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Using Email to Facilitate Wiki-based, Coordinated Collaborative Authoring

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ABSTRACT

Dandelion is a wiki-based tool that supports coordinated, collaborative authoring. In this paper, we present an extended version of Dandelion, which provides an email interface for users to accomplish their tasks by email in a coordinated, collaborative authoring process. Specifically, Dandelion employs a semi-structured, template-based approach that allows users to use templates to specify their requests in email. These emailed requests can be interpreted by Dandelion and the interpretation results are then used to automatically drive the collaboration flow. As part of its actions, Dandelion also automatically creates a wiki page and dynamically updates it to record co-authoring tasks and collate co-authored content. As a result, users can use their familiar tool (email) to accomplish their tasks in a co-authoring process, while leveraging a wiki for additional benefits (e.g., collaboration awareness and document editing). Our preliminary study with two groups of users shows the usefulness of both Dandelion email and wiki features and their impact on collaboration effectiveness.

Author Keywords

Coordination, collaboration, co-authoring, email, wiki

1 INTRODUCTION

Wiki is a commonly used collaborative authoring tool. For example, a sales team may use a wiki to keep track of the team's sales leads and status, while a group of software developers may use a wiki to post their development schedule and progress. In a business setting, collaborative authoring often requires coordination, including assigning authors to specific sections and managing their progresses [4]. However, regular wikis do not directly support coordinated, collaborative authoring [4]. We thus have built a tool, called Dandelion, on top of a wiki to support a coordinated co-authoring process [4]. Specifically, Dandelion uses a tag-based approach to support two key user roles and their respective tasks in such a process. First, it supports the role of a *coordinator* or *lead author*, who can insert tags in a wiki page to specify co-authoring tasks. Second, it supports the role of a *participant*, who is a co-author invited by a coordinator to write designated sections of a wiki. The user-inserted tags can be executed by Dandelion to automatically drive the collaboration workflow (e.g., notifying co-authors about their tasks), and provide collaboration awareness for all the collaborators (e.g., co-authoring task status).

Although we successfully deployed Dandelion wiki in our company with several groups of dedicated users early on [4], we found that after a while most of the users abandoned Dandelion. We followed up with these users and learned that they reverted to email for their tasks for a similar reason. Like any wikis, Dandelion wiki is not part of their typical work practice [12]. To use Dandelion wiki, they have to interrupt their normal work flow and take an extra step. This includes going to the wiki site, logging on, and then performing their tasks in the wiki, such as assigning authoring tasks or inputting content. On the other hand, these users live in their email [3, 20]. As part of their routine work, not only do they use emails for communication
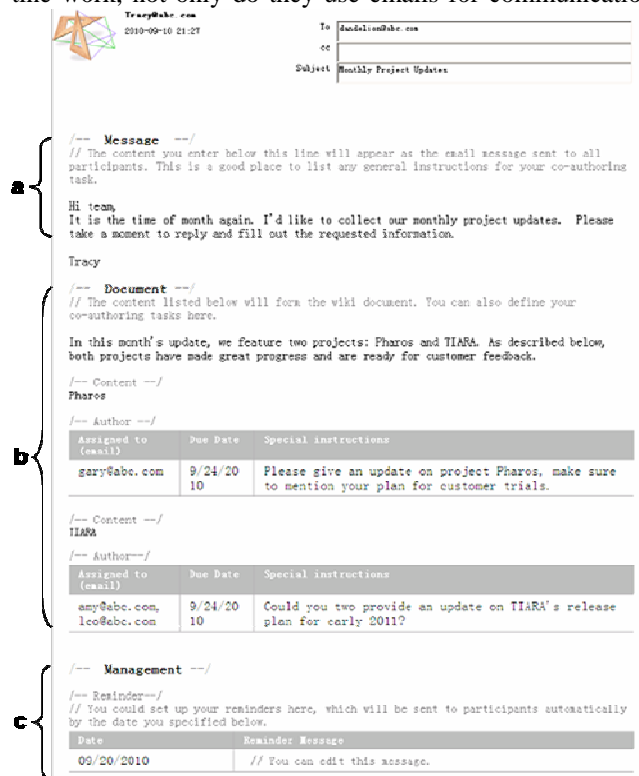

Figure 1. A partially filled email template for a coordinator (Tracy) to launch a collaborative authoring process: (a) Tracy's general message to all the co-authors, (b) a filled template for defining a set of co-authoring tasks, and (c) a filled template for setting up a reminder to help manage the co-authoring process.

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[21], but also use emails to perform a wide range of tasks, including team coordination [9], information sharing, and requesting actions [7].

While email provides a flexible and easily approachable means for these users, they did state several pain points in using regular email tool for coordinated, collaborative authoring tasks. First, it is laborious for a coordinator to manually track the responses from different contributors, monitor the overall status, and collate the individual responses into a final document. Second, it requires additional effort for the coordinator to share the synthesized results, which are often kept in a personal inbox or in a Word document, with the co-authors, let alone allowing them to easily modify or update their responses. Third, it is also difficult for participants to be aware of each other's progress, thus affecting their collaboration efficiency [13].

To address user frustrations described above, we have explored the opportunity of combining email and wiki to leverage both their benefits but avoid their weaknesses. Since completely redesigning an existing email system [10] is a daunting task, we have extended Dandelion wiki with an email module to facilitate coordinated, collaborative authoring. In particular, Dandelion employs a semi-structured, template-based approach, which allows users to use templates to specify their requests in email (e.g., assigning co-authoring tasks in Figure 1 and submitting a response in Figure 2). These emailed requests can be then be interpreted by Dandelion to automatically drive the collaboration flow (e.g., notifying co-authors about their tasks or extracting a co-author's response from an email). As part of its actions, Dandelion also automatically creates a wiki page to record all co-authoring tasks and co-authored content (Figure 3). The wiki page may be updated by both users and Dandelion.

Figure 2. An email reply sent by a participant (Gary) to respond to his co-authoring assignment. (a) Gary's general message, (b) Dandelion-generated email notification, (c) Gary's input for the requested content.
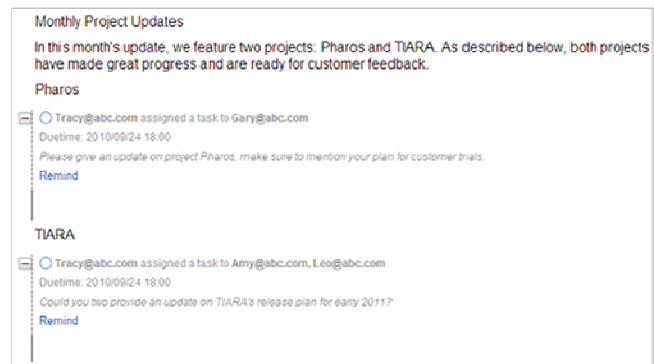
Figure 3. Dandelion-generated wiki page recording the co-authoring tasks and co-authored content collected from an email message.

For example, Dandelion can extract a user's response from his email (Figure 2), and uses it to update the corresponding wiki section (e.g., the Pharos section in Figure 3).

As a result, with the help of Dandelion, users can complete their co-authoring tasks by email with much less required manual effort (e.g., monitoring the progress and collating multiple responses). Furthermore, users can leverage the Dandelion-created wiki to access the co-authored content and perform additional tasks (e.g., content formatting). As a shared work space, the wiki also provides all collaborators with the desired collaboration awareness.

To the best of our knowledge, there are few efforts that tightly couple email and wiki to maximize the value of both. Our work thus offers two unique contributions:

- We present a general solution to integrating email and wiki. Our solution not only allows users to employ their familiar tools (email) to accomplish collaborative tasks (in our case, co-authoring), but it also helps users adopt new tools (wiki) for added benefits (e.g., a shared workspace offering collaboration awareness and easy information sharing/update).

- We develop a semi-structured, template-based approach to email understanding, which can be used to drive a collaborative authoring workflow *automatically*, greatly reducing human manual effort often required in an email-driven process (e.g., synthesis of co-authors' input).

In the rest of the paper, we first briefly discuss the related work. We then use a sample scenario to explain how the current version of Dandelion (email + wiki) can be used to achieve a collaborative authoring task. Finally, we present our approach and a preliminary evaluation.

2 RELATED WORK
There are numerous research efforts on extending wiki or email, respectively, to support collaborative tasks.

Our current work is most related to the effort of extending wikis in support of collaborative task management. For example, the previous version of Dandelion uses a tag-based approach to augment a wiki to support coordinated,
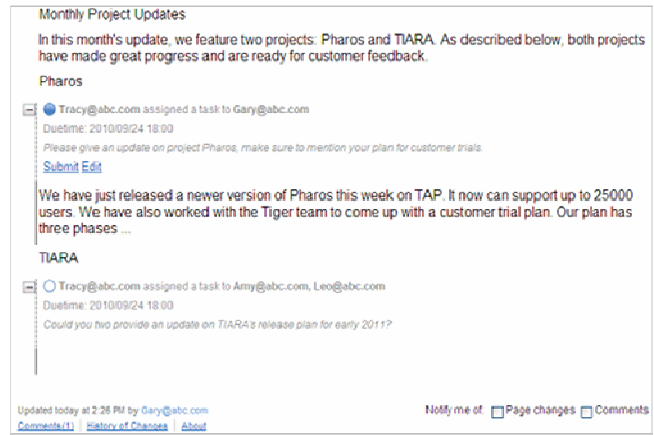
collaborative authoring within a wiki page [4]. In that version, Dandelion uses email only as a notification mechanism (e.g., notifying co-authors about their designated authoring tasks), but not an interaction channel (e.g., allowing co-authors to submit their input by email). In contrast, the extended version of Dandelion described in this paper allows the lead author and co-authors to initiate and accomplish the co-authoring tasks by email.

TaskDock [18] is a wiki extension on top of Confluence [6], which allows users to create a task from a wiki page to request co-author actions, including commenting on a page, and uploading an attachment to the page. In addition, TaskDock allows users to add comments or attachments to a wiki page directly via email. Since TaskDoc supports only page-level tasks, it does not support co-authoring tasks *within* a page (e.g., authoring or commenting on a particular section) as Dandelion does. As a result, users of TaskDoc must switch to wiki for content editing. In comparison, Dandelion currently supports finer-grained co-authoring tasks via email (e.g., emailing one's input and comments for a specific section of a wiki page).

In parallel, researchers have extended email systems to better support task management [e.g. 2, 10, 22]. For example, Bellotti et al. [2] developed Taskmaster that redesigns an email system as a task manager to help users handle various tasks specified via email (e.g., information or action request). While Taskmaster focuses on enhancing email alone, Dandelion is on exploring and leveraging the synergy between email and wiki.

Our work is also related to semantic email [15], which proposes to use an ontology to help process and understand one's email messages and act upon them (e.g., synthesizing responses extracted from multiple email messages). However, it requires domain knowledge and complex reasoning to process each email. It is thus a challenge to apply semantic email robustly to emails in different application domains (e.g., legal versus healthcare). In contrast, we ask users to use a semi-structured, human-readable template to submit their email input (e.g., initiating a co-authoring task or submitting requested information). Although our approach is limited in terms of understanding the semantics of one's email messages, it is adequate and robust in support of collaborative authoring tasks.

There is also a big body of work on developing intelligent technologies for automatically processing emails and extracting information from the email messages to aid people in their work. For example, Cohen et al. have developed methods to classify email according to its attention [5]. There are also approaches to automatically sorting emails into folders [16], creating a summarization of multiple emails [19], and detecting user tasks from email messages [17]. While our work can certainly leverage these advanced NLP and machine learning technologies to enhance Dandelion's email interpretation capability, our current goal is to

Figure 4. Dandelion-updated wiki page showing one of the co-author's (Gary) input extracted from an email.

support collaborative authoring processes robustly in real world scenarios using practical and extensible approaches.

3 SAMPLE SCENARIO: REPORT GENERATION
Here, we use a concrete scenario to explain how Dandelion helps a team complete a collaborative authoring task.

Tracy is a manager of an IT department. At the end of each month, she needs to create a monthly project report for her project sponsors. Now it is time to compose the September monthly report. Tracy uses Dandelion to co-author the report with three of her project leads. She starts by using Dandelion-provided email templates to compose a new email. She first inserts a message template, where she could enter a customized, general message to her co-authors (Figure 1a). Next, she uses a template to define a set of co-authoring tasks (Figure 1b). In this template, Tracy specifies the content to be authored (preceded by delimiter /-- Content --/) and the designated co-author (preceded by /-- Author --/). She also includes her own input (e.g., between the delimiters /-- Content --/ and /-- Author --/). For each co-author, she specifies the author's email address, due time, and her special instruction to the author. To make sure that her co-authors submit their input on time, Tracy uses a reminder template to set up a reminder (Figure 1c), which will be automatically sent to the co-authors on September 20th if they have not submitted their input by then.

After filling in the template, Tracy emails it to Dandelion. Upon receiving Tracy's email, Dandelion processes it and acts upon it. First, it uses the information extracted from the email to automatically create a Dandelion wiki page (Figure 2). The generated wiki page includes Tracy-authored content and the skeleton of the sections to be authored by the three project leads, respectively. To provide desired collaboration awareness, each section is also tagged with various meta information, including its designated author, due time, Tracy's instruction, and the task status [4]. After creating the wiki page, Dandelion then sends a notification email to each of the co-authors (i.e., Gary, Amy and Leo).

Figure 2(b) shows the Dandelion notification email received by one of the co-authors, Gary. Dandelion also sets up a reminder as Tracy requested in her email (Figure 1c).

Gary decides to send his project update directly by email. To do so, he simply replies to the notification email that he received from Dandelion. His reply includes two parts: a short comment (Figure 2a) and the actual update (Figure 2c). After receiving Gary's reply, Dandelion extracts Gary's comment as well as his project update, and updates the wiki page accordingly (Figure 4). Accordingly, the task status for Gary is also updated and marked as "Finished".

It is now September 20th. Dandelion detects that Amy/Leo has not submitted their project updates yet. Using Tracy's reminder setting, Dandelion emails Amy/Leo a reminder message. After sending Amy the reminder, Dandelion also emails Tracy a status report to keep her updated about who has or has not finished their tasks and a snapshot of the report composed so far (Figure 6).

In summary, Tracy and her team members are able to use Dandelion to initiate and participant in a co-authoring task by email. Moreover, the co-authored results with meta information (e.g., author information and comments) are automatically captured in a wiki page to facilitate information sharing, retrieval, and update.

4 OUR APPROACH

As mentioned earlier, Dandelion is designed to support the tasks of both coordinators and participants in a coordinated, collaborative authoring process. Our initial version of Dandelion required both coordinators and participants to work directly in a wiki to accomplish their tasks. To help users especially those who live in email, our current focus of Dandelion is to let the users perform their tasks by email whenever possible. To achieve this goal, we have extended the initial version of Dandelion with an email module. In this section, we first give an overview of the extended Dandelion. We then describe in detail how Dandelion uses both email and wiki to support the key user tasks in a coordinated, collaborative authoring process.

4.1 Overview

As shown in Figure 5, Dandelion has two main modules: an email module and a wiki module. The *email module* is built on top of an existing email system to support email interaction between a user and Dandelion. It has two components, a *front-end* component that supports a user to compose a Dandelion-understood email, and a *back-end* component that processes a user's email messages. On the other hand, the *wiki* module supports user interactions with a wiki. As described in [4], Dandelion wiki is an extension on top of a regular wiki to support a coordinated, co-authoring process (e.g., granting a co-author permission to edit a particular wiki section and updating co-authoring task status).

Since we have described the Dandelion wiki module previously [4], here we focus on its email module. Currently,

Dandelion supports the three most critical user interactions[1] in a coordinated, collaborative authoring process by email: (1) launching a collaborative authoring process, (2) responding to a co-authoring task, and (3) managing the co-authoring process. First, a coordinator can launch a collaborative authoring process by email. Specifically, she defines a set of co-authoring tasks in an email. Upon receiving such an email, Dandelion automatically creates a wiki page and emails all the co-authors about their respective tasks. Second, a participant can respond to his assigned co-authoring task by email. Specifically, the participant can just include the requested content in his reply to the email notification from Dandelion. Dandelion can then extract the submitted content to update the wiki. In case where the participant decides to reject or delegate the task, Dandelion forwards such responses to the coordinator for her decision[2]. As indicated in Figure 5, in all three interaction flows, the coordinator will also receive email notifications from Dandelion to be kept in the loop (e.g., being aware of co-authoring tasks assigned or reminders sent)

Third, the coordinator can also manage the collaborative authoring process by email. She can specify various management actions, including reminding and removing a co-author. Per the coordinator's email request, Dandelion can then act upon on her behalf.

As described above, the common challenge in support of the three user interactions is that Dandelion must understand a user's email message (e.g., specifying co-authoring tasks) and act upon it (e.g., creating a wiki page and notifying co-authors). As natural language (NL) understanding technologies are far from perfect and task specifications could be inherently complex (e.g., defining multiple co-authoring tasks), it would be very difficult if not impossible for Dandelion to process users' free text input in an email. On the other hand, if the input format is too restricted (e.g., allowing only typed values), it may be difficult for users to express they requests flexibly (e.g., the instruction to a co-author). To meet the needs of both users and computers, we are inspired by Malone et al. [14] to support semi-structured email input. Specifically, we have designed a set of semi-structured email templates for users to specify their intended tasks. Following these templates, Dandelion can interpret a user's email message and use it to drive the collaboration authoring process.

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[1] There is a fourth user interaction in a coordinated, collaborative co-authoring process: a coordinator writes/edits part of content. However, it is difficult and unnatural for someone to specify fine-grained content authoring/editing requests (e.g., editing specific sentences) by email especially after a version of a document already exists. Currently, a coordinator can only input her content by email as part of the launch process (e.g., Figure 1b). Otherwise, she must use the wiki to edit the existing content or add new content.

[2] To minimize the change of an email client, currently we do not embed GUI controls in an email to solicit user response, e.g., using a check list to ask a participant to indicate whether they accept or reject the task.

Next, we describe in detail how we support each type of the user interaction in such a process.

4.2 Launching Collaborative Authoring

As described above, a coordinator's main task is to launch a collaborative authoring process by defining a set of co-authoring assignments. In this section, we describe how we use an email template to capture the key elements of a co-authoring assignment and how Dandelion responds to such an email request.

Email Templates for Defining Co-Authoring Tasks

In general, defining a co-authoring task requires four basic elements: content, author, due time, and instruction. *Content* is the information to be authored by a designated participant (e.g., Figure 1b). In some cases, the coordinator may provide part of the content (Figure 1b). Moreover, the *content* may specify multiple items to be authored. When composing an employee assessment report, for example, a coordinator may ask his co-authors to supply multiple pieces of data, including employee name, band level, and performance rating. The *Author* field is an id (i.e., email address) that can be used to uniquely identify a co-author. There are two additional fields, one to specify the *due time* of the task and another to record the coordinator's *instruction* to the co-author.

In practice, users may also use different combinations of the elements to define different types of co-authoring tasks. For example, Tracy (coordinator) defines two co-authoring tasks in Figure 1. The first task ("Pharos") has one author assigned, while the second one ("TIARA") has two authors appointed. To cover various types of co-authoring tasks, we have examined hundreds of existing wiki co-authoring practices (including those using Dandelion). From our observation, there are two most commonly used co-authoring tasks:

Type 1: [Content, Author, dueTime, Instruction]
Type 2: [Content, [<Author>+, dueTime, Instruction]+]

Here, *Type 1* specifies one author per task, while *Type 2* defines multiple authors per task with or without the same due time or instructions. Since *Type 1* can be considered a special case of *Type 2*, we further generalize *Type 2* to define multiple co-authoring tasks:

[Content, [<Author>+, dueTime, Instruction]+]+   (1)

Formula 1 now is a very general template and can be used to capture all the co-authoring tasks that we have observed.

As represented by Formula 1, the information captured by this template can be potentially very complex, including multiple co-authoring tasks with different compositions of the elements. To help users fill in this template and help Dandelion process the filled in information, we decide to use a combination of tables and text blocks to represent this email template. In particular, we use tables to represent simple and deterministic information, while encoding complex content in text blocks. As shown in Figure 1(b), the content to be authored is in a text block and the author in-

formation is represented in a table. Here, the tabular form would allow Dandelion to easily process and extract the needed content, while the text block is natural for a user to follow the text flow. Note that we also considered using a table to represent the entire template. However, the table structure could become quite complex due to the structure of complex co-authoring tasks (e.g., multiple but different types of co-authoring tasks). This would reduce Dandelion's capability of understanding the email. On the other hand, we did not want to represent all the information in text blocks either, as it will introduce too many delimiters which could distract users from reading the real content.

Validating Email of Defining Co-Authoring Tasks

Using the above template, a coordinator can easily specify a set of co-authoring tasks in an email. However, users may make mistakes when filling in such a template (e.g., entering an invalid email address for a co-author). Correcting these mistakes would require additional email interactions between the user and Dandelion. Given Dandelion's limited understanding of a human email message, this may cause even more mistakes and user frustration. To address these issues, we allow a coordinator to interactively validate her email before sending it to Dandelion so that user mistakes can be caught and rectified *before* an unwanted or erroneous email is sent. Validating an email message in this case is simple, since it just needs to check the validity of each filed (e.g., email ids and a valid due time).

Handling Email Containing Co-authoring Tasks

Following the template format, it is straightforward for Dandelion to parse a coordinator's email to extract co-authoring tasks. Using the extracted information, Dandelion does two things. First, it creates a Dandelion wiki page, which contains the content that the coordinator has authored and the content to be co-authored. It also uses the extracted information to create and insert a set of task tags (e.g., co-authors, due time, and task status) in the wiki. As described in [4], these task tags not only are useful for driving the collaboration flow but are also for providing collaboration awareness. Second, Dandelion composes a set of notification emails to be sent to all the participants.

4.3 Responding to Co-Authoring Tasks

In a collaborative authoring process, a participant's main and only task is to respond to his co-authoring assignment. The assignment email that a participant receives from Dandelion has two parts. The first part is a general message wrote by the coordinator to provide the participant with some context about the assignment (e.g., Tracy's message to Gary in Figure 2b). The second part is the actual assignment defined by the coordinator (e.g., the part below Tracy's general message in Figure 2b).

When receiving such a notification email from Dandelion about his assignment, the participant could accept to write the requested content, reject the task, or delegate the task to others. Since a wiki link is also provided in the email, the participant could choose to respond by email or using the

wiki directly. Here we describe how Dandelion handles a participant's email response.

Handling Participant's Email Reply
If a participant decides to accept the task, he can simply include the requested content as instructed in his reply to the email from Dandelion (e.g., Figure 2). In this case, Dandelion extracts the intended input and uses it to update the corresponding section in the wiki page. To associate the submitted input (e.g., Gary's write up for project "Pharos" in Figure 2c) with the corresponding section (e.g., the "Pharos" section in Figure 3), Dandelion currently uses a unique id to index each participant's emails and the corresponding wiki section(s).

On the other hand, if the participant rejects the task or delegates it to others, Dandelion would not be able to find any input in the specific location (e.g., Figure 2c) in the reply. In such cases, Dandelion would forward such responses to the coordinator. Our rationale is that Dandelion itself could not make decisions anyway in such situations.

Handling Exceptions
A participant's email response may not be as expected. In our pilot, we have identified three exceptional situations where participants did not follow Dandelion email instructions. In such cases, Dandelion must use other means to address the situations.

Change of Templates. In some cases, a user may change the elements of an email template intentionally or unintentionally. For example, a participant who is submitting his write-up in his reply to Dandelion accidently deletes the delimiter that indicates where he should enter his write up. As a result, Dandelion would not be able to properly parse the participant's reply due to the missing delimiter.

To handle such cases, Dandelion's current policy is to leave the decision to the coordinator of a co-authoring process. Specifically, Dandelion forwards the questionable email to the coordinator with an attached rationale (e.g., cannot extract a co-author's input from the email reply).

Unexpected Replies. Instead of changing an email template, sometimes users may provide unexpected input in an email. As shown in Figure 2, participant Gary not only provides his write up on "Pharos" as instructed, but he also gives additional input at the top of the email (Figure 2a). Given this unexpected input, currently Dandelion's policy is not to discard any information. Specifically, it extracts the unexpected input and uses it to update the "comment" of the actual write-up in the wiki (Figure 4).

The situation could become more complex, if a participant chooses to completely ignore the email instruction and simply enters all his comments and write-up at one place (e.g., at the top of the email message). In such situations, Dandelion would not find the expected content where it should be (e.g., below the delimiter /-- Content --/ in Figure 2). To handle such exceptions, Dandelion puts all user input in the
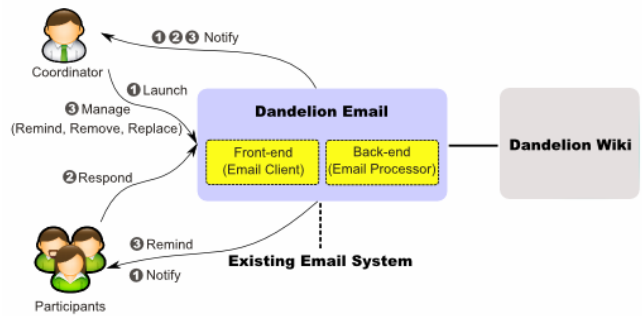
Figure 5. Dandelion main components and three key interaction flows: (1) Launch a collaborative authoring process, (2) Respond to co-authoring tasks, and (3) Manage the collaborative authoring process.

designated section in the wiki but in the meantime informs the coordinator the out-of-place input and leaves it to her for further action.

Multiple Replies. In some cases, a participant may not be satisfied with his previously submitted write-up. So he would reply to Dandelion again with a modified write up. Very much like version control, there are several ways to handle the situation. For example, the modified write up could be used to replace the existing one or be simply appended to the existing one. For simplicity, if the write up comes from the same person, Dandelion currently just replaces the existing one with the new. In contrast, if there are *multiple* users who are assigned to work on the same section, Dandelion then appends one's input to another's. Our rationale is to provide the coordinator multiple points of view and let her decide which one to keep.

4.4 Managing Collaborative Authoring
In addition to launching a collaborative authoring process, another major responsibility of a coordinator is to monitor and manage the overall co-authoring process. There are three major management actions: (1) reminding co-authors of their tasks, (2) removing a co-author, and (3) replacing a co-author with a new one. Next we show how we support these three actions by email.

Templates for Management Actions
We design three templates, one for specifying each of the three actions described above.

Remind: [timer, <targetAuthor>+, message]+	(2)
Remove: <targetAuthor>+	(3)
Replace: [<originalAuthor>, <targetAuthor>]+	(4)

As shown in Formula 2, the *Remind* template has three basic elements: *timer*, *targetAuthor*, and *message*. Here the *timer* defines when the reminder should be sent to one or more target authors. By default, the target authors are those who have not finished their assigned tasks when the timer expires. Template *Remove* requires only one element: one or two target authors to be deleted (Formula 3). The last template, *Replace*, requires the specification of two elements: the original co-author and a new one (Formula 4).

Figure 6. Dandelion-generated email status report, summarizing the co-author task status and the co-authored content submitted so far.

Note that we do not need a separate template for *Add* (adding a co-author or a co-authoring task), which is already subsumed by the interaction of defining a co-authoring task described in Section 4.2.

Conditions of Using Management Action Templates
In order to use a management template to specify a management action, two conditions must be met. First, a collaborative authoring process must exist (has already been launched) otherwise there is nothing to manage. Second, the coordinator must be able to indicate *which* collaborative authoring process to manage. To satisfy the first condition, currently Dandelion would not make management templates available to users if no co-authoring tasks exist. To help meet the second condition, Dandelion lists all ongoing collaborative authoring projects in a menu from which a coordinator can select one to manage. After selecting a co-authoring project, the coordinator can then use an action template to specify her management needs in an email (e.g., removing a participant for this project).

Handling Emails of Management Actions
Upon a coordinator's management request (e.g., sending a reminder to participants), Dandelion acts on the coordinator's behalf. This process is straightforward. Dandelion simply imitates as if it were done by a person in a Dandelion wiki. However, it takes an extra step to provide the desired awareness, which is otherwise missing in an email interaction. Specifically, for all three actions (*Remind*, *Remove* and *Replace*), Dandelion emails the coordinator a confirmation with a status report after it performs the action per the coordinator's request.

5 IMPLEMENTATION AND EVALUATION

To support email-driven collaborative authoring, we have extended Dandelion, which was originally built on top of Lotus Connections 2.5 Wikis, with an email module. In our current deployment, our email module is built on top of Lotus Notes 8.5, where a Dandelion Lotus Notes email account is set up to send/receive emails to/from users. The email module's *front-end* component extends Lotus Notes

8.5 client to allow users to interact with a list of email templates and use them to compose emails. Its *back-end* component is in Java for processing user email messages in the Dandelion inbox and automatically driving the whole collaboration process.

To formally evaluate the current version of Dandelion in support of collaborative authoring by email, we designed and conducted a comparison study, where a group of users was asked to perform collaborative authoring tasks with and without using Dandelion.

5.1 Study Setup
We recruited two groups of people, one with five members and the other with ten. Since email helps people collaborate across locations [8], we ensured that both groups consisted of members distributed in three locations. The make of the two groups were similar except their size, since we would like to examine whether the size of a group would impact coordinated, collaborative authoring by email. For each group, we also appointed one user as the coordinator.

Based on the collaborative authoring scenarios exhibited on our deployed Dandelion wiki system [4], we designed two similar but not identical tasks. Each task asked a group to co-author a document (e.g., a project proposal), each member responsible for writing part of the document.

5.2 Study Method
We asked both groups to accomplish the two tasks, one using Dandelion, and the other using the tool(s) of their choice. We randomly decided on the task and the system usage order to avoid potential biases. At the beginning of each task, we asked all users to complete a pre-task questionnaire that assessed their knowledge about Dandelion and their experience in collaborative authoring. We then briefed the two coordinators about their respective tasks so they could start the process with their own team. We allotted one week for each task. After each task, we also asked all users to complete a post-task questionnaire that recorded the tools that they used if not using Dandelion and the purposes of using these tools. We also solicited user feedback on the usability and usefulness of Dandelion, as well as their most and least liked features of Dandelion. At the end of the study, we also asked all the users to submit all their emails (both received and sent) related to this study.

5.3 Results and Analysis
Both groups completed their tasks within the allotted time. When Dandelion was not to be used, both groups used email as their main tool (except a couple of online chats) to complete their tasks. Using the logged data, we summarize our key findings below.

Usability
Both the coordinators and participants found Dandelion main email features easy to use. Specifically, the coordinators found that it was easy for them to understand and use Dandelion email templates (mean=6.5, mean=6, on the

scale of 1 to 7, 1 being the most difficult and 7 being the easiest). It was also very easy for them to assign co-authoring tasks (mean = 7) and set up reminders (mean =7) by email. Similarly, the participants thought that it was easy for them to understand what they should do (mean = 5) and how to do it (mean = 6), when receiving a co-authoring task in email.

However, the coordinators did not think it was easy for them to access the co-authoring results (mean = 3) or the overall status (mean = 3.5) by email. Compared with the regular email system that they used (mean = 1.5, mean = 1.5), nonetheless, it was an improvement. We examined the situation further and found that although a coordinator could request a status report by email (e.g., Figure 6), none of them did. Instead, both coordinators used the generated wiki page to view and monitor the co-authoring status and results. When asked, one mentioned that the email form of the status report that she received from Dandelion (i.e., after Dandelion sent a reminder) did not give her all the information as the wiki did (e.g., Figure 4). She also hoped that Dandelion could send status report to her periodically without her explicitly asking for it. The other coordinator mentioned that he would prefer to get such information via instant messaging instead of email for instantaneous feedback.

Usefulness
In general, both coordinators and participants found Dandelion key features very useful in helping them accomplish their tasks. Specifically, both coordinators listed the same three most useful features of Dandelion: (1) specifying and assigning co-authoring tasks by email, (2) setting up reminders by email, and (3) automatic composition of co-authors' responses. When not using Dandelion for a similar task, on average, the coordinators spent quite some time on these three tasks manually: 15+ minutes on composing emails for assigning co-authoring tasks, 15+ minutes on writing reminders, and 25+ minutes on composing co-authors' input. For participants, 64% of them (7/11 responses collected) found the most useful Dandelion feature was that they could submit their co-authoring results by email. It was also interesting to see that both coordinators

	Task-related Messages	Social Messages
Other	2.3	1.8
Dandelion	1.6	0.1
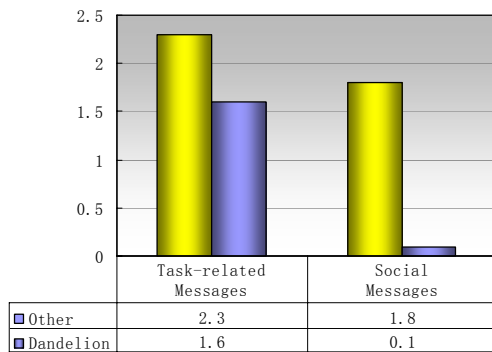
Figure 7. Different numbers of email messages sent by type when using and not using Dandelion.

(2/2, 100%) and most participants (9/11, 82%) visited the generated wiki page. The top reason for them to visit the wiki page was to check out the content authored so far and the co-authors' tasks and status. The coordinators also felt strongly that email alone without wiki would not be effective (mean = 1.5 on a 7-point Likert scale, 1 being the most negative and 7 being the most positive). This observation not only verifies that collaboration awareness is important for all collaborators in such a process, but it also shows that email and wiki complement each other in their functions.

Impact on Collaboration Effectiveness
We examined all the logged email messages. As a rough measure, we used the number of *messages sent* by a user to estimate the collaboration effort involved in each task. On average, a coordinator sent 8 emails when not using Dandelion, while sent only 3.5 emails when using Dandelion. Similarly, a participant sent 3.1 and 1.3 emails under respective situations. Overall, a user sent 4.7 versus 1.7 emails when not using and using Dandelion. A repeated measures ANOVA test showed that their difference was statistically significant (p<.002). We further examined the factors that might affect the difference. The one-way ANOVA test showed that the tool usage was the only factor that had significant impact (p <.013).

We then carefully examined the content of these email messages and classified them into two categories: task-related messages (e.g., assigning and reminding tasks) and social messages (e.g., thank-you note). Figure 7 shows the distribution of the two types of messages. It was interesting to observe that the use of Dandelion reduced the number of social messages by 95%, while reducing the number of task-related messages by 30%. We investigated further and came up with the following explanation. When Dandelion was not used, both coordinators sent the co-authoring requests to *all* the participants in one email. When participants received the email, they started to ask the coordinator questions about the task and sent social messages among themselves. When a participant submitted his/her input to the coordinator by email, the coordinator also felt obliged to send a confirmation/thank-you note. In contrast, when Dandelion was used, it engaged a participant in a one-on-one email interaction. Most people did not feel comfortable conversing with a system (Dandelion) freely. Moreover, participants generally were not aware of each other unless they visited the wiki. This unawareness prevented them from emailing each other for social calls.

When designing Dandelion, we made a conscious decision *not* to let Dandelion email multiple participants together for two reasons: (1) customizing a message for each participant to facilitate their tasks, and (2) avoiding a human-started reply-to-all email "brawl" that will confuse Dandelion. From our study, our decision seemed helping achieve our goal. It also alters the group behavior, especially in the sense of making people more focused on their tasks with fewer exchanges of social messages.

Prior to our study, we also hypothesized the size of group would impact collaboration effectiveness and Dandelion would have different impact on groups with different size. However, our analysis of the collected data from this study showed that the group size had no significant impact on collaboration effectiveness (i.e., the number of emails sent) when using or not using Dandelion. We also examined the coordinators' subjective feedback, which did not suggest any evidence that could help validate our hypothesis either. As we continue monitoring the use of Dandelion in its practical deployment, we hope to gather more data to examine how a group's characteristics including its size would impact the use of Dandelion.

6 DISCUSSIONS

In this section, we share some of the lessons and limitations that we have learned from our development and evaluation process and highlight the remaining challenges.

6.1 System Extensibility

When using a template-based approach, one common concern is the extensibility of such an approach. Our templates are specifically designed for users to fulfill their tasks by email in a coordinated, collaborative authoring process. Most of our templates except a few (e.g., *Message* or *Reminder*) thus might not be reusable for arbitrary collaboration other than co-authoring tasks. However, the templates are application *independent* so they can be used to support co-authoring tasks in different domains (e.g., legal versus healthcare).

6.2 Collaboration Awareness in Email Interaction

Collaboration awareness is critical to an effective collaboration [13]. Our previous study also shows that in a collaborative authoring process, both coordinator and participant desire collaboration awareness and use it to drive their actions [4]. Although Dandelion provides collaboration awareness naturally (e.g., co-authoring tasks and status) through its wiki, users may not be able to take advantage of it if they choose not to visit the wiki. In addition, email communications in Dandelion are point-to-point and kept in individual inboxes, it is even harder for users (coordinators and participants) to be aware of the overall status.

To help users who choose to use email alone, Dandelion thus provides additional collaboration awareness via email. First, Dandelion always embeds the wiki link in all its email communications with users. Second, it automatically sends a status report to users whenever appropriate. For example, Dandelion automatically sends a status report to the coordinator (Figure 5), when sending a reminder to the designated participants. Third, users can explicitly request a status report. However, these policies will increase a number of email messages received by users. Moreover, as commented by the users in our study, these email-based status reports seem still insufficient in providing them with the desired collaboration awareness. It thus remains to be a challenge as how to balance between providing sufficient collaboration awareness by email but without inundating

users with an excessive number of email messages (e.g., sending frequent email status update).

6.3 Understanding Users' Emails

As mentioned earlier, understanding one's email is an open-ended problem. We carefully designed Dandelion interaction flow so that it only needs to understand specific types of emails but does so robustly. However, in practices, it is difficult to predict what kind of emails Dandelion would receive from a user. For example, one user in our study submitted her write-up by directly replying to Dandelion's reminder instead of replying to the original email that Dandelion sent with a reply template. In this case, Dandelion failed to extract the submitted input, since the reminder currently does not include a reply template. As this special case can be easily addressed by attaching the reply template to every reminder, however handling a user's arbitrary email will always be a hurdle for Dandelion to overcome. As mentioned earlier, our current strategy is for Dandelion to forward the emails that it could not handle to a human (coordinator) for his/her attention.

6.4 Co-authoring Interdependent Content

Currently, Dandelion assumes that the content to be co-authored is independent of each other. In real-world applications, however, a group of people may be required to co-authoring interdependent content. Consider a coordinator who is setting up a visitor's agenda. She lists the visitor's available time slots and then asks her colleagues to enter their proposed topics and preferred time slots to meet with the visitor. Since two people cannot occupy the same slot, one person's decision/would depend on the others'. In this case, if replying by email, a person would be choosing a slot "blindly" without knowing others' choices due to a lack of awareness of the overall status in email. Since Dandelion does not process user-authored content, it could not detect conflicts in interdependent content like a schedule either. To handle such cases, our current solution is to let Dandelion gather user inputs from emails and post them in a wiki, and then let the coordinator organize them manually. As an alternative, users could always view others' input in the wiki and then decide on their own.

6.5 Preserving Only Text between Email and Wiki

For simplicity, Dandelion currently preserves only the text when it moves the text between email and wiki. For example, when it uses a participant's email reply to update the wiki, it just extracts the text but not the format used in the email. Likewise, when it uses the information on a wiki to compose a status report in email, it uses just the text but not its format or meta information. Ideally, it would be great to have the same *look and feel* across work spaces (email and wiki) so users do not need to reorient themselves when they switch work space. However, it is quite challenging to do so in reality due to the incompatibility in different work spaces.

7 CONCLUSIONS

Dandelion is a wiki-based tool supports coordinated, collaborative authoring. In this paper, we have presented an extended version of Dandelion, which allows all users to accomplish their tasks *by email* in a coordinated, co-authoring process. Users can use email templates to specify their requests in email or simply fulfill their co-authoring tasks via email reply. On the other hand, Dandelion can understand template-based email messages from users. It then uses the information extracted from these emails to drive the collaboration flow, including automated generation and update of a wiki page to persist and share co-authoring results. As a result, Dandelion allows users to use their most familiar tool (email) to complete their tasks in a co-authoring process, while using a wiki as a back channel to provide collaboration awareness. Our preliminary study with two groups of users shows the usefulness of both Dandelion's email and wiki features and their impact on collaboration effectiveness.

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