display, they can interact and control its contents directly via both gestures and touch. Essentially, SPALENDAR gradually increases the detail it shows as a function of the viewer's proximity to the display, and supplies explicit interaction techniques as the person is near or within reach of it.

Similar to [2, 19], we model interactions as four stages that occur into four proxemic zones defining the areas in front of the display (Figure 4-1 to 4). As a viewer approaches from afar (Stage 1) to just out of reach (Stage 3) of the display, SPALENDAR alters the visualization to slow it down and to show greater detail (Figure 4-1' to 3'). Stage 1 shows a simple characterization of space and the location of people and events within it, where time is proceeding at a fast pace. This gives a passer-by a gestalt sense of what is going on. As the viewer moves through Stages 2 and 3, the animation slows and more details of people and event locations are revealed. Because SPALENDAR knows who the viewer is, it in-parallel highlights viewer-specific information (e.g., the text naming the viewer's dot is larger, as are the descriptors of those known to work closely with the viewer). Within Stage 3, he or she can now explicitly control several aspects of SPALENDAR via gestures. For example, a horizontal hand gesture controls the timeline range (Figure 5, 8-a&b). As the viewer moves within reach (Stage 4), he or she can further control SPALENDAR via direct touch. For example, a single-tap on a graphic reveals full details of events, attendees and locations (Figures 4-4 & 6-c), double-tapping zooms in and out, and a long-press creates a



**Figure 4. Interacting with the SPALENDAR.** (1) The viewer starts by watching it from afar where it shows simple flows of people moving between their events (1'); (2&3) Gradually approaching the display reveals more information (e.g., 2' shows identities; 3' highlights the viewer and his immediate collaborators) until (4) finally using direct touch to access the calendar's interface (e.g., 4' reveals shown-on-demand event details).

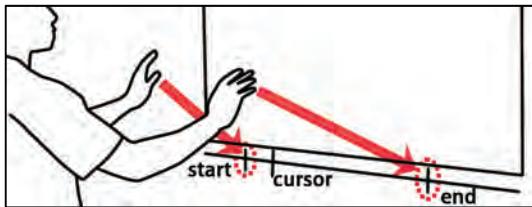
public event (Figure 8-c). Further details of some of these actions are discussed shortly.

### 4.3 Implementation

Our implementation exploits the features of the Proximity Toolkit [11], which, amongst other things, returns the proxemics relationships between entities in a room-sized space. This includes the location and identity of entities, as well as their relative distance and orientation from one another. The Proximity Toolkit in turn currently uses a Vicon motion capture system<sup>1</sup> to track markers attached to people's clothing, although other hardware technologies can be used as well (e.g., Microsoft Kinect). In SPALENDAR, the entities are people and the display, where we use the information returned by the Proximity Toolkit to calculate the proximity of the viewer to the display, which in turn identifies the interaction stage they are in. We also use that information to track the persons' hand gestures (e.g., using the two hands to shift and scale the time range, as shown in Figure 5). Finally, we use a SMARTBoard interactive whiteboard<sup>2</sup> as our display surface that also detects touch input.

To provide the viewer with feedback of how SPALENDAR 'sees' their proximity and actions, it visualizes the viewer's body as a large circle, and their two hands as two small circles (Figure 3-f).

The rest of SPALENDAR's implementation is fairly routine software development, e.g., in how visualizations are constructed and in how the data comprising the group calendar information is



**Figure 5. Gestural interaction with SPALENDAR:** tracking people's hand movements and taking them as an input to control the time range (i.e., time window) of the calendar visualization.

<sup>1</sup> <http://www.vicon.com/>

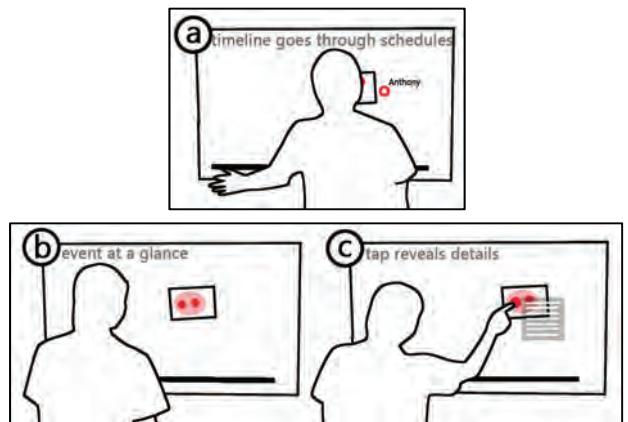
<sup>2</sup> <http://smarttech.com/SmartBoard>

maintained in a database.

## 5. DEMONSTRATING SPALENDAR IN USE

In §3 we briefly introduced a basic SPALENDAR use case. Here we continue to present more detailed scenarios, each of which demonstrates unique features of our calendar design, and how these features are leveraged to compliment conventional calendar applications and further foster new calendar usages. First, *checking personal schedules* presents the very basic features of SPALENDAR – it allows people to walk up and query their calendar schedule similar to how they use a conventional calendar. Second, *catching up with other's activities* promotes serendipitous usage of SPALENDAR's information. Although such usage is unfamiliar to conventional calendars, it is substantially supported by SPALENDAR's unique design strategies. Third, *initiating casual interactions* represents a more complex task that leverages SPALENDAR's space-oriented visuals to create a new event 'scheduling' mechanism.

**Checking Personal Schedules.** SPALENDAR acts as an expressive and ubiquitous gateway to individuals' calendar information, as



**Figure 6. Checking personal schedules:** scrolling the timeline (a) to go through one's schedules where event stands out at-a-glance (b), immediately saying what will happen and where; a single tap reveals further details.

shown in the following scenario.

*Anthony is leaving the lab for home when he receives Jim's call asking about his availability for a meeting the next morning. To find out his schedule, Anthony walks up to a nearby display that runs SPALENDAR. The simplified sketches in Figure 6 show how he can quickly obtain this information while holding the call. First Anthony swipes and shifts the timeline to the next day (Figure 6-a) where he first sees himself*

*moving to attend a meeting held at the other side of the campus (Figure 6-b). The time cursor says this meeting begins at 10am. Tapping at the dot reveals more details (Figure 6-c). He also sees that Jim is going to be close to a coffee shop that he will be walking by on his way back from the meeting. Anthony tells Jim on the phone that he can meet him at 10:20 at that coffee shop, and verifies that Jim will indeed be near that location.*

One unique feature of SPALENDAR is its using geographic space to organize visuals which immediately tells people what is coming up and where to go, without requiring them to search and reveal that information from textual fields.

**Catching up with Other's Activities** – a somewhat less familiar calendar ‘function’, is enabled by SPALENDAR in the following scenario:

*Anthony is having a coffee break in the coffee room. He glances at SPALENDAR and notices a forthcoming group event – quite a number of people are moving to the dining center (the moving orange dots, Figure 7-a). Curious, he moves to the calendar to find out more (Figure 7-b). It says people are organizing a group lunch on Friday. Not to miss this opportunity to gather with lab people, Anthony schedules himself at that location, and quickly sets off to learn more about joining this social event (Figure 7-c).*

In this usage scenario, SPALENDAR serves beyond a tool for well-defined, analytic tasks; instead, it promotes serendipitous usage of calendar information. Unlike conventional calendars, SPALENDAR makes the discovery of people’s activities over time easier and more natural. Because it is situated on a public display, its information is ambient and can be noticed at a glance at the edge of awareness. Because people and activities are animated on a map, viewers are effectively notified of group activities occurring at particular locations and how people congregate to those locations (Figure 7).

**Initiating Casual Interactions** can be made easy and lightweight with SPALENDAR:

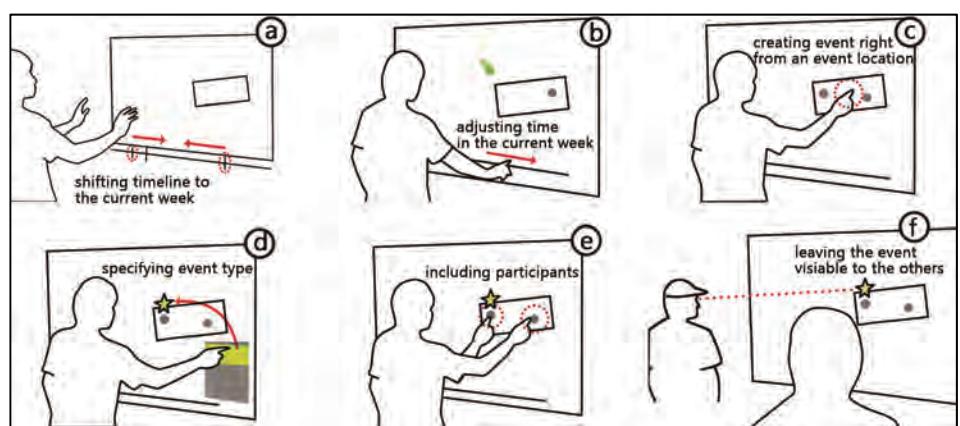
*Anthony has a quick question for Sam but finds him out of his office. As he walks back to the lab, he sees SPALENDAR and thinks it might help him catch a good time to briefly meet with Sam. He first uses gestures to shift the time window to the latter half of the current week (Figure 8-a). Then, by either watching the animation or explicitly adjusting the timeline, he follows both his and Sam’s trajectories (Figure 8-b). Before*



**Figure 7. Catching up with others' activities.** In SPALENDAR larger group activities are easier to spot (a) where one can quickly find out what many people are doing (b) and catch up with them (c).

noon on Thursday, he sees that Sam will be in a nearby lab building for a meeting, and that, like Anthony, he has nothing scheduled afterwards (both their dots appear grey - see Figure 8-c). Anthony creates an event at that location and time simply by pressing the lab building (Figure 8-c). The event is visually marked at the location (the ‘star’ symbol in Figure 8-d), and Anthony then picks a color from the legend to specify the event type (e.g., yellow is discussion, see Figure 8-d). Anthony then taps at Sam and himself, which invites both to the event (Figure 8-e). Thus an event is created, left on the map and will now be visible to others (Figure 8-f). Others can look into details of that event, perhaps to join it, invite more people, leave a note, etc. Alternatively, Anthony may not have scheduled a meeting, but could have just scheduled an event for himself at that location, where he could then ‘ambush’ Sam as he walks out of his meeting.

While various scheduling tools are available for creating formal meetings, they are less applicable for casual interactions between people who want to meet informally and briefly at a convenient time and place without adding extra overhead to each other’s existing schedules. SPALENDAR’s space-oriented visuals make it straightforward to spot a ‘good’ time and place to initiate a casual meeting with others. One can simply follow people’s trajectories and to look for two visual ‘patterns’: (1) when most appear greyish (meaning they are free), and/or (2) when most are geographically collocated (suggesting a reasonable place to meet). Further, the event is now posted on SPALENDAR, so that it is available for others to view and possibly join. Additional mechanisms can enhance this feature – visually/audibly notifying people involved in the event as they pass by, synchronizing such events to people’s conventional calendars, etc.



**Figure 8. Initiating casual interactions:** (a) gestures locate time to current week; (b) adjusting date/time where people are free and collocated; (c) pressing a location directly creates an event from there; (d) setting event type (i.e., yellow is discussion); (e) tapping on people invites them to the event; (f) after the event is created, others can see and check its details.

## 6. RELATED WORK

In designing our calendar, we build upon three streams of work as detailed below.

**Visualizing events across time and/or locations.** Much of the current research on visualizing calendars, schedulers, and even event histories keeps time as predominant sorting axis, e.g., zooming or drilling-down into hierarchies [10], timelines [5, 10, 15, 16, 19], detail and context methods such as by fisheye views [4] and mapping events onto 3D spaces [10], and creating a live ‘clock’ whose face portrays activities captured as slices from a video feed [6]. Our work differs, as our goal is to consider *time* and geographic *location* equally, and to integrate them under the same visualization scheme. Such *spatiotemporal visualizations* have been explored previously, although not (to our knowledge) applied to calendar data. For example, others have plotted sensor location and its generated data on a map, where time is captured as a ‘growth ring’ [1] or as a time-lapse controlled by a timeline [8]. The Active Badge captures people’s current location in a building, where the authors suggest that those locations can be displayed on a floor plan [20]. Our work differs, as it uses schedule date – particularly the *location* attribute – to depict people’s past, present and future calendar events over a geographic space animated and controlled by a timeline.

**Group calendars** share our goal of designing the calendar suitable for a small social network. Early work, besides enabling merging and analyzing multiple calendars [10], had focused on specific features like scheduling group meetings [3]. Such calendar merging and scheduling features are now commonplace on commercial calendar applications (e.g., Google Calendar, Microsoft Outlook, etc.). Meanwhile, others were interested at the impacts and issues of group calendars. For example, Palen argued that the design of groupware calendar systems should be approached with a synthesis of technological, individual and social perspectives, as the three inevitably come into play during their adoption [13]. Lately, ubiquitous computing also influenced the design of group calendars. For example, Neustaedter et al. studied a family’s calendar usage, and from that designed an electronic family calendar that ran on a dedicated information appliance as well as other more conventional devices: their goal was to keep family members closely connected via the family schedule [12]. Inspired by this work, our calendar seeks to highlight the ‘group’ aspect in two ways. First, we visually correlate individuals’ past, present and future events to reflect the group dynamics. Second, and reviewed in more detail below, we enable ubiquitous access to promote how the group can keep aware of each other’s activities and whereabouts.

**Ambient and situated displays** are architecturally located in strategic locations in physical environments [18, 21]. Recent work has showcased a large body of visualization and interaction designs, all displayed/Performed while people are orienting themselves in the environment (e.g., [2, 17, 19]). Perhaps the most related work is Phelan et al.’s Ambient Calendar – a calendar that encodes and embeds the information in symbolic visual elements, which together form an ambient display to inform people of their calendar events, subscribed blogs, transit schedules, etc [14]. Our calendar is influenced by both ambient and situated displays, but more akin to the latter – our goal is to present calendar information progressively to passers-by, ranging from view at-a-glance, to gradually revealing more details, and to close and direct manipulations.

In summary, these three streams of work inform our calendar design from different perspectives. In reviewing past work on

designing calendars’ visuals, we find them still conformed to the conventional time-oriented, hierarchical structure. This has led us to explore a significantly different approach where we learn from another stream of work to visualize calendar events not only across time, but also across geographical space in which these events will happen. As our calendar is essentially a group calendar, we also observe how prior work has integrated individuals’ calendars and further enabled the communications between the group members. Finally, we draw related work on ambient and situated displays, which is highly relevant to our goal of turning the calendar into a ubiquitous information gateway.

## 7. DISCUSSION

In reviewing our calendar design, we identify several issues, limitations and tradeoffs.

**Obtaining geographic maps.** Spatial maps that are relevant and easily understood by a group are crucial to our design. While our example focuses on a map of nearby buildings, other maps are possible. One example may show two floors in a building as two side-by-side floor plans. Another example may create a composite of maps, such as a map of a head-office in one city and two other maps of two satellite offices located in other cities. Meta-data describing map locations may be needed so that events can be tied to a particular site. An issue is how to manage or incorporate non-routine locations. A possible solution is to generate these maps dynamically.

**Explicit vs. implicit events.** Many scheduling systems create explicit meeting events, where it knows who is attending and where. However, implicit events are also possible. For example, the system can infer an event just by noticing that individuals have scheduled themselves to be at the same location at the same time. SPALENDAR does both. An issue is that such inferred events may be wrong, e.g., two group members may happen to be in the same room, but they may not necessarily be meeting each other.

**Inferring people’s locations and movements.** Our design suggests that the calendar will always know people’s true locations. This is not always possible, and indeed it is unlikely given how people are often reluctant to specify all their schedule details. Consequently we can infer people’s locations by several means. First, we assume that a person’s scheduled location is correct for the duration of an event. Second, we assume a ‘default’ location, e.g., a person would normally return to their office when an event is completed and no new event is scheduled for the near future. Third we can assume that there is a predictable rhythm and pattern to people’s activities and locations [5], e.g., when they typically arrive and leave during the day, where they go for lunch, etc. We can use that as our defaults. Given this information, we can then show people moving to their ‘default locations’ when leaving a completed event. Of course, these inferred locations will not be correct all of the time.

**Addressing privacy concerns.** As Palen pointed out, privacy issues exist in groupware calendar systems [13]. We mitigate potential privacy issues in several ways. Our designed calendar only shows events that belong to a group of organizationally connected people. It also situates the display in their physical work places rather than a truly public space. We recognize that this may not be enough. Considerable group calendar research has to be done so as to identify and validate mechanisms to mitigate/avoid potential privacy problems. Some solutions include manual control of information disclosure, such as allowing people to ‘hide’ or ‘show’ their own event-attending trajectories or creating events that are only visible to a designated set of people. However, this is heavy-weight and likely will not suffice for many situations.

*This visualization needs to be complemented by others.* Any visualization is good at some things, and bad at others. We do not expect SPALENDAR’s mapping of time over geographic space to satisfy all calendar uses. In practice we would expect other visualizations – including traditional calendar views – to complement and work alongside the one outlined here.

*Multi-person scenario.* We have not discussed what happens when two or more people are using SPALENDAR. However, we expect the set of actions to be a union of these people, albeit with tradeoffs that mask privacy-sensitive information (e.g., see Vogel et. al. [19]) while still adding to their collaboration.

## 8. CONCLUSION

SPALENDAR is a prototype that embodies a novel calendar design strategy: geographic space organizes visuals (i.e., locations, events and people) as a time-driven animation. It shows a social network of people’s past, present and upcoming scheduled movements between locations of events. To realize this type of calendar, we employed a rich set of visualization techniques and situated it on a public highly interactive display to allow people to see and interact with it from within the group’s shared work places (e.g., office hallway). Through the design and implementation, we found new calendar usages beyond those known from conventional ones, such as serendipitously discovering group activities, and initiating casual interactions between group members. As mentioned, SPALENDAR is not mature enough for useful testing [7]. Its contribution is as a proof-of-concept system that realizes particular ideas, and that can be used as an inspiration and spring-board to next generation systems built upon the same premises.

We envision this design being adopted in a wider context, in which the data is spatiotemporal and is relevant to a social network of people. For example, hospitals can visualize nurses’ scheduled whereabouts on their shifts to help manage and schedule their duties. Scheduled public transit information can be drawn as the vehicles moving on a city map to inform passengers of their expected arrival time. Attendees of multi-track conferences can ‘bookmark’ the sessions they will go to and a large display can then show an image of the dynamic ‘entropy’ of different sessions and the people attending them directly at the venue.

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