Aduno: Real-Time Collaborative Work Design In A Shared Workspace

Braden Simpson, Eirini Kalliamvakou, Nathan Lambert and Daniela Damian
Department of Computer Science, University of Victoria
brsmp@acm.org, ikaliam@uvic.ca, nlambert@uvic.ca, danielad@cs.uvic.ca

Abstract—In this paper we describe the design and evaluation of Aduno, a shared workspace tool that allows distributed software teams to collaboratively establish and prioritize work items for the purposes of task management and planning during the design phase. Aduno is highly visual and real-time, offering features that are often lacking from other popular collaborative development tools. Aduno also links to Github's issue tracker and easily translates work items on a whiteboard to project work items. Here, we describe the concept and design of Aduno and present its initial evaluation.

I. INTRODUCTION & MOTIVATION

As software development has become highly distributed, teams need to coordinate for different sets of activities until they have built the end product. This creates a need for tools that support their collaboration and keep members aware of each others’ actions, to minimize disruptions in their workflow and coordination. During the earlier stages of development, developers need to establish work items to plan and organize their work around. Current tools for collaborative software development (Table I), mostly rely on text-based methods of establishing work items and handling workflow, not providing highly visualized features and not being particularly real-time.

<table>
<thead>
<tr>
<th>Similar Services</th>
<th>Real-time</th>
<th>Control of WorkItems</th>
<th>Tags</th>
<th>Visual layout</th>
<th>Chat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Github Issues</td>
<td></td>
<td>✓</td>
<td>✔</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Google Code</td>
<td></td>
<td>✓</td>
<td>-</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Jazz</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>MindMeister</td>
<td></td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Trello</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Aduno</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

TABLE I COMPARING COLLABORATIVE TOOLS

The limited visualization and real-time editing in these collaborative software development tools might still be efficient for teams that have also more informal means of communicating and negotiating work, but distributed teams mostly miss out on these direct communication methods. We hypothesize that a highly visual, real-time environment for creating and managing work items between team members, can better support developers through the design process and can produce benefits in terms of the clarification, errors and speed of this part of the work process.

We propose Aduno, a shared workspace application that enables visually creating and organizing work tasks in real time, targeted towards software development teams. Our solution originates from the basic concept of a shared whiteboard, incorporates communication and collaborative features that are present in the state-of-the-art tools developed for the same target group, and successfully supports group and workspace awareness as a collaborative basis in development projects. In line with the growing best practice of using Github as a collaborative platform for development management, Aduno supports synchronizing with Github’s issue tracker for quickly translating work items to actionable pieces of development effort. In this paper we describe the design of Aduno, as well as the expert judgement study involving eight users.

II. BACKGROUND & REQUIREMENTS

Requirements for Aduno were systematically derived from the background knowledge on CSCW applications and the features that successful groupware should provide.

In building groupware applications, effort is placed on how to support collaboration through visibility and mutual awareness. McCarthy et al.’s [1] experiments with teams collaboratively solving problems with and without a shared space, showed that the degree of disagreement is inversely related to the development of common ground within teams. Gutwin et al. [2] enhanced a shared workspace application with widgets providing activity and location information of participants and found that the add-ons provided value towards the successful completion of the tasks and the degree of awareness maintained within the team.

<table>
<thead>
<tr>
<th>Category</th>
<th>Element</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who</td>
<td>Presence</td>
<td>Is anyone in the workspace?</td>
</tr>
<tr>
<td></td>
<td>Identity</td>
<td>Who is participating? Who is that?</td>
</tr>
<tr>
<td></td>
<td>Authorship</td>
<td>Who is doing that?</td>
</tr>
<tr>
<td>What</td>
<td>Action</td>
<td>What are they doing?</td>
</tr>
<tr>
<td></td>
<td>Intention</td>
<td>What goal is that action part of?</td>
</tr>
<tr>
<td></td>
<td>Artifact</td>
<td>What object are they working on?</td>
</tr>
<tr>
<td>Where</td>
<td>Location</td>
<td>Where are they working?</td>
</tr>
<tr>
<td></td>
<td>Gaze</td>
<td>Where are they looking?</td>
</tr>
<tr>
<td></td>
<td>View</td>
<td>Where can they see?</td>
</tr>
<tr>
<td></td>
<td>Reach</td>
<td>Where can they reach?</td>
</tr>
</tbody>
</table>

TABLE II ELEMENTS OF WORKSPACE AWARENESS FROM [3]

Gutwin & Greenberg [3] produced a conceptual framework of the information required for workspace awareness (Table II) with the basic elements coming from answering the questions of “who, what and where”. These elements make up
workspace awareness and although in a physical setting they are easy to attain, they need to be explicitly supported in groupware applications. Designers of collaborative tools need to account for workspace awareness through the features they offer and help a collaborating team establish and maintain common ground to ensure a successful result.

Tools that support web-based collaborative work that is real-time are a definite trend today, enabling teams to achieve common ground fast, and coordinate of others’ actions more effectively, and coordinate more smoothly. Google Docs, a web-based text, spreadsheet, presentation, and form editor, with data storage from Google, is only one successful example. Google Docs [4] is a truly collaborative tool for document editing, allowing sharing and editing by multiple users at the same time. The design features offered by Google Docs are awareness solutions that allow collaborators to have real-time information about others’ activities and location in the form of remote cursors, participant lists, revision history, etc.

Distributed software development teams face the same challenges of distributed collaboration in terms of grounding and maintaining workspace awareness. Especially during the initial stages of a software development project, effort is required to define and prioritize work items as well as assign or negotiate who is responsible for what. As distributed teams aim towards leaner organizational structures and modularized work items to overcome some of the challenges of distribution [5], [6], [7], tools that enable teams to define work items collaboratively, as a starting point for their development work, are essential. The underlying rationale here is that the modularity of the product design will decide the modularity of the work tasks and if this process can be as transparent and as commonly agreed upon as possible in the project, it will set the stage for smoother coordination down the road.

Based on this background knowledge, the design of Aduno is aimed towards supporting distributed teams during the design phase when work item creation and management are crucial. Our goal is to implement features that visually provide workspace awareness to team members, and embed them on a web-based infrastructure to allow for real-time collaboration. Aduno also promotes a more flat and flexible team structure, allowing team members to negotiate and establish roles through self-organization by working on specific work items, or outside the tool.

III. ADUNO: FEATURES AND DESIGN

A. Aduno’s functionality

Aduno offers a shared workspace where a software development team with a Github-hosted project, can collaboratively manipulate their workflow using visual components. Teams can sign in with their Github account details and access their repositories, and Aduno imports the project’s issues on the workspace in the form of work items. Users can create, edit, link, and move around work items to organize their joint actions, and coordinate about them by communicating through the tool’s chat area. In real-time users can also see all changes that other team members are making on the work board and Aduno’s visual layout allows them to maintain workspace awareness. The contents of the work board can then be exported to Github’s issue tracker, integrated directly into the team’s workflow.

The functionality offered by Aduno is mostly targeted towards the initial stages of a software project’s life cycle, when task management activities are more intense. Identifying, creating, and linking tasks in a real-time manner that makes the whole group aware of the process, while leaving room for task negotiation since it is done collaboratively, brings benefit to all users involved in the software development project, from the project manager to the developer. Once work items are in the project’s issue tracker then the team can smoothly begin their coding tasks. Aduno proposes enhancements on two levels of collaborative work design for software development; creating a real-time collaborative environment and making use of a highly visual interface.

The tool supports the following areas of functionality:

- **Team communication and coordination**
- **Synchronization to Github & Workflow management**
- **Organization of work items on a work board**

**Team communication and coordination** is an integral part of the software development process and a challenge whenever collaborating teams are distributed. Although typically project management systems allow comments on issues, we have included a chat area in Aduno as a secondary communication channel allowing developers to engage in a synchronous discussion about work items, maximizing cohesion. **Synchronization to Github** allows users to sign in Aduno with their Github credentials and have all their repositories and respective issues in place for workflow management without switching environments. “Sync” indicators signal edits in work items and the user can just click and synchronize. Finally, users have the ability to **organize work items on the work board**, a particularly important feature, as in other services work items are displayed in a list without any notion of priority. A visual representation of the links provides a complete view of the related work items. Allowing users to move the work items around on the work board enables arranging them in whatever context is appropriate and ordering them accordingly.

**B. Maintaining workspace awareness**

Aduno’s design follows Gutwin’s & Greenberg’s [3] framework of information to support workspace awareness for real-time groupware. The framework is intended to aid the design of real-time groupware, is tested through different theories and observational studies, and targets real-time distributed groupware, shared workspaces and both generational and execution tasks. Referring back to Table II, awareness relating to the “Who” category sets the aim for groupware to provide information of others present in the workspace and who they are, while authorship information maps an action to the person performing it. Regarding the “What” category, a tool must successfully communicate information about what other users are working on, either in detail or in general. Aduno’s features
cover these two categories, fulfilling the requirements for real-time groupware supporting awareness. Information relating to the “Where” category, is intended for large workspaces and better fitted to construction tasks, such as the one discussed in [2]. To this end, they are not explicitly part of Aduno’s design. However, location and gaze information can be inferred by the work items a user is moving around the workspace.

Aduno’s work board features a navigation bar showing currently online users, thus satisfying the presence element of workspace awareness. Unique badges show up when users are modifying items, satisfying the framework’s requirement for authorship and artifact information. The system of unique user badges and colors establishes the user identity while, once user action is performed on a work item, the changes are propagated in real time to all other connected clients. Authorship is provided by user badges and work item history.

Readers are strongly encouraged to look at our information page\(^1\) for a comprehensive tool screenshot with comments and/or experiment with Aduno\(^2\).

IV. EVALUATION & RESULTS

To evaluate Aduno’s usability and fit for the intended use, we carried out an expert judgement study involving eight users, forming four pairs. The participants had on average four years of experience in distributed software development and have participated in multiple collaborative projects.

A. Setup & Questionnaire

The experts were invited to participate in the evaluation session and were randomly assigned to pairs. In each evaluation session, the experts were given a short demonstration of the tool’s features and the shared workspace layout. Following that, participants were given a short description and high-level requirements for a fictional website they would have to build in collaboration and were asked to use the tool to define and link work items. The experts were not allowed to communicate outside the tool, as a way to account for them being distributed. For the final part of the evaluation session, experts were given a short questionnaire to fill out, evaluating the tool’s fulfillment of its purpose as well as its potential impact on a project.

The questionnaire’s design was guided by insights from literature regarding collaborative behaviours that should be successfully supported by CSCW applications. Clark [8] defined eight behaviors for collaboratively carrying out joint actions:

- **Connection** – locating with whom to collaborate and how to contact them
- **Transmission** – sending a message
- **Notification** – alerting the intended party of an incoming transmission
- **Identification** – designating the sender, receiver, and subject of a transmission
- **Common Ground Preservation** – establishing and maintaining a shared context and meanings in transmissions
- **Confirmation** – notifying the sender of a transmission that it has been received
- **Synchronization** – orchestrating actions to facilitate joint action
- **Election** – group process of selecting among alternatives

Thompson [9] defined three types of coordination, standardized, planned and mutual adjustment. Software development fits under the latter type of coordination, which includes all collaboration behaviors. As a result, tools such as Aduno, aimed towards supporting this kind of tasks, must include features that cover the respective behaviors. To account for this during the evaluation, the questionnaire was designed to check how well these behaviours were supported.

Readers are encouraged to examine the questionnaire used for the evaluation online\(^3\). In the first section, experts gave information about their development experience, tools they use for task creation and management, and indicated whether they have so far experienced difficulties with managing work tasks in previous projects. The experts were then asked to rate Aduno’s usefulness and ease to use, learn, and integrate with their current workflow. 5-point Likert-like scale were used for rating, ranging from “Not useful” to “Very useful” and “Not Easy” to “Very Easy” respectively. The experts were then asked to rate the importance of Clark’s [8] eight collaborative behaviours for software development, and their satisfaction by Aduno’s support for them. Importance and satisfaction were rated on a 5-point Likert scale ranging from “Trivial” to “Critical” for importance, and “Not satisfied” to “Fully satisfied” for satisfaction. Finally, experts were asked to describe their expectations for Aduno in terms of impact on team productivity, as well as challenges expected for their workflow. Participants could also suggest future improvements and/or development areas for Aduno.

B. Results

Overall, Aduno impressed the experts and received positive feedback (Table III). Aduno was considered a useful tool, receiving its highest score for visualizing work items. The experts also appreciated how easy Aduno is to learn (4.75 mean), use (4 mean), and integrate into their current workflow (3.875 mean).

Experts assigned their highest importance ranking to the responsivenes of the application (4.5 mean), relating back to the requirement for real-time environments. Maintaining awareness and sharing an information space were also ranked as very important elements for collaborative software development tasks with a mean of 4.375. Given the frameworks we reviewed in Section II, this is not a surprising demand for a CSCW tool. At the same time Aduno also scored high in terms of the experts’ satisfaction with supporting the latter two elements, as shown by the respective means. The lower score of 2.74 obtained by Aduno with regard to responsivenes mostly relates to the choice of architecture and infrastructure.

\(^{1}\)bradens.github.com/Aduno

\(^{2}\)http://aduno.meteor.com/

\(^{3}\)http://segal.uvic.ca/resources/Aduno_survey.pdf
Support for larger teams is a crucial feature for Aduno that will be addressed in the tool’s ongoing development. The implementation could include a zoomable work board, which could act as a map that can be scrolled and interacted with.

B. Evaluation

We plan a more extensive evaluation of Aduno in terms of user engagement, and a quantitative analysis to assess the impact of Aduno’s use on a team’s speed and the need for clarification. We essentially want to answer the research question:

Can we effectively use real-time collaborative tools for task management in distributed software development?

Since Aduno helps the team collaboratively define and link work items, especially during the initial stages of the project, we expect less time spent for clarifications in later stages of development and an increase in development speed associated with that. Our research question breaks into the following two questions:

Does the use of real-time collaborative tools for task management in the design phase speed up the following stages of development?

Does the use of real-time collaborative tools for task management in the design phase lead to fewer clarification requests in the following stages of development?

Aduno aims towards consistently supporting the development team through their design work and, as a result, minimize the timespan for clarification activities and increase their productivity. We plan to design a field study around these two research questions, using geographically distributed teams.

TABLE III

<table>
<thead>
<tr>
<th>Collaborative Behaviours</th>
<th>Mean</th>
<th>Median</th>
<th>St. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visualizing work items</td>
<td>4.125</td>
<td>4</td>
<td>0.83</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>3.375</td>
<td>4</td>
<td>1.19</td>
</tr>
<tr>
<td>Translating ideas to actionable items</td>
<td>4</td>
<td>4</td>
<td>1.07</td>
</tr>
<tr>
<td>Easy to use</td>
<td>4</td>
<td>4</td>
<td>0.75</td>
</tr>
<tr>
<td>Easy to learn</td>
<td>4.75</td>
<td>5</td>
<td>0.46</td>
</tr>
<tr>
<td>Easy to integrate with current workflow</td>
<td>3.875</td>
<td>4</td>
<td>0.83</td>
</tr>
</tbody>
</table>

The remaining two experts recognized Aduno’s potential but would like it to cater to larger groups and be more explicit with milestones to have a strong positive effect.

Regarding challenges, the experts were only concerned with the scalability of Aduno and whether it will be able to support large groups and a large number of work items. Participants were also asked to provide suggestions and improvements for future development on Aduno, discussed below.

V. Future Work

Future work for Aduno will be carried out on two levels: extending the tool’s features based on the experts’ feedback, and carrying out a quantitative evaluation.

A. Development

Aduno’s evaluation through an expert study provided focused and detailed feedback and highlighted new features. Apart from small user interface improvement suggestions, the main points of interest were more robust support for large number of work items, stronger chat features, and more robust API mapping to Github. The future work on Aduno will include a significant amount of development in these areas, as well as potentially interfacing the backend with other project management services. Due to the modular design of the Aduno API, the developers can easily plug in new services.


table

### TABLE III

<table>
<thead>
<tr>
<th>Collaborative Behaviours</th>
<th>Mean</th>
<th>Median</th>
<th>St. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visualizing work items</td>
<td>4.125</td>
<td>4</td>
<td>0.83</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>3.375</td>
<td>4</td>
<td>1.19</td>
</tr>
<tr>
<td>Translating ideas to actionable items</td>
<td>4</td>
<td>4</td>
<td>1.07</td>
</tr>
<tr>
<td>Easy to use</td>
<td>4</td>
<td>4</td>
<td>0.75</td>
</tr>
<tr>
<td>Easy to learn</td>
<td>4.75</td>
<td>5</td>
<td>0.46</td>
</tr>
<tr>
<td>Easy to integrate with current workflow</td>
<td>3.875</td>
<td>4</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Support for larger teams is a crucial feature for Aduno that will be addressed in the tool’s ongoing development. The implementation could include a zoomable work board, which could act as a map that can be scrolled and interacted with.

B. Evaluation

We plan a more extensive evaluation of Aduno in terms of user engagement, and a quantitative analysis to assess the impact of Aduno’s use on a team’s speed and the need for clarification. We essentially want to answer the research question:

Can we effectively use real-time collaborative tools for task management in distributed software development?

Since Aduno helps the team collaboratively define and link work items, especially during the initial stages of the project, we expect less time spent for clarifications in later stages of development and an increase in development speed associated with that. Our research question breaks into the following two questions:

Does the use of real-time collaborative tools for task management in the design phase speed up the following stages of development?

Does the use of real-time collaborative tools for task management in the design phase lead to fewer clarification requests in the following stages of development?

Aduno aims towards consistently supporting the development team through their design work and, as a result, minimize the timespan for clarification activities and increase their productivity. We plan to design a field study around these two research questions, using geographically distributed teams.

### TABLE III

<table>
<thead>
<tr>
<th>Collaborative Behaviours</th>
<th>Mean</th>
<th>Median</th>
<th>St. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visualizing work items</td>
<td>4.125</td>
<td>4</td>
<td>0.83</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>3.375</td>
<td>4</td>
<td>1.19</td>
</tr>
<tr>
<td>Translating ideas to actionable items</td>
<td>4</td>
<td>4</td>
<td>1.07</td>
</tr>
<tr>
<td>Easy to use</td>
<td>4</td>
<td>4</td>
<td>0.75</td>
</tr>
<tr>
<td>Easy to learn</td>
<td>4.75</td>
<td>5</td>
<td>0.46</td>
</tr>
<tr>
<td>Easy to integrate with current workflow</td>
<td>3.875</td>
<td>4</td>
<td>0.83</td>
</tr>
</tbody>
</table>

The remaining two experts recognized Aduno’s potential but would like it to cater to larger groups and be more explicit with milestones to have a strong positive effect.

Regarding challenges, the experts were only concerned with the scalability of Aduno and whether it will be able to support large groups and a large number of work items. Participants were also asked to provide suggestions and improvements for future development on Aduno, discussed below.

V. Future Work

Future work for Aduno will be carried out on two levels: extending the tool’s features based on the experts’ feedback, and carrying out a quantitative evaluation.

A. Development

Aduno’s evaluation through an expert study provided focused and detailed feedback and highlighted new features. Apart from small user interface improvement suggestions, the main points of interest were more robust support for large number of work items, stronger chat features, and more robust API mapping to Github. The future work on Aduno will include a significant amount of development in these areas, as well as potentially interfacing the backend with other project management services. Due to the modular design of the Aduno API, the developers can easily plug in new services.

Support for larger teams is a crucial feature for Aduno that will be addressed in the tool’s ongoing development. The implementation could include a zoomable work board, which could act as a map that can be scrolled and interacted with.

B. Evaluation

We plan a more extensive evaluation of Aduno in terms of user engagement, and a quantitative analysis to assess the impact of Aduno’s use on a team’s speed and the need for clarification. We essentially want to answer the research question:

Can we effectively use real-time collaborative tools for task management in distributed software development?

Since Aduno helps the team collaboratively define and link work items, especially during the initial stages of the project, we expect less time spent for clarifications in later stages of development and an increase in development speed associated with that. Our research question breaks into the following two questions:

Does the use of real-time collaborative tools for task management in the design phase speed up the following stages of development?

Does the use of real-time collaborative tools for task management in the design phase lead to fewer clarification requests in the following stages of development?

Aduno aims towards consistently supporting the development team through their design work and, as a result, minimize the timespan for clarification activities and increase their productivity. We plan to design a field study around these two research questions, using geographically distributed teams.

### REFERENCES


