Chapter 13
Interactive Digital Cardwalls for Agile Software Development

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Abstract Agile software development is characterized by very intensive communication and collaboration among members of the software development team and external stakeholders. In this context, we look specifically at cardwalls, noting that despite the wide availability of digital cardwalls, most Agile teams still use physical cardwalls to support their collaborative events. This is true even though a physical cardwall hinders efficient distributed software development and causes extra effort to capture story artefacts into digital tools to meet traceability and persistence requirements. We conducted two empirical studies in industry to understand the use of existing digital Agile cardwalls and to find out the needs for an ideal digital Agile cardwall. The *first study* was with eight Agile teams of committed digital cardwall users. The study showed the reasons why some teams use projected digital cardwalls and their detailed experiences with them. The study showed that most digital cardwalls seem not be sufficient for the highly interactive and collaborative Agile workstyle. The *second study* was with eleven Agile companies. The study comprised of the development of *aWall*, a software prototype of a large interactive high-resolution multi-touch display that supports varied Agile meetings where cardwalls are used. The results of the study emerged with design considerations for digital Agile cardwalls from the evaluation of aWall in a user workshop. Both studies, which were

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conducted concurrently, began with an interest in new large interactive surface technologies which might have the potential to provide not only the required interaction possibilities to support intensive collaboration, but also the required large display format necessary for a collaborative space. The results of the studies collectively seem to confirm our assumption, that large interactive surface technologies could bring the support for the collaboration of Agile teams to a new level, potentially making the teams more productive.

13.1 Introduction

As expressed in the original Agile Manifesto [1], Agile software development is a highly collaborative, communicative and interactive software development method. Transparency, openness and continuous feedback play an important role for the success of this development approach. As well as being a successful approach, Agile developers often show a very high identification with their Agile team and project [2, 3]. One of the core tools to support this approach are *cardwalls*. Cardwalls play a central role with respect to

- supporting collaboration among team members
- serving as an information radiator about the project state
- providing immediate feedback about state change
- providing the transparency about the project
- fostering the Agile team spirit

Despite the availability of many digital Scrum board tools, by far most Agile software development teams still use physical cardwalls for their daily stand-up meetings, as our own studies and others [4, 5] show. However, using physical cardwalls hinders efficient distributed software development and causes extra effort, since artefacts must be captured into external digital tools, to provide the often required traceability and persistent storage requirements.

We believe that large interactive surfaces have the potential to provide not only the required interaction possibilities but also the required large size for the type of collaborative workspace needed by Agile teams. With this type of cardwall, the whole team can meet in front of the wall and interact with it directly, potentially sharing results with remote team members instantaneously.

In this chapter we provide an overview of the usage of digital cardwalls in software development and our own research work in this area. The rest of this chapter is structured as follows. Section 13.2 provides an overview of work in the area of physical and digital cardwalls. We then present two independent studies, one conducted in North America and the other in Europe. Section 13.3 presents the results of a North American study of 64 digital cardwall users. The study resulted in a series of guidelines for developing collaborative digital cardwalls using large multi-touch displays. Section 13.4 presents a European prototype of a practical, large, digital cardwall that supports collaborative Agile practices, called aWall and a user study. Section 13.5

discusses the two studies in conjunction with a focus on multi-touch digital cardwalls to support collaboration in Agile teams. Section 13.6 concludes with a summary of this chapter.

13.2 Background

We now present background on cardwalls for Agile software development teams focusing on physical cardwalls, web-based cardwalls, story repositories, and digital cardwalls. We present case studies about cardwalls and tools that support these tasks.

13.2.1 Physical Cardwalls

The cardwall is a physical artefact that is typically used as a tool for planning and tracking the progress of an iteration during an Agile software development project. But how can the necessary level of detail and complexity be captured on a few cue cards pinned to a wall, and how can the cardwall help software development teams to meet their goals?

These questions were addressed in Sharp et al.'s five-year observational study of an XP software development team's use of physical storycards and cardwalls where she addressed the topics of both physical and social interactions with these artefacts [5]. The authors applied Green's Cognitive Dimensions framework [6] to understand the value of notations used in storycards and cardwalls and how they support (or fail to support) the various cognitive dimensions of Green's framework (See Table 13.1). The study also addressed how the social context of the XP team's process frames the underlying agreements about how these artefacts are used, and how they support the goals of producing working software.

Sharp et al. found that the storycard notation supported the following cognitive dimensions: abstraction, closeness of mapping, low diffuseness, provisionality, and low viscosity. User Stories capture requirements and are therefore an abstraction of them, which also means they are necessarily close to the domain which supports closeness of mapping. Low diffuseness is supported by the stories being written in the language of the user; they are brief and terse by design because they are only intended to be a reminder for further discussion. The storycard medium on which the story is presented (i.e., on an index card or sticky note) gives the storycard a feeling of provisionality. This medium also supports low viscosity because it encourages the engagement of a storycard by the users of the cardwall. However, the storycard does not have much support for the following dimensions, error proneness, progressive evaluation, premature commitment, hidden dependencies, and hard mental operations.

Table 13.1 Cognitive dimensions used by Sharp et al. [5]

Cognitive dimension	Definition
Abstraction	Can elements be encapsulated? If so, to what extent?
Closeness of mapping	How directly can the entities in the domain be expressed in the notation? Does the notation include entities that match the key concepts or components of the domain?
Consistency	When some of the language has been learned, how much of the rest can be inferred? Are similar features of structure and syntax used in the same way throughout?
Diffuseness	How many symbols or graphic entities are required to express a meaning?
Error-proneness	Does the design of the notation induce 'careless mistakes'?
Hard mental operations	Does the notation use mechanisms such as nesting and indirection that require mental unpacking or 'decoding'? For example, are there places where the user needs to resort to fingers or additional annotation to keep track of what's happening?
Hidden dependencies	Is every dependency overtly indicated in both directions? Is the indication perceptual or only symbolic?
Premature commitment	Do developers have to make decisions before they have the information they need?
Progressive evaluation	Can a partially-complete representation be executed or evaluated to obtain feedback on 'how am I doing'?
Provisionality	Can indecision or options be expressed?
Role-expressiveness	Can the reader see how each component relates to the whole, and what the relationships between notational elements are?
Secondary notation	Can developers use layout, colour and other cues to convey extra meaning, above and beyond the 'official' semantics of the language?
Viscosity	How much effort is required to perform a single change? How much effort is required to perform multiple changes of the same type? Does making one change then have the 'knock on' effect of requiring other changes?
Visibility	Is every part of the notation simultaneously visible—or is it at least possible to juxtapose any two parts side-by-side at will? If the notation is dispersed, is it at least possible to know in what order to read it?

The cardwall generally supported the following dimensions: provisionality, low viscosity and process visibility. It is easy to move cards, change labels and, start new iterations which all contribute to the cardwall's high provisionality and low viscosity. The cardwall's columns help reveal the underlying process and can be easily understood, which makes the visibility of the process high. There were also dimensions that were not directly supported by cardwalls: consistency, hidden dependencies, role expressiveness, progressive evaluation, and error-proneness.

The storycard or cardwall notation alone did not directly support all of the dimensions. Social agreements, discipline and interactions that framed the use of the storycards and cardwall, contributed to the support of the missing cognitive dimensions. Without the social interactions the benefits of the storycard and cardwall would be significantly reduced. Sharp et al. concluded by advising "Any Agile team looking to move towards digitising the team's support will need to take account of the complex relationships that exist within this social system if they wish to retain key properties of successful teams [5]."

For example, while a general template for stories usually exists such that key information is presented as follows: "As A < *Role* >", "I want < *Description* >" "so that < *Benefit* >", one still finds differing notations being used across Agile teams. However, within any one team the notation and use of cards is strictly adhered to. Everything on the card has meaning to the team including the location of the storycard, its colour, the size of the lettering and other meaning-laden annotations. A mature established team might have a well-defined notation while a new team might still be looking for what works best for them. To support these social behaviour storycards must be modifiable.

The use of the cardwall is also an extremely flexible procedure but has its generalities in that teams use walls for the duration of a project and leave them on constant display where they are easily seen—usually in a common space where anyone walking by could get an idea of the progress of the project. The cardwall is generally regarded as an 'Information Radiator' [7] and helps ensure the transparency of the project. Like the storycard, the cardwall is full of meaning not obvious to an observer who lacks familiarity with Agile methodologies or team specific notation. However, key information that one should be able to gather almost instantaneously from any cardwall is the general progress of the project. The placement of stories signifies whether or not they are in active development, waiting to be started or finished. Again the cardwall is generally without structure when considering its use among distinct teams, but it is used in an extremely consistent manner within any one team.

Using cardwalls requires an active participation between customers and developers and was originally described as 'The Planning Game' [8], where the objective is to prioritize the cards, sort them into releases and sprints, assign them to developers and have the developers accept or decline them until the cards were sufficiently sorted into at least the next sprint; unassigned stories are left in the project backlog, to be dealt with at the next iteration or release planning meeting.

The social interactions involved in the whole process enables teams to determine their best use of the storycard and cardwall's notation, which includes the organization and layout of the storycards on the cardwall. These interactions reveal the importance and meaning of the stories and thus drives their physical placement on the cardwall, which, in turn drives the story's progress through the system. The physical size of the cards is also of utmost importance since the size limits the information it can hold, and therefore encourages a communicative dialog.

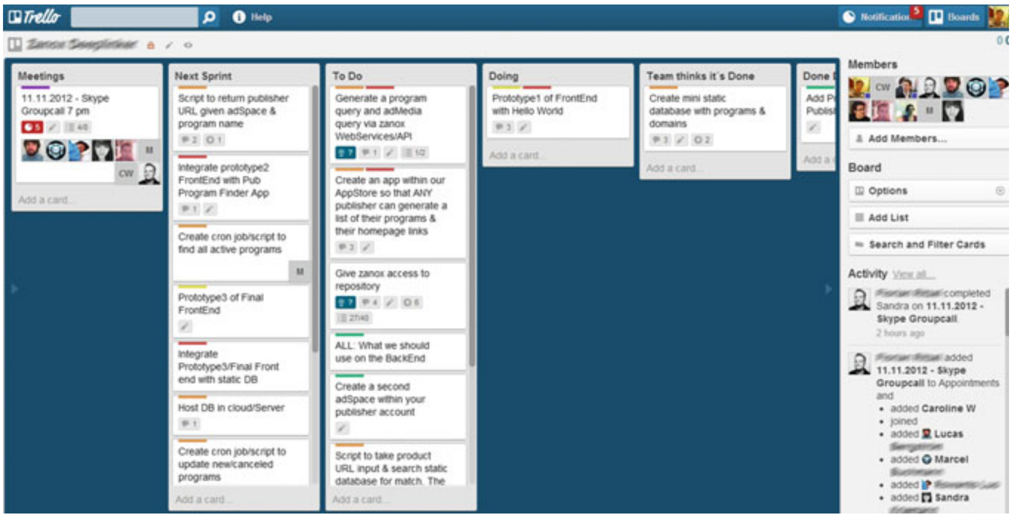

Fig. 13.1 Trello—web-based cardwall for a software development project

13.2.2 Web-Based Cardwalls and Story Repositories

Some tools have explored adapting physical cardwalls and story repositories to the web, notably Trello a web-based card wall and Jira a web-based story repository.

Trello [9] was created by Fog Creek Software. Perhaps more than any other digital tool for story management, Trello captures the simplicity of the traditional physical cardwall. The simple design allows flexibility in how it can be used. Trello can align with many different workflows, from simple to-do lists to Agile development as seen in Fig. 13.1, and also to other personal, business or management applications.

Each new board starts with three empty lists titled: Todo, Doing and Done, but you can add as many lists as you want, each with its own title. Similar to the storycard, in Trello you add new content to a list by clicking the “add a card” button at the bottom of any list. The cards have two views, a minimal view used while viewing the board at large and a detailed view, where you can see and edit all the extra content that is hidden on the back of the card. Each list can grow arbitrarily and the cards allow the user to easily add rich content, such as images and URLs or even embedded videos. With Trello, everything is saved automatically so there is no need to remember to save or update. On the Trello homepage, they explain that the simplicity of their applications allows users to use it in a flexible manner that can reflect the way they think or the processes they follow.

Trello has been designed very well from a user interaction perspective, but it does have limitations. For example, it is not possible to view the details of a storycard while still viewing the cardwall. Similarly, one can only see the details of one particular story which makes it difficult when planning and the discussion involves the details of more than one story. Finally, Trello is not designed to support simultaneous, co-located multi-user interaction which may have an impact on its support for collaboration.

JIRA [10] is an issue tracker tool developed by Atlassian. JIRA allows software development teams to track and assign issues as well as help to track the activity of teams and their members. Issue Trackers, also known as bug trackers, ticket support systems, or management workflow systems, allow teams to enter and track the progress of whatever the particular system is designed to track. They provide useful search features and reporting capabilities, including graphs to help visualize the progress, and reports for management. Such systems are not really designed to support Agile planning with User Stories, but are widely used for this purpose in practice.

JIRA is one of the most popular issue tracker tools and has been adopted and repurposed by Agile software development teams to manage their User Stories. The major impetus for this development was that Agile teams were looking for a solution to the distributed team dilemma where team members working from different locations had no access to the team cardwall. The use of JIRA by Agile teams for this purpose became so popular that an add-on was developed to add a cardwall view on top of JIRA as seen in Fig. 13.2; this add-on is available under the name JIRA AGILE. Several of the teams involved in our field study, which will be described in Sect. 13.3 used JIRA in combination with the Greenhopper plugin (the predecessor of JIRA AGILE).

13.2.3 Digital Cardwalls

Large high-resolution displays are now readily available, as is the support for multi-touch capabilities. Leveraging these technologies seems like an obvious place to start

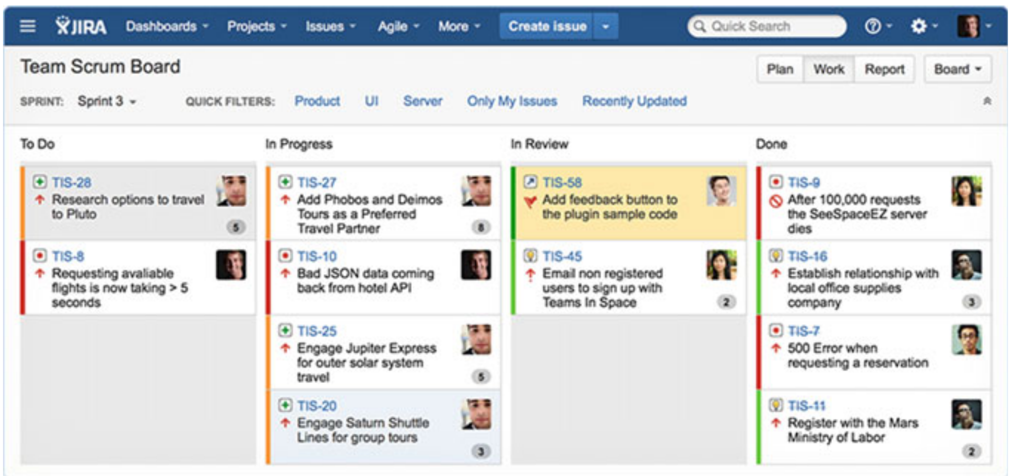

Fig. 13.2 JIRA—typical cardwall used by the teams in our study using the JIRA Agile type of cardwall. Each card is associated with an issue in JIRA. Such cardwalls were projected on walls in team meetings

when thinking about developing a digital cardwall. Every day more devices are being produced at a reasonable cost with support for two or more simultaneous touches; a critical feature for the development of truly collaborative tools.

The Agile Planner for Digital Tabletop (APDT) [11] was designed based on a prototype by Weber et al. [12] which was intended for co-located collaboration on a single touch surface. APDT chose to use this as a starting point, but wanted to enhance it with support for multi-touch, the ability to interface their cardwall with other Agile planning tools, and real-world evaluation based on user studies. It was designed after observing traditional Agile planning meetings, as well as meetings conducted using the Distributed Agile Planner (DAP) [13]. As the name suggests DAP was designed to support distributed Agile teams in the planning and maintenance of an Agile project through the use of a digital whiteboard and storycards. DAP had been developed with a traditional single user interface paradigm (one keyboard, one mouse), to enable users to collaborate remotely; it did not support multi-user interactions in a co-located environment. APDT also studied and drew from the literature available on the use of multi-touch tabletops for group collaboration. APDT was developed as a multi-touch enabled tool, specifically for two tables designed by Smart Technologies Ltd. using Smart's proprietary SDK. The first table used DViT (Digital Vision Touch) [14] technology and had support for two concurrent touches. The second table used FTIR (Frustrated Total Internal Reflection) [15] technology and had support for 40 concurrent touches. The two touch capabilities of the DViT table limited the users' ability to work concurrently, while the small form factor of the FTIR table meant that it was difficult to leverage its support for a much greater number (e.g., 40) simultaneous touches.

Our previous work includes Collaborative Multi-touch Agile Planner (CMAP) [16]. APDT (as described above) was a highly functional, full featured tool, however, it only supported two simultaneous touches; a limitation that influenced our design. With CMAP hardware and operating system independence was a goal. We also wanted to support multiple concurrent touches. CMAP extends previous work on Agile tool support by addressing key issues outlined by Scott et al. about group collaboration around digital tabletops [17]. We also attempted to address issues found by Sharp et al. about how the physical nature of storycards and cardwalls affect their use and have a "reflexive relationship" with the social interactions in which the use of the cardwall is grounded [5]. Sharp and her colleagues stress that software designed to digitise the storycard and cardwall must carefully consider both the notational and social aspects of these artefacts.

The basic goals for the development of CMAP was to design a digital cardwall (a horizontal tabletop) with support for multiple concurrent inputs (to support multiple users), and was not limited to any specific hardware. We wanted to explore the use of touch gestures and how they could be used efficiently to manipulate the stories. At the time, we were working with horizontal surfaces, so we needed to understand the implications of user orientation and their effects on the usability of the tool. We also wanted to create a distributed system with a back-end that could be accessed simultaneously from multiple sites.

To support these goals several design decisions were made. The use of PyMT [18] and Python meant built-in platform independence, multiple concurrent user interaction and support for multiple inputs. PyMT allowed the use of gestures and rotatable widgets to deal with orientation issues. The need to support persistent and shared data was achieved by using a combination of open source projects including Git, GitHub and the Petaapan Google Application Server. Git took care of local and remote storage while the Google App Server took care of change notification through a publish/subscribe mechanism and notification hook between it and the GitHub repository.

CMAP took a structured approach to the storycard and cardwall. This was an attempt to capture all the relevant data that seemed to be critical to the Agile planning process. XML was used to define the data of the storycards and other artefacts and the view was a form-based widget with labels and text fields. Users could use traditional data entry via real or virtual keyboards. In an attempt to limit the amount of information contained by an artefact, a default minimal view was created, which only allowed the entry of a name for the artefact and a description. A second view was created for stories to allow the user to enter more information. This view was built so that the developer could, in conversation with the customer, elaborate on the information provided by the minimal view.

Some other researchers have looked at multi-touch interactive surfaces for supporting Agile teams. dBoard [19] provided an Agile cardwall on a single vertical touch display to support distributed teams with video conferencing capabilities. One screen was located locally while another remotely. However, the tool only utilized one screen at each location and did not support all the types of Agile team meetings. SourceVis [20] focused on code reviews for pairs of developers around large tabletops. SourceVis supports a suite of visualizations to explore code artefacts. However, the tool did not support many other types of Agile team meetings and was not connected to any issue tracking or source code repositories. CodeSpace [21] provided an environment based on CodeBubbles for exploring code that used a vertical touch screen, 3D gestures with Kinect, tablets, and laptops for collaboration. The aim was to provide support for software teams to explore code in a team setting. However, the tool did not focus on any Agile processes per se.

We now present a case study on the use of digital Agile cardwalls in practice, followed by a novel digital cardwall prototype and a user study.

13.3 Case Study: Cardwall Usage

As a result of a review of existing online tools, we observed there are many software tools to help manage Agile projects using user stories, but none of these tools are specifically designed for multi-touch technology or for large high-resolution displays. We envisioned a large high-resolution vertical cardwall that would use these technologies to support the known advantages of the large vertical physical cardwall (e.g. being an “information radiator” resulted from the physical cardwall’s vertical nature), while allowing the introduction of new functionality only possible with a computerized system. Our research question was: How should one design a *digital* story cardwall which captures the known benefits of physical story cardwalls *and* provides additional functionality only possible with a software solution?

We wanted our design to be informed by the actual needs of real-world Agile teams. We therefore conducted a field study using observations and interviews to explore the priorities from the perspective of developers who currently use digital cardwalls. We designed a study to investigate real work environments of this type. We wanted to understand more of the reasons leading to the adoption of digital story cardwalls and the frustrations experienced by teams using digital cardwalls. Our study is described in detail in our recent paper [22]. Here we summarize our results and present the implications for the design of large multi-touch digital cardwalls that follow from the outcomes of our study.

We began by conducting a pilot study of a team of physical cardwall users to ensure we were aware of the behaviours and advantages of physical cardwall usage. We then designed a week-long expedition to observe and interview 8 professional, digital cardwall Scrum teams in four different organizations—two in Canada and two in the United States of America. Our observations would help us to *observe* cardwall behaviours and the interviews would help us to *explain* the behaviours we observed. The teams we studied used either JIRA/Greenhopper (now JIRA Agile) (See Fig. 13.2) or an in-house digital cardwall called StoryBoard as their digital cardwall. We observed 64 participants, using standard ethnographic methods [23–25], in iteration planning meetings (IPMs), daily standups, and retrospectives. We interviewed 8 team members for one hour each, using a semi-structured interview technique [24, 26–28].

Our data consisted of notes from 13 meetings, and 8 interview transcripts. We entered our data into a qualitative analysis program called Atlas.ti, and used grounded theory [29] combined with a thematic analysis technique [30] to analyse the data. Both these techniques use an inductive approach. One strength of this approach is that the researcher remains grounded in their data. The end result is that themes that are generated are a very good fit to the data collected. Our paper [22] describes how we found 15 saturated codes and reduced them to 7 themes. We next briefly summarize these 7 themes and present design implications for each one.

13.3.1 Cardwall Formats

The teams we observed were mostly using projectors to display cardwalls of external customer projects, although occasionally internal projects would be managed by a dedicated inhouse physical cardwall. Projected cardwalls have the advantage that they are portable and can be used in any available meeting space where there is a projector. The project lead was typically responsible for updating the cardwall as the team worked. This solved a few problems: the limited wall space, the need for customers who attended team meetings to only see their cardwall and not the cardwalls of other customers, and the need for remote team members to view the cardwall on their laptops and see it update in real time during team meetings.

Digital cardwalls allow teams to conduct meetings in shared locations like meeting rooms, which ensures privacy and confidentiality for customers. This means that teams working on sensitive projects can reap the benefits of a cardwall, while their customers can rest assured that their sensitive data is not compromised. This also has the benefit of reducing the requirement for wall space and allows meetings to be conducted in any office or boardroom (including the customer's site) using existing standard equipment.

A down-side to this practice is that teams lose the benefits incurred from the always-on and constant display of the physical cardwall as "information radiators." Therefore, teams should also consider using a dedicated display, located in a shared space close to the team. In this way, teams can benefit both from the flexibility of this 'display anywhere' solution, and from having the cardwall available in a central dedicated location.

With respect to interaction possibilities with projected cardwalls, we consistently saw the Scrum master interacting with the cardwall on behalf of the rest of the team, which kept the work tightly coordinated, but also slowed it down. The ability to interact directly with the cardwall through physical touch would be ideal and would support the principle of maintaining a level playing field among team members.

Digital cardwalls open up the possibility for combining cardwalls in multiple formats. We observed cardwalls displayed on large shared surfaces for meetings, but we saw the same cardwalls displayed on laptops or smaller desktop displays for standup meetings or for remote team members. Furthermore, although we did not see participants using smaller personal devices like smartphones or tablets, these formats may also be important and should be considered when designing. With a web-based cardwall, there could be any number of distinct form factors used for displays, ranging from smaller personal devices to larger shared displays. For displays with truly high resolutions like the 4K and 8K displays or tiled displays, we advise using general guidelines for designing on these types of high-resolution surfaces [31–36].

G1: Support diverse screen sizes with appropriate design to support the varied team practices around digital cardwalls and storycards.

13.3.2 Scaling the Design of the Cardwall

Our participants pointed out that there were problems with maintaining either physical or digital cardwalls, especially when projects were large. For digital cardwalls, the problem of page refreshing is an annoyance, but with physical cardwalls clutter is a challenge because of space limitations. Interestingly, the added benefits afforded by the digital environment were viewed as either a blessing or a deterrent. One of our project managers loved how you could link JIRA with other tools. However, a developer working on the same project recounted his frustrations with the number of email notifications he was receiving as a result of changes to the code base.

G2: Design for large Agile cardwalls that support displaying many cards at once. Consider the placement of cards for usability, their visibility, and the responsiveness of the user interface. Limit the number of notifications sent to developers, which can disrupt individual and collaborative workflows.

13.3.3 The Big Picture and Story Relationship Visualisations

Participants mostly described how digital stories helped developers to track their work. In the physical cardwall study we observed how the visualization of relationships between stories was supported through the use of simple methods like the use of colours, annotations, and swimlanes. In the digital cardwalls we observed support for some of these simple methods, but teams did not attempt to visualize sophisticated story relationships. From our interviews we learned that the ability to see these relations was either difficult to do, or was not supported by the cardwall being used. Participants wanted to see relationships between stories made more evident, but currently kept track of such dependencies ‘in their heads’.

Large displays facilitate team planning work and are ideal for capturing a big picture view of the project. In our field study, all of the iteration planning meetings and retrospectives used projected images of the team’s cardwall which was large enough for it to be easily seen at a distance by all participants. We also observed that during iteration planning meetings (IPMs), each story being considered as a candidate for the next iteration was viewed and discussed in detail. Fortunately, large displays have enough screen real-estate such that a group of co-located collaborators can easily view the details of one or more stories. From our observations, the short stand-up meetings were generally not held in meeting rooms and they did not generally have access to a large view of their cardwall. For these meetings, the big picture cardwall was used more as a point of reference similar to a cue card, and was ideal for keeping the meeting focused and on point.

G3: Always support a large format overview of the entire project to ground team and stakeholder discussions around a large display.

While the large display format is important, it is also important to support the scenario where a cardwall application is viewable on a variety of formats, including large displays. Our guidelines are based on Shneiderman’s visual information seeking mantra: overview first, zoom and filter, then details on demand [37].

Overview first: Since one of our goals is to try and leverage the benefits of the physical cardwall, we make the assumption that whatever is on display on a large display should be discernable from a distance of approximately five to ten feet. An overview first view is best.

G4: Always begin with, and default to, a general overview display. If the display is large this view should be discernable at five to ten feet to ensure the display works as an "information radiator."

Zoom and pan: Since a digital cardwall can be viewed on virtually any display format, it can be difficult for the software to adapt to the actual size of the display and the resolution. Being able to re-size the current view of the cardwall should be possible. When zoomed in sufficiently, such that parts of the current view are no longer visible, panning allows the user to easily access the parts of the view that are hidden. When zooming in users should be made aware of the ability to pan and the directions in which they can pan to reveal the hidden content.

G5: Support zoom and pan to allow users to adjust dynamically to the demands of the social practice that they are engaging in.

Details on demand: We observed that the details of any particular artefact are not always important and therefore should not always be present. However, a digital cardwall needs a mechanism which allows users to show and hide details whenever they are available. To reduce user frustration, the user should see a visual cue indicating there are additional viewable details.

G6: Allow optional display of details that would otherwise clutter the current view to support detail-oriented conversations.

Designing for touch interaction: Many large display formats are now beginning to support touch interaction.

G7: Interactive components, whatever the display format, must always be displayed in a way that they are large enough to enable touch interactions easily. This is especially a concern for large high-resolution displays. This necessary prerequisite for interactivity removes a potentially frustrating roadblock to collaborative interactions.

13.3.4 Exploring and Filtering Information

Experienced Agile practitioners described how cardwalls help them keep track of the status and progress of multiple projects. More experienced participants envisioned how added functionality could help increase awareness about important, but currently invisible, aspects of their projects like how long it would take to implement a group of stories, or how many defects are associated with it. They wanted to group stories by software component so that the team could select different software components and see the associated stories, the progress of those stories and other aspects. This would tell them who would be impacted by a change.

One project manager wanted to see a feature that would help him remain aware of business goals because this could impact technical solutions. He also wanted to easily drill down from higher-level, more abstract ideas to lower-level, more detailed-oriented issues. He imagined the ability to visualize features on a cardwall would be ideal for meetings with high-level executives, but he also imagined wanting to drill down to the epics and stories which would help increase the overall awareness of the projects' real progress and provide a more realistic understanding of the work involved in the implementation of a feature amongst executives.

With traditional physical cardwalls, users cannot explore details and complex relationships since the whole idea is to present a big picture of a work in progress. The digital cardwall can be much richer and it can allow users to explore the project in several ways including viewing previous iterations, the backlog, and even other projects. When we further enhance the digital cardwall with the ability to filter, we open the door for more tailored explorations via a query language capability. In our field study, the participants expressed their frustration with regards to difficulty of searching, filtering, and tagging capabilities in their existing digital cardwalls. They also wanted to see dependencies and relationships between stories, to break down epics into smaller stories, and have the ability to trace a story back to an epic. Furthermore, the participants wanted to create sets that could be used as the data for a query. Based on this, the following guidelines have been identified.

Working sets and queries: Working sets identify a collection of stories of interest. A good default for a working set of stories is the contents of the current view or iteration. The point of the working set is to help users focus and quickly find information that may not be obvious or visible. Working sets can be outcomes of queries. In addition, users should be able to save and label a working set so that it can be re-visited. Ease of use is an important consideration in implementing this feature.

G8: Allow users to create sets of stories based on story details and further explore them via the composition of queries. This supports 'chunking' at an individual and social level, speeds interactions and eases demands on memory.

Query: The operations we need to query working sets are a simple query language based on predicate calculus, with basic support for the unary "NOT" operator, the binary "AND" and "OR" operators, the for-all and for-each operators as well as parenthesis for changing the order of precedence. Queries can be used to ask complex questions like "Find all the stories that have been completed, but for which there are reported bugs."

G9: Make simple queries easy, but also support a rich set of query operators. This functions enables important conversations about sets of stories.

Custom attributes and annotations: The ability to apply attributes to artefacts allows users to filter the working set by including or excluding artefacts that share a particular attribute. Filtering can be performed before or after a query and should be dynamic such that the addition or removal of categories should automatically refresh the results of the working set to reflect the change. It should be possible to use named attributes directly in user queries. The literature review of physical cardwalls found that teams often marked up their storycards with meaningful symbols, however, we did not see this behaviour in our study because this feature was not supported by the digital cardwalls being used. However, in our data there was evidence to support the use of custom attributes to mark different components, business goals, roles, people, and epics.

G10: Allow users to mark-up their cardwall and the stories within it. Optionally, let them assign meaning to their annotations. This supports teams to develop specific work practices relevant to their workplace.

13.3.5 Managing Backlogs

Backlogs were displayed congruently with a digital cardwall, and developers dragged stories from their backlog and dropped then onto a cardwall. The backlog is a significant element for large projects; the ability to see the backlog's stories, and to sort and prioritize the stories becomes increasingly important as the size of the project increases because larger projects have larger backlogs. Team members were very interested in the prioritization of the backlog items and how the stories were selected for each new iteration. The backlog was sorted by priority, but items came off the backlog into an "In Progress" list, which was "just a bucket." Developers could choose any item in the bucket. If a developer was done and no other developer wanted to pair program, that person would choose the next item in the backlog. Prioritization as a practice, also varied with how close the team was to releasing. The closer to releasing, the more the team prioritized.

We also saw how teams sometimes used different backlogs for infrastructure-type work that needed to be done, and another for customer stories.

Sometimes teams wanted to use the backlog to store information that would be useful for planning, estimating and reporting purposes such as bugs or vacations, because this improves visibility of these items.

G11: Backlog management is an important part of cardwall design. Sorting techniques within a backlog should support the concept of 'buckets' to support overall structuring of the backlog and also traditional sorting from most to least important within a bucket. Items in backlogs should be taggable. Allowing parts of backlogs to be sorted while others are not, mirrors the way backlogs are used in an Agile practice where just enough work is done to advance the team at the time.

13.3.6 Multi-disciplinary Use of Stories

We knew that stories were important to developers, but we learned that digital stories are vital to testers, designers and project managers, too. Cardwalls are becoming a multi-disciplinary team tool. However, we also noticed that the effectiveness of the information radiator aspect of a wall depended on the role of the person using it. For example, for developers and designers, the constant display of the current sprint is very useful for increasing the awareness of the status of the project, and it can even serve a motivational function. However, for the team's testers, their interest in the project is limited to the column of the wall that contains a list of stories that require testing, which tells them the size of their task.

Although the teams we observed were using digital story cardwalls, these tools were limited in their support for concurrent multi-users. Their cardwalls allowed distributed users to access and view the cardwall from their remote location however, there was no support for real-time concurrent use in terms of editing and viewing the details of more than one story simultaneously. This sometimes caused inconveniences, where the details of distinct stories of interest had to be remembered instead of simultaneously viewed.

G12: Allow simultaneous multi-user access to allow all team members equal access to the cardwall so work will flow.

A cardwall where the stories could be pulled from a variety of sources would help teams in a support role adopt the cardwall as a collaboration tool within their own teams. Teams from QA, testing and interaction design would potentially benefit from this ability. It is common for team members occupying roles of this nature to work simultaneously on different projects, and as of yet they do not have standardized methods for organizing work across projects. It could be useful to allow such groups to get a big picture of their work which could be organized into multiple projects using swimlanes.

G13: Support roles where team members' responsibilities extend beyond a single project. This will allow other groups like QA and UX who work on multiple projects at once, to also use cardwalls.

G14: Stories associated with various roles should be visually identifiable and the use of swimlanes is ideal for this purpose. Whether or not those who fulfill the role of QA or UX are seen as part of the team or outside the team, their work contributes value and the status of their work should also be visible.

Cardwalls can also be valuable tools at a personal level. In this situation, the story someone is working on could be broken up into tasks. Each task could be treated as a story, including estimates, and as tasks are completed the overall progress of that story on the team cardwall can be updated to show the progress.

G15: Design digital cardwalls for use also by a single user.

One important reason that cardwalls can be easily aligned with so many distinct processes is that teams can customize the columns to match their process. To seamlessly support virtually any team, the digital cardwall must allow teams to add, remove and rename columns. This way each column on their cardwall aligns with a distinct step in their process.

Another important customization option is the ability to customize and create new annotations, which would be re-usable and would allow teams to quickly identify artefacts that share the same annotations. This can be further enhanced by designing the system to differentiate between distinct annotations so that they can be used for querying, searching and filtering.

G16: Allow teams to customize the cardwall so that it aligns with their particular process.

13.3.7 Updating the Cardwall

Users complained that there were too many steps to accomplish simple tasks with their existing digital cardwalls. At the top of their list was saving and refreshing their cardwalls. Our participants felt that it was an annoyance to manually remember to save updates and to refresh their client to see changes made by others, which others may or may not have even saved.

Automatic save and refresh: Every action performed by users on the cardwall should automatically be saved. A cardwall for collaborative work designed as a distributed system with single database should automatically push local changes in real-time. A conflicting change should be sent back to the originating source (or sources) for manual resolution. Similarly, remote changes should automatically be sent to all clients.

G17: Support automatic synchronization of cardwalls; extra steps to save and refresh should be avoided. This supports workflow when some team members are remote.

To enable awareness, when a client receives an update, there needs to be a visual cue that draws the attention of users. In this way, the instances of change blindness will be reduced when teams are collaborating at-a-distance.

G18: Create awareness of remote changes to reduce errors and increase usability.

While this detailed observational study produced useful guidelines for digital cardwall construction, another research team in Switzerland used information from surveys and their own experiences with digital cardwalls to build a large interactive digital cardwall called aWall. This is the topic of the next section of this chapter.

13.4 Case Study: aWall—a Large Digital Cardwall

The previous sections have shown the limitations of current physical Agile cardwalls, especially with respect to their ability to support the highly interactive Agile collaborative workstyle. These limitations include the inability of physical cardwalls to be flexible, their lack of transparency where missing information is concerned, their ease of use, the inadaequate haptic experience, and the mismatch between required and available space. Physical cardwalls, however, remain an essential tool for team

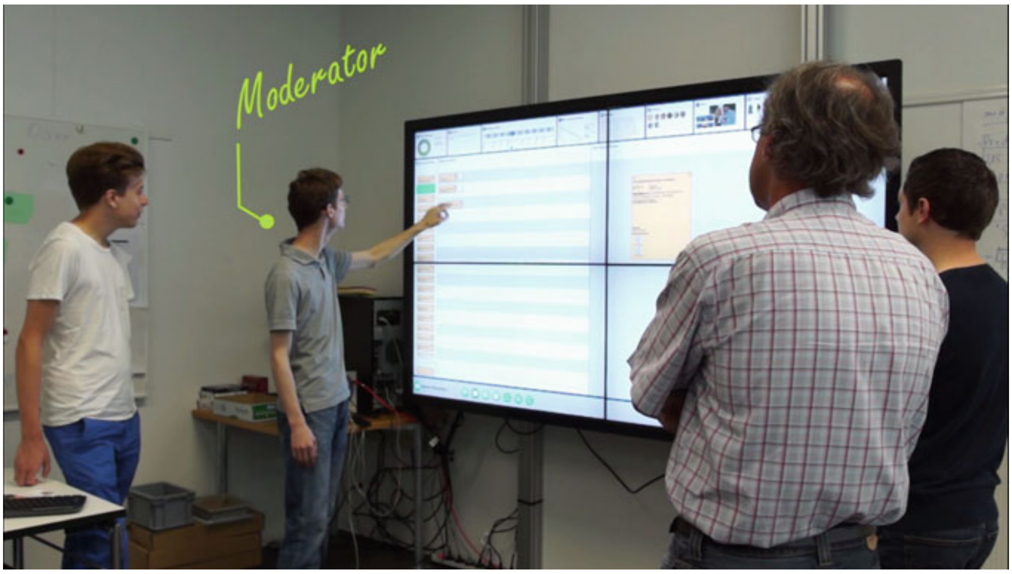

Fig. 13.3 aWall—digital Agile cardwall displayed on a large high resolution multi-touch wall (2 × 2 46 Inch 4 K displays) for Agile planning and team meetings

collaboration in software development, and are still used in most Agile teams [4, 22]. These findings are confirmed by our own study, which shows that 10 out of 11 teams still use physical cardwalls, typically in combination with digital tools [38]. Despite their prevalence, physical cardwalls still have issues as content is not digitalized and not integrated with other software development tools such as issue tracking and project management systems, and are not suited for distributed team collaboration.

In an endeavour to overcome these limitations and issues with physical cardwalls, we developed a research prototype *aWall*, which is a large high-resolution multi-touch digital Agile cardwall (see Fig. 13.3). The goal of aWall is to provide a digital collaborative workspace which supports Agile teams in their Agile workstyle. aWall supports elements of the natural aspects of physical cardwalls, and integrates with existing issue tracking and project management systems. aWall aims to support co-located, as well as distributed teams in their collaboration, allowing them to conduct typical Agile team meetings with the cardwall. aWall is described in more detail in [39].

13.4.1 Field Study

To deepen our understanding of how Agile teams collaborate and use cardwalls in practice, and what the requirements for an "ideal" digital cardwall would be, we conducted a field study with 44 participants from 11 companies in Switzerland [38]. The study consisted of semi-structured interviews: 10 group interviews and 3 individual interviews. The group interviews lasted 2 hours and the individual interviews lasted 1 hour. All interviews were audio recorded and transcribed, for later analysis.

When asked about the requirements for a digital Agile cardwall, the interviewees stressed the importance of non-functional requirements, like the need for a large display size, configurable views, instant availability of information, overview of information, always-on information, easy reachability of context dependent information, easy readability of information, simultaneous multi-user touch interaction, direct interaction with data, and “navigation-less” operation.

Our hypothesis, that existing digital tools do not adequately support the communication and collaborative aspects for Agile team meetings effectively, was confirmed through our study, which also revealed that mostly only one team member (often the Scrum Master) fed information into project management tools.

Based on our study results, we developed *aWall* to support Agile teams (co-located or distributed) more effectively than existing physical and digital tools. aWall is designed to support Agile team meetings like daily stand ups, sprint plannings, and retrospectives by providing information dashboards, maintaining user stories and tasks, supporting the customization of Agile processes, and integrating with external issue tracking systems, like JIRA [10]. aWall was developed by an interdisciplinary project team of computer scientists and psychologists (from the School of Engineering, and the School of Applied Psychology, from the UAS Northwestern Switzerland).

13.4.2 Design Considerations

Based on the requirements elicited during the interviews of our field study, we identified the following core design considerations for digital Agile cardwalls which helped guide the design of aWall.

Physical Size. Digital cardwalls need to satisfy not only the requirements for interacting with digital content, but also provide enough physical space to display information to effectively support team collaboration. Therefore, the size of a digital cardwall needs to be at least comparable to that of physical cardwalls. Thus aWall consists of four 46 inch displays (2×2), for a wall size of 2.05 m width and 1.25 m height (see Fig. 13.3).

High Resolution Display. Digital cardwalls should have a high resolution display to provide enough real estate to display large amounts of information at once while still ensuring the readability of text elements, widgets, and views. Each display in aWall is 3840×2160 pixels, for a total resolution of 15360×8640 pixels.

Multi-user and Multi-Touch. Digital cardwalls should support multi-touch capabilities to allow multiple users to work simultaneously with artefacts and provide an accurate and effective touch experience. aWall consists of a 12 point multi-touch infrared optical overlay (PQ Labs frame[1]) which is attached to the display wall.

[1] http://multitouch.com/.

Integration with Issue Tracking Systems. Digital cardwalls should be integrated with issue tracking systems as they are fundamental for the work flow process within software development teams. aWall is designed to run on top of existing third party issue tracking systems such as JIRA. Therefore, infrastructure functionality can be reused and already customized Agile processes can be utilized.

Availability of information and transparency. Digital cardwalls should be installed in a team's open office area, always being switched on, and have a permanent view of the task board. Therefore digital cardwalls can replace physical cardwalls and act as the team's external memory of the project, thus provide the desired transparency in Agile teams. aWall is designed to be large and portable, which allows large amounts of information to be displayed and can be moved to different locations within an open office area.

Ubiquitous and Deployable. Digital cardwalls should support co-located and distributed teams by being ubiquitous and easily deployable applications. aWall was developed as a web application based on HTML5, JavaScript, and interact.js for multi-touch support.[2] Though we especially focused on the support of co-located Agile team work, aWall could be extended with specific concepts for distributed team work like those developed by Esbensen et al. [19].

Foster communication and collaboration. Digital cardwalls should foster communication and collaboration, serve as a teams external memory, and provide all context specific needed information. aWall implements the concepts of *information widgets* which provide additional information on the display to the teams core activities. For example this information includes: Definition-of-Done Lists, Burndown charts, Pair-Programming planner, team viewer, and meeting timer.

13.4.3 User Interface

The aWall user interface contains a number of different views, widgets, and interaction techniques designed to support the different types of Agile team meetings.

Action and information view. One of the findings of the study is that most cardwall interactions take place during Agile meetings. Each meeting, however, has its own specific goals, operates on different data, and requires various supporting tools and information. To support these different types of information needs, the aWall display is divided into an *action view* and an *information view*. Figure 13.4 shows the view for a daily standup meeting highlighting the separation into information view on top (red bordered) and action view in the center (blue bordered). The action view is the main working area, which is dedicated to the core artefacts of a specific meeting. The main interactions during a meeting are performed by users on the action view. It is designed to make changes on the core artefacts as easy as possible, and with

[2] http://interactjs.io.

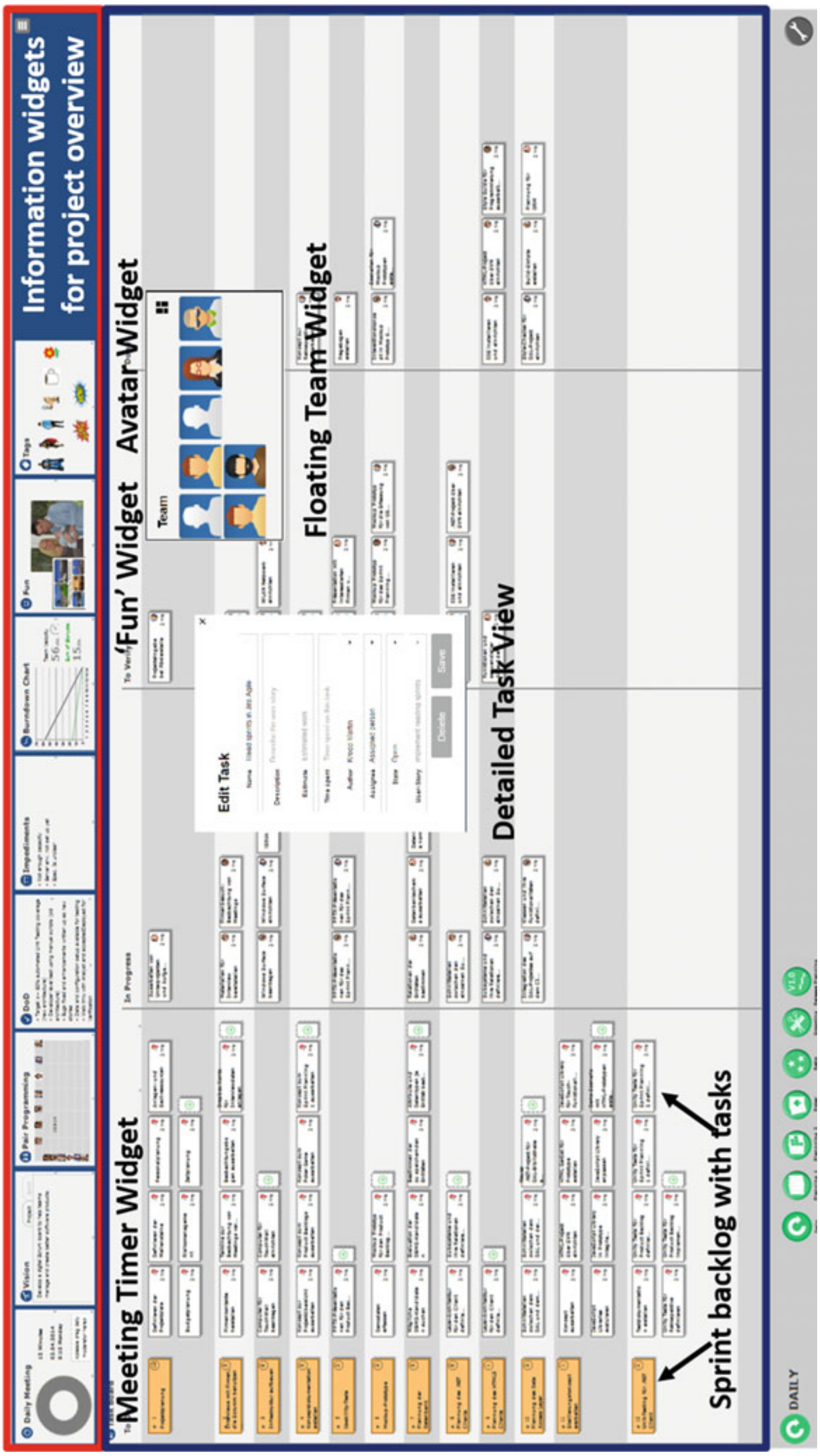

Fig. 13.4 Daily standup meeting screen with information view (*top* section with *red* border) and action view (*middle* section with *blue* border) and meeting navigation at *bottom*

this foster interaction and collaboration in the team (for example, moving cards by simple drag-and-drop gesture). The information view provides supporting information and tools needed for the meeting. It represents the *dynamic memory* of the team. As any dynamic system, the information view allows for change, and is specifically customized for the different meeting types. For example, the information view for the daily standup meeting contains specific information, like a timer widget showing the name of the meeting moderator and a countdown, a team widget showing the names of team members, a definition-of-done (DoD) widget, an impediment list widget, and a burndown chart for an iteration. All widgets can be switched on and off on the information view as needed.

Dedicated views. To provide the information needed for the different activities of Agile teams, aWall provides dedicated views for each Agile meeting. These views are tailored to the specific needs of this meeting. Figure 13.4 shows the classical task board view for the daily standup meeting. Figure 13.5 shows the screen for the sprint planning 1 meeting. The action view is divided into three columns. The left column shows the top priority user stories of the product backlog. The centre column shows the user stories that have been selected thus far for the next iteration. The right column shows a detailed view of the currently selected user story. The information view again shows supporting information that might be needed during the sprint planning meeting. So this view is optimized for the discussion and clarification of open issues during the sprint planning meeting with the development team. Relevant documents can be easily attached and opened on the wall. As another example, Fig. 13.6 shows the retrospective meeting view after team members have sent feedback on the iteration; their notes have been ordered on the right side. Users can navigate between the different meeting views using the navigation bar at the bottom of the screen.

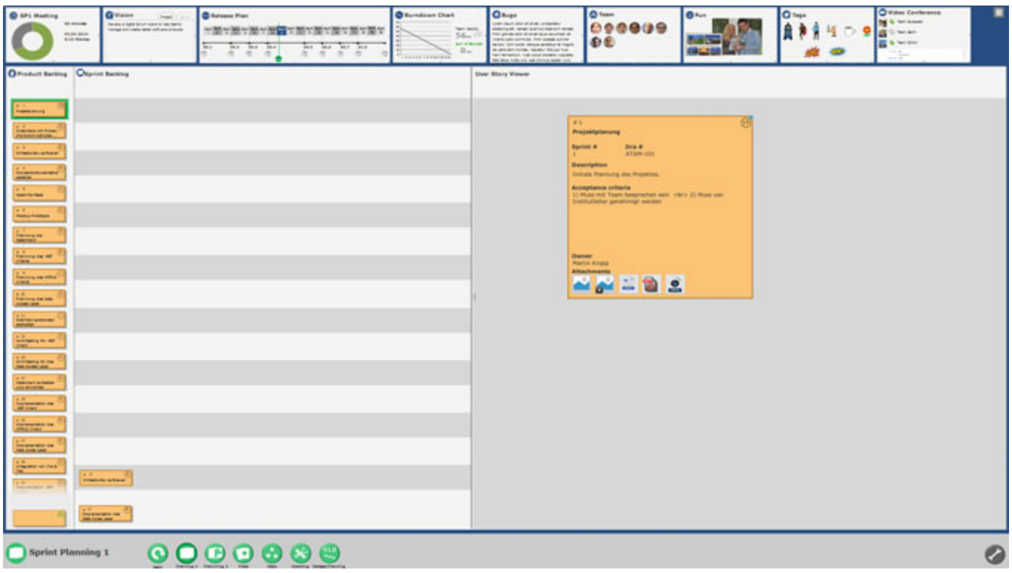

Fig. 13.5 Sprint planning meeting with a user story detail view

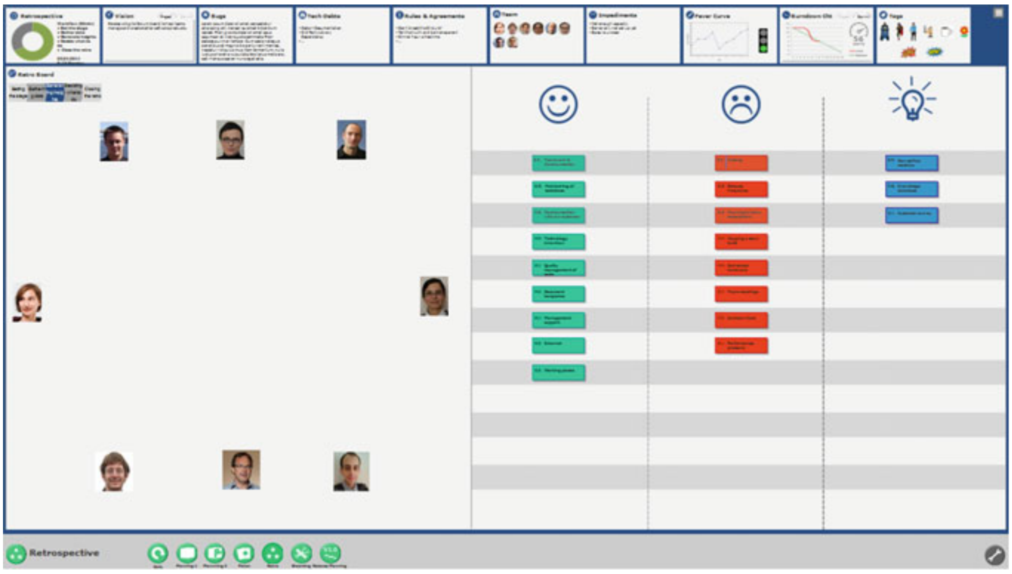

Fig. 13.6 Retrospective meeting view

Information Widgets The information view consists of a set of widgets (e.g. team widget, timer widget, burndown chart, definition-of-done widget, fun widget, avatar widget—see Figs. 13.4, 13.5 and 13.6) and can be independently configured for each Agile meeting. Each widget is designed to support distinct aspects of the collaborative Agile process. The team widget shows avatars and the names of the team members, and can be used to assign people to tasks during a daily standup meeting, for example. The timer widget supports time boxing during the meeting and can be used by the team when choosing a meeting moderator. The moderators' names are stored in the application and future moderators can be suggested based on previous selections. The fun widget allows users to post personal or fun images to the information view to help to evoke emotion from cardwall users and foster team thinking. The avatar widget can be used to drag avatars to any position on the wall or it can be attached to tasks or user stories. Both the fun and avatar widgets are designed to help with the interpersonal process in Agile teams (emotion management, team spirit). All widgets can be detached from the information view and moved around the cardwall to facilitate user interaction and ease of access (see Fig. 13.4).

Availability of Information. Any information needed for a meeting is visible and easily accessible; either on the action view or on the information view. If the team needs different supporting information, additional widgets can be switched on or off in the configuration button on the right side of the information view.

Interaction. aWall supports multi-touch and multi-user interaction. Fluid interaction with widgets and cards is enabled by gestures like tap, double tap, drag-and-drop, and pinch-to-zoom supporting changing task and user storycard position, moving widgets around on the cardwall, and changing the size of a widget. Data can be entered either on the cardwall with a virtual or physical keyboard or via the underlying issue tracker system, or mobile devices such as tablets.

Scalability of Information. The results of the field study identified that teams usually do not need to see all details at any time, since they can often remember the card content just the title, or even by its position on the board. So by default, user story cards and task cards show only minimal information in large font size (e.g. title, priority and story points). By increasing the card size with a pinch-and-zoom gesture more information is displayed. The text size increases concomitantly with the widening of the card so that information can be more easily read depending on the distance from the cardwall. When all information is shown, the widget automatically switches into edit mode, so that data can be added or modified.

13.4.4 User Study

To evaluate the design of aWall we conducted a user study with professional Agile practitioners. The main purpose of the study was to evaluate the usability of functionality in aWall, the support of the Agile workstyle, and the applicability to real life situations in Agile teams performing the daily standup and sprint planning meetings. The user study was conducted with the aWall prototype where participants had to complete various tasks with the aWall working in groups. In particular the study aimed to address the following research questions:

- How easy is it to find and manipulate information?
- Is all the necessary information available and transparent?
- Does the platform stimulate discussion and communication?
- Can the appropriate tasks be fulfilled efficiently?

13.4.4.1 Participants

We recruited 11 employees (9 men and 2 women) from the same companies that participated in our interview study [38]. Most participants had extended experience in IT (mean 11.5 years), and several of them in Agile development (mean experience 2.8 years). They worked previously in different fields and covered a wide spectrum of Agile team roles (four Scrum Masters, two Agile coaches, two senior developers, one Agile grandmaster, one UX consultant and one head of a software development department). The companies also operated in different domains (two insurance domain, one manufacturing, two service providers, one engineering, and one from an enterprise software development company). Four companies sent two employees, and three companies sent one employee each. All companies had been applying Agile processes for at least one year.

13.4.4.2 Procedure

Prior to the user study, the participants received a presentation of the interview study results, but did not receive any information about the aWall application. We divided the 11 participants randomly into two groups. Both groups completed the same tasks with the aWall. Upon signing an informed consent statement, the participants were asked to act as a team during the workshop. Each participant received three tasks to be solved together in groups using aWall. The tasks involved a daily standup meeting and a sprint planning meeting. After receiving the task, each participant read the task out aloud to the other participants and completed it with their help.

The *daily standup tasks* were to start the daily standup meeting, choose a moderator for the meeting, and update the task board during the meeting by moving tasks to the appropriate columns. The tasks were formulated as follows:

- In this team you play the role of team member Dario. aWall shows already the daily standup view. Please find the functionality to start a daily standup meeting. The application suggests a moderator. Please ask the team member suggested by the application to play the moderator. The team member is willing to take this role and starts the meeting with the meeting timer. Please act as a team according to the received instructions.
- In this team you play the role of team member Roger. You report that the task "Implement Login Dialog" has been completed. Undertake the appropriate action on the board to visualize the new state. Now you want to start the task "Write acceptance tests for login". Again, perform the appropriate action on the board to visualize the new state.
- Switch off the Fun-Widget and switch on the Impediment list widget.

The *sprint planning tasks* were to show and discuss a user story during the meeting and move the selected user story to the sprint backlog. They were formulated in the same way as the daily standup tasks.

After completing the tasks for each type of meeting the participants discussed the benefits and deficiencies of aWall for that type of meeting with their two moderators. Both workshops were conducted by two moderators and lasted one hour each, and the discussions and results were recorded.

13.4.4.3 Findings

The overall feedback for aWall was very positive, with the participants considered the prototype to be effectively usable, capable of supporting Agile processes in general, and especially capable of supporting the collaborative workstyle of Agile teams. We now present the main findings with respect to our research questions.

Size aspects. The participants especially valued the large size and high resolution of aWall. The large size supports real team collaboration capabilities, similar to physical cardwalls. Displaying large amounts of information at once was deemed positive. As one participant stated[3]:

> With the large size you can display many user stories and tasks.

Readability of information. Most participants considered the displayed information to be legible, especially since the card titles are relatively large. Some participants considered the actual cards to be too small. Therefore, it is very important to be able to display the whole content of a card and enlarge the font size so that the whole team can read it from a distance (3–5 feet). One participant stated:

> That's really a nice feature, that cards can be enlarged and font size increases to improve readability.

Availability of information. The participants especially valued the availability of additional information and functionality for the different meetings. The separation of the display into action view and information view was easily understood and valued. Some participants mentioned that elements placed on the upper side of the display wall might be out of reach for smaller people. Another participant liked the extra features:

> I like the extra features around the main view and the additional information.

Discoverability of functionality. The participants discovered most of the functionality of aWall by themselves and could easily interact with the application. There were some issues with discoverability of those functions that were not a straightforward transfer of physical cardwalls into the digital world. For example, the timer widget has no corresponding artefact in the practice of Agile teams. Whereas, direct implementations of the pin-board's functionality (e.g. the task-board shown in the daily standup meeting) were instantly understood and deemed as valuable by the participants. That was also the case for the widgets inspired from Agile practices such as the team widget which is based on the observation that Agile teams sometimes write the team members' names on the cards or even hang their pictures on the pin-boards.

Third-Party system integration. The integration with third-party tools was positively rated. Tasks modified during the daily standup meeting are immediately synchronized in the Agile project management tool (JIRA). There is no extra effort to update the tasks manually, as is typically required after a meeting using a physical cardwall. One participant stated:

> The link to JIRA with automatic update of data is important.

Flexibility and customization. Increased flexibility with respect to both the manner of conducting the meetings and the display of information was considered important by the participants. For example, the timer widget solicited choosing a moderator

[3] All quotes have been translated from German.

at the beginning of a meeting. The flexibility provided by aWall was also positively rated, especially with respect to conducting retrospective meetings that sometimes might prove strenuous. The participants considered that it is important to create a proper environment especially for this type of meeting as sometimes they tend to transmute into a drill. Most participants were in favour of a greater flexibility of the time boxing capabilities, preferring that it only optionally choose a moderator and not show the elapsed time, but the time of day during the daily meeting. The participants valued the team widget, but wanted to have more information displayed (e.g. absences, vacation days and the like) and wanted more ability to customize. Furthermore, the participants remarked that they should be able to add functionality to aWall on their own and not be dependent on standard functionality as is often the case with other Agile tools.

Agile collaborative workspace. Offering tags and avatars as well as the fun view was positively seen as bringing positive emotion into collaborations. One participant mentioned the positive effect of avoiding media disruption, because his team was able to do all of their interactions with only one medium:

> With such a board we could probably avoid media discontinuity.

Filtering and representation of information. The participants especially requested to have filter functions, to highlight and show the desired information. As an example, participants wanted to highlight all tasks of a team member when touching that person in the team view. Participants suggested using different colours for different types of user stories to increase readability (e.g. to distinguish between technical tasks, bug reports, or user requirements).

Task time recording. Some participants suggested automatically capturing the time spent on a task combined with computing the work hours on the task, which they felt would help provide further metric details of performance.

Provenance of information. Some participants suggested having automatic recordings of meetings with voice recognition and transcriptions of the discussions and the interactions in front of the display wall for later recollection and analysis of the meetings.

The user study with aWall has shown that large multi-touch wall technology combined with appropriate interaction and visualization features have the potential to provide a collaborative workspace, information transparency, direct interaction with information, as well as serve as an information radiator. We found that users especially valued the large size of the wall due to the physical space affordances, the dedicated views with context specific information, and the always visible and direct information access. A combination of these technologies and features has the potential to replace physical cardwalls in the future. We now discuss the previous cardwall usage study and guidelines with the aWall prototype.

13.5 Discussion

Cardwalls have been part of Agile software development since the beginning, and have roots in displays of index cards common in the pre-history of Agile methods, such as CRC cards [40].

Since the earliest days, there has been praise for characteristics of physical paper cards on an actual wall, emphasizing flexibility of cards and layout, scale of large walls with wide visibility and team access, as well as immediacy and speed of interaction. Studies of physical cardwalls confirmed these advantages [4, 5] and exposed the rich benefits of team use of cardwalls. In contrast, there were early cautions about digital cardwalls, with warnings about the detriments of small screens, rigid formats, and interaction limited to a single person.

As time has moved on, however, the limits of digital cardwalls have been reduced, with very large screens now commonplace, and touch surfaces allowing more than one person to interact. At the same time, use of workflow tracking systems has come to be regarded as essential, and distributed teams ubiquitous; both of these trends would be better supported by digital, rather than physical cardwalls.

Our two studies were done independently, and our two groups only began working together afterwards. The first study was done in North America, and the second in Europe. The studies explored the present and, especially together, suggest a possible future.

The present, as examined in our first study, is that many teams use a form of digital cardward, typically a display based on a workflow tracking system, such as JIRA, and typically present the Cardwall using a projector during team meetings for sprint planning and reviews. On the basis of our observations and interviews, our study identified a number of guidelines for improving the experience. The guidelines fell into several categories, repeated in the list below.

1. Cardwall Formats
2. Scaling the Design of the Cardwall
3. The Big Picture and Story Relationship Visualizations
4. Exploring and Filtering Information
5. Managing Backlogs
6. Multi-Disciplinary use of Stories
7. Updating the Cardwall

The first and second category concerned size, emphasizing flexibility, but especially the ability to scale up to sizes common in physical cardwalls and the importance of designing for team interaction. The third and fourth categories involved support for seeing the big picture and relationships: the team needs to see the situation overall, without clutter, but also needs to explore relationships and filter information. Both of these abilities support team discussions. The fifth and sixth categories identified the need to include information sometimes ignored, such as the backlog, or work that is done that is not software development work, but adds value. Finally, the seventh guideline is a reminder of the importance of synchronizing records, such as integration with workflow management systems or a distant digital cardwall.

The second study looked to a future that could begin now. The study examined the aWall system [39], which attempts to use currently available technology to create a digital cardwall to compete with physical cardwalls. The aWall prototype was designed around an array of four 46 inch 4 K (3,840 × 2,160) displays. The total display is therefore 7680 × 4320 pixels, and 92 inches diagonally. This is comparable in both resolution and size with many physical cardwalls. Moreover, the aWall uses touchscreen technology, allowing immediate and multiple simultaneous interaction.

A study of aWall involved professional developers assessing realistic Agile team tasks that require a cardwall, and the findings were positive overall. In particular, there is much alignment between comments from the participants and the guidelines identified in our first study. For example, the size and resolution receive positive comments and indicate they are sufficient for a real-world application, offering both project coverage and readability. Moreover, there were also comments on the presentation of stories on the aWall, offering an uncluttered view of the main content, but with easily discoverable features that allow exploration. The abilities for filtering were seen as very useful by participants. All these also align with guidelines from study one. Lastly, the support for other meetings was seen as important, and the integration with JIRA was praised for supporting updates from either system to maintain a shared state.

Despite our two studies being done independently, the result are strongly in alignment, and suggest the same implications: that there are certain issues that must be addressed for digital cardwalls to be successful; and that we now have both the technology and the knowledge to make that a reality. The time for digital cardwalls may now have arrived.

13.6 Conclusions

In this chapter, we presented two studies that inform the design of large multi-touch digital cardwalls for software development. Both studies were empirical. One was in the workplace and the other was conducted in a lab setting. The results of the studies were design guidelines and considerations for digital agile cardwalls.

The first study in this chapter was an ethnographic study of digital cardwall users. Observational data of teams at work and interview data was collected from 8 Scrum teams (64 participants) in Canada and the United States. The study identified the current needs of digital cardwall users and the difficulties they experienced with their digital cardwalls. The seven themes were: (1) the need for digital cardwalls to be designed for multiple formats to support different types of meetings and remote team members, (2) the need to design cardwalls that will support large projects with many stories, (3) the need for a big picture view that can also display relationships between stories, (4) the desire to explore and filter sets of stories to support decision-making, (5) the need for specialized functions for managing backlogs, (6) the potential for cardwalls to support team members in other roles, and (7) that a usability cardwall is one that updates automatically, keeping everyone up to date on the status of the work.

Guidelines for the design of large multi-touch digital cardwalls emerged from each theme. These guidelines are valuable for prioritizing the work of digital cardwall developers.

The second case study—*aWall*—presents the design and implementation of a digital cardwall for large multi-touch displays. It discusses the design considerations for the implementation, the user interface and the evaluation of the current implementation. The design considerations are based on a previous study with in-depth interviews with 8 teams (44 participants) in Switzerland [38]. *aWall* was designed with a special focus on supporting co-located and distributed Agile teams. *aWall* provides a collaborative workspace using large multi-touch displays, information transparency, direct information interaction without the need for navigation, support for the whole Agile process, and dedicated views for different types of meetings. The study we presented here evaluated aWall with 11 professional software developers from varied industries, and shows that the Agile practitioners especially valued the large-size of the wall due to the physical space affordances, the dedicated views with context-specific information, and the always visible and direct information access.

The studies show that neither physical cardwalls nor current digital cardwall tools seem to provide all affordances needed by the highly interactive and collaborative Agile software development approach, neither for co-located nor for distributed teams. On the other side, the second study seems to show that todays technology for large displays and multi-touch interactive surfaces seems to have the potential to provide the needed tools for the highly collaborative workstyle. Both studies provide basic design guidelines, but nonetheless more research work is needed.

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