"How fancy you are to make us use your fancy tool": Coordinating Individuals' Tool Preference over Group Boundaries

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When a group makes a decision, it necessitates the understanding and amalgamation of information from different group members. This process becomes particularly intricate in cross-boundary teams, which consist of individuals from diverse organizational backgrounds, each bringing in unique informational tools and representation modalities. People share information generated from their personal tools, and the variance in representation of such information makes it challenging to form cohesive group decisions. We conducted workshop studies with 11 knowledge workers to understand current practices of tool adaptation and negotiation in such teams. The results indicate a reluctance to adopt new tools due to perceived violations of social acceptance, often leading to negative judgments of those suggesting new tools. Consequently, participants in cross-boundary teams gravitated towards their preferred tools, complicating the aggregation of inputs and impeding cohesive decision-making. To address these challenges, we developed a platform facilitating sensemaking and decision-making without necessitating compromises on tool preferences. In our mixed-method within-subject experiments, this approach enabled faster, more informed decision-making with reduced mental load and increased engagement through enhanced social interaction and acknowledgment of diverse contributions.

CCS Concepts: • **Human-centered computing → Collaborative and social computing systems and tools**.

Additional Key Words and Phrases: cross-boundary team, tool adaptation, tool preference, group coordination, group-decision making

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1 INTRODUCTION

A cross-boundary team refers to a team comprised of individuals hailing from different organizations, each contributing to a shared project or goal. Decision-making within such teams is inherently challenging due to a multiplicity of factors emphasized by both individual information processing and collective amalgamation of perspectives. The members of these teams bring unique habits and

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perspectives shaped by their respective organizational cultures and tool suites, leading to a disparate approach to information management and processing, crucial in group decision-making [3, 43]. The struggles are compounded when tasks involve merging distinct pieces of information presented in varied formats, like consolidating different recipes in a group chat [27]. The discrepancies in information representation and the lack of a unified platform or understanding can hinder the seamless transition of ideas, affecting the collaborative aspect of decision-making. Moreover, the frequent changes in team membership, typical of cross-boundary teams, further complicate the situation by limiting the development of mutual understanding among members [28]. Furthermore, the absence of universal organizational rules and converging tool suites intensifies the difficulty in synthesizing information and opinions [5, 55, 59]. These collective challenges underscore the intricate nature of decision-making in cross-boundary settings and highlight the need for meticulous approaches to information management and interpersonal understanding.

Consider a cross-boundary team consisting of members from different organizations, collaborating on a shared project. They plan to align their project strategies and develop a unified project roadmap. In their shared communication platform, they begin proposing ideas and sharing documents, each in the format accustomed to their respective organizations. One member posts a link to their standard project template, another uploads a PDF of their organization's workflow, and yet another types out a list of their organizational priorities. These documents have several common elements, so one team member decides to consolidate the information to build a unified project plan. To do this, they need to ensure they gather all the required details, open each document one-by-one, and iterate through each contribution. This scenario exemplifies the struggles of making group decisions with different tools in cross-boundary teams. Similarly, aligning meeting schedules for participants who use different scheduling tools exemplifies another prevalent challenge. The common difficulties in these group decisions arise from individuals' divergent tool use; each person has ingrained habits shaped by their choice of tools, likely represented differently in every group decision occasion [3, 43].

In this work, we focus on cross-boundary teams and how they coordinate tool differences. We conducted a workshop study with 11 participants who routinely engage in coordination with various people outside of their organizations as a part of their daily jobs (for example, client-relation managers and admins) to understand how people cope with gaps between their personal tools and group-decision making. Each person was assigned to a group of 3-4 participants. We presented a common scenario of cross-boundary coordination using different personal or collaborative technologies and asked participants to talk aloud their perception. We adopted a comfort board [4] and instructed participants to indicate their perceived level of the amount of useful information and simplicity of interaction required to complete the task.

We found that our participants engage in careful negotiations with others in order to agree on which tools to use for the group-decision process. Unlike other domain of tools co-usage [19, 27] where co-users proactively confront each other and resolve conflicts, people exhibit different behavior in group decision making; They often "gave up" protesting for their preference due to the fear of being judged rude or inconsiderate, even if it means that the group-decision making process becomes jarring and inefficient. We also identified two classes of people in the group-decision process. The first class is a bystander type, who engages at a minimal level. The second is a leader type, who is not necessarily the formal leader of the group, but takes on additional work to get through the group decision process.

To further explore a design concept, we develop and evaluate CollaboRanger[1], a novel messaging system designed to streamline group decision-making for cross-boundary teams. CollaboRanger allows users to gather and make sense of responses from various preferred tools, eliminating the need for team members to switch from their personal tools during cross-boundary collaborations. A key challenge in collaboration is the reluctance to adopt new tools, yet paradoxically, our solution also involves embracing a novel tool. To resolve this contradiction, our tool has been designed to be minimally invasive, leveraging universally familiar messaging interfaces complemented by a universal representation format, such as tables. CollaboRanger enables users to collect information from individuals' choice of tools and helps to perform a visual comparison between them for more efficient and effective coordination. The interface of CollaboRanger provides the users with a shared table during a free-form conversation in which they can enter their responses using the tools of their choice, so that the participants can see the responses from different tools in a single view. Furthermore, our interface does not require a dedicated user to build the tables, allowing users of different classes (bystanders vs. leaders) to spontaneously lead the collaborative sensemaking process.

To evaluate CollaboRanger, we conducted a within-subject experiment consisting of lab and deployment studies. We recruited knowledge workers (N=23) to conduct various coordination tasks (scheduling group meetings, organizing networking, and planning trips). CollaboRanger users were able to finish group-coordination tasks 1.7 times faster than in the control version, were more informed and made more effective group decisions. They also reported that making group-decisions using CollaboRanger demanded around 30% less mental load. Using the collaborative tables, participants were also able to send social signals, such as acknowledging other responses and contributions, which led to more social discussion and promoted engagement even for the bystanders. Participants said that they would like to use CollaboRanger in their daily life, especially since the tool allows them to make group decisions without forcing their team members to switch from their personal tools.

This work makes the following contribution: it introduces underlying tension and challenges of cross-boundary teams. Given the lack of team structure and history, we find how they build norms and what roles naturally appear. Furthermore, we suggest a concrete design concept and empirical results that visualization serves as a useful temporal summary for not only newcomers, but also longer group tasks, as well as its effects on accountability and engagement across natural roles. Similar systems with straightforward representations in a group conversation may accelerate norm-building and coordination in cross-boundary teams.

2 BACKGROUND

The scope of our work touches upon several aspects in HCI that have been explored by prior researchers. In our review of related works, we focus on three main areas. We first describe individual differences in behavior and preference for personal task management. Given these distinctions among individuals, we then examine previous works describing group dynamics and behaviors of choosing and using tools. Finally, since the focus of our work is to support better sensemaking for groups across individual contributions, we consider a series of successful systems for both individual and collaborative information gathering and sensemaking.

[1]CollaboRanger means collaboration for a range of different users. CollaboRanger helps groups with different tool preferences to work together.

2.1 Cross-boundary Teams

Cross-boundary teams are composed of individuals who often hail from distinct organizations [12]. These teams face substantial hurdles stemming from their fluid membership and the clash of norms stemming from their diverse organizational backgrounds. Among these challenges, perhaps one of the most formidable is the need to navigate and harmonize disparate practices [44]. The complexity of this task is intricately linked to the nature of the practices in question. In cases where practices are highly organization-specific and shrouded in tacit knowledge, the task of reconciling them within cross-boundary teams becomes markedly more challenging [12, 27].

To enhance the effectiveness of cross-boundary teams, the incorporation of boundary objects plays a pivotal role in bringing together individuals from different organizations [30]. These boundary objects, however, are inherently context-specific and can vary based on the specific task at hand and the organizational members involved [17]. Often, the responsibility of managing these boundary objects and facilitating collaboration falls to boundary spanners, individuals who bridge the organizational divide [58]. Their role is multifaceted, encompassing the task of identifying a middle ground to mediate asymmetries and differences that may emerge [55]. This often involves the astute recognition of common practices facilitated through communication within cross-boundary teams [9, 47]; boundary spanners diligently monitor and label effective team actions. For instance, consider a scenario where a cross-boundary team repeatedly encounters synchronization issues when one member needs to request a list of changes from another member. In this context, a boundary spanner may discern that a previous successful instance involved one team member sharing a collaborative editing document containing the requested list with their colleague, effectively streamlining the task's follow-up process. Under the guidance of boundary spanners, team members gradually acquire the knowledge and skills necessary to navigate and collaborate effectively within the unique context of cross-boundary teams [64].

In this project, our focus centers on the examination of boundary objects within the realm of collaborative technology as applied in ad hoc cross-boundary teams. Distinct from other forms of boundary objects, reaching a consensus on collaborative technology is not a matter of identifying common practices between participating organizations. Unless these organizations happen to employ the exact same suite of collaborative software, the decision-making process typically involves either all team members adopting a tool used by one of the members or selecting an entirely new tool altogether. Our research underscores the social complexities associated with negotiating collaborative technology choices. In light of these insights, we have developed an innovative interface designed to empower cross-boundary teams in making collective decisions without necessitating the abandonment of their individual tools or compromising on efficiency and functionality.

2.2 Individual Differences in Personal Tools

Individuals adapt and develop unique digital habits which are manifested in using different tools or same tools differently [53]. It takes effort to collate together pieces of individual works when the individual contributions are done in isolated tools [31, 42, 57]. Prior work has investigated how such a gap developed. Once individuals settle into a habit of conducting certain tasks or a tool, they hardly budge on it and only switch to newer tools when substantial benefits are present [46]; when introduced to newer software or software updates, while individuals grasped the idea or potential benefits of adopting the new technology, they lack self-motivation for the actual adoption [39]. This is because choosing particular tools to work on various tasks not only *is influenced* by personality, but also *influences* users [43]. Hence, over time, users of a tool adjust their working style in accordance with the tool. Furthermore, users prioritize finishing the immediate

task quickly in the present moment despite the bigger benefits in the future [33, 54]. Considering all this together, individual users are unlikely to be motivated to switch tools or methods that they use to handle various tasks.

One might suggest entirely converting to a group application to reduce the *extra work* of merging individual contributions. However, such conversion is a double-edged sword; while groupware systems can help groups be on the same page [15], groupware systems might not be flexible enough to embrace individuals work habits and force them to handle different tasks in a totalistic manner [43]; prior work also anticipates that groupware might not survive in groups if using a groupware system disturbs social process [21].

Reinforcing groupware is more unlikely in cross-boundary teams, which consist of individuals who are likely to be members of different organizations thus governed by different organizational, cultural regulations and policies [27, 51]. Therefore, as personal preference for conducting individual parts of the group work can be drastically different, there is no way of coming together without compromising to a shared tool or requiring significant coordination effort. In our work, we delve into this issue and understand how cross-boundary teams coordinate (or not) each individual's difference and what challenges they face. Based on this we present a design concept to manage coordination in cross-boundary teams.

2.3 Group Behavior on Choosing and Using Tools

Groups develop norms for using CSCW systems over time [55]. Societal norms and values play a significant part in determining how groups negotiate individual choices and reach consensus [13]. In more community-oriented cultures (i.e. collectivist), people prefer collective decision-making with distributed responsibilities; while in individualist cultures, people are less affected by the decisions of others [37]. In turn, societal values influence a group's choice in what tools to use for collaboration. Furthermore, social activities are believed to be fluid and nuanced, where individuals demonstrate considerable agility in handling interactions and may change the way they work and collaborate according to the organizational norms [1].

Among different types of groups, tool usage and adoption in organizations are widely studied. In organizations, the choice of tools is more likely to be based on organizations' goals, instead of organic, and come from top-to-bottom [21, 59]. Hence, individuals take a more passive role when it comes to deciding tools to use for various tasks. For example, Tyre and Orlikowski studied the tool introduction and adaptation process at two different organizations with diverse priorities and practices. The first organization, a manufacturer of precision metal components, prioritized manufacturing process improvements and production where factory personnel were introduced to capital equipment for such purposes. The second organization, a multi-national software consulting firm where hours spent on software production translate directly into fees billed to clients, had the dominant objective to maximize production for current revenues. Engineers at the second organization were thus introduced to computer-aided software engineering tools. However, the patterns of adaptation in both organizations were highly discontinuous in Tyre and Orlikowski's study when introduced to technologies believed to support more productive operations [59]. The initial intensive episode of adaptation was followed by rapid decline in usage. The learning curve of new technologies and the established stable routines and habits that require less discussion, coordination and effortful decision making were among the main factors causing the decline in adaptation [18]. One possible way to combat the learning curve of a new system is to make one user in a group integrate the system on top of existing systems and hide it from the rest of the group [8, 36]. Calendar.help [8] helps a group of people find a time to meet when a user forwarded a message thread to the system. This allows the smooth introduction of the system to the rest of

people, where the rest of users (i.e. bystander class) might not even realize that the system was being used.

Taken together, previous work suggests that deciding tools to use for groups is influenced by group norms, hence it takes a long time to nurture. In this work, we adopt a different strategy. Rather than examining longitudinal processes, we focus on ad hoc cross-boundary teams, which necessarily require tools that can be learned and adopted quickly. Unlike organizations or long-term teams, cross-boundary teams lack norms, fixed roles and time to organically adopt tools as a group. Through our workshop study, we discovered how tool adoption happens specific to cross-boundary teams when they did not have norms or fixed roles.

2.4 Systems for Sensemaking

Collaborative tasks often involve group members jointly contributing and constructing meanings, interpretations, arguments, and eventually consensus based on their individual opinions (e.g., preferences, knowledge or expertise). This process involves both individual sensemaking (e.g., [6, 38]) and collective sensemaking (e.g., [22, 32]). Awareness of the relationships across individual contributions can support consensus building for group tasks [23, 25, 26, 29, 62]. Here we review a series of systems that researchers have built and explored for complex information gathering and sense-making for both individual and group to inspire our work.

Extracting and gathering critical information are the first steps to effective sense-making. To help people better make sense of online information, various systems enable users to first collect useful snippets of content from multi-media, web pages [10, 60, 61] or group discussion [8, 36] and later gather them into a single place for easy access and processing. The systems support users to help collect information in different manners, some of the tools are merely helping users have different information in one place, whereas others systems employ crowdsourcing techniques to extract information in a uniform way that users can further use and process. For example, prior work in email management extracts information of interest from senders, then a user can customize auto-drafted responses depending on the extracted information [36].

Once the relevant contents are collected, how to categorize, organize and synthesize the complex information collection becomes key to decision- and sense- making [22]. Unakite [38], a decision-making tool for developers, built upon the idea of collecting snippets to empower users to save desired content as snippet cards through text selection and drawing a bounding box around the targeted area of information sources. For each decision they are making, Unakite guides users to create a table to compare different options across multiple criteria. By categorizing and organizing the collected snippets into corresponding table cells, Unakite facilitates users to more easily visualize information and compare the trade-offs for better decision-making.

The collaborative decision-making introduces new challenges to sensemaking, as it not only involves information of complicated relationships but also sensitive human preferences to be addressed. An extensive amount of previous literature has explored the use of visual awareness to facilitate the process for group tasks [11, 20, 63]. For example, [2, 45, 66] visualize responses from different group members and highlight the difference between the responses. Twine [35], designed to support collaborative sequence construction, also utilizes side-by-side visual comparison of individual's preferences to promote more efficient and effective sense-making and consensus building from the complex pool of group opinions. Our work takes inspiration from these previous designs for information collection and synthesis, but allows collaborative sensemaking across multiple media and platforms on one site simultaneously. In our work, we aim to augment previous work so that individuals can contribute using their own tools while being able to easily make effective group decisions.

The upcoming sections will sequentially unfold our investigations, starting with insights drawn from a workshop involving individuals frequently navigating cross-organizational coordination, providing an initial understanding of the negotiation and adaptations surrounding diverse tool usage. Subsequent sections will delve into nuanced behavioral patterns, uncovering a spectrum of engagement levels and social considerations shaping tool negotiations and identifying two distinct participant types—bystanders and leaders. The findings from these discussions will pave the way to introduce CollaboRanger, a solution-oriented messaging system designed to harmonize divergent tool preferences without enforcing changes in individual usage.

3 WORKSHOP STUDY

We sought to understand how individual members of casual groups cope with differences in tool preferences and information sharing in group coordination, and what are their decision factors or challenges. We conducted three sessions of semi-structured workshops with 11 individuals whose jobs require coordination with various backgrounds and occupations.

3.1 Study Design

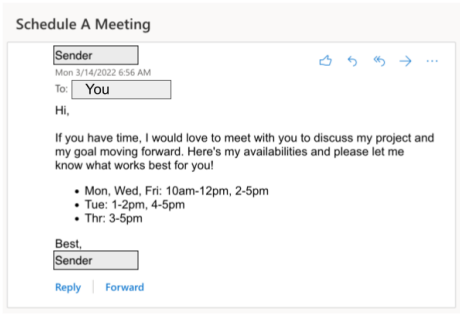
Pre-workshop survey. To ground our workshop task, we deployed a survey before the workshop. We sought to prepare the sample scenarios so that most participants will be familiar with them and experienced enough to offer insights. Therefore, we designed a survey to explore the most common requests received and sent via email or messaging apps during daily working scenarios. We provided an initial list of task categories for participants to choose from and they were also encouraged to contribute new examples with a reward of $20 for unique and creative answers. The full questionnaire is attached in the Appendix. The survey was distributed through various mailing lists within a private university and was taken by 123 people who are professors, managers, administrative assistants, company employees, accountants, head music producers, undergraduate students, graduate students, and postdoctoral researchers.

Our survey concluded with 86.6% of participants on average having engaged in event scheduling tasks (both asking others to do and being asked to do), 74.8% on average in providing feedback, and 63.9% on average in preparing documents and approvals. Other frequently mentioned coordination tasks contributed by participants included work coordination and planning, networking, as well as invitation to events.

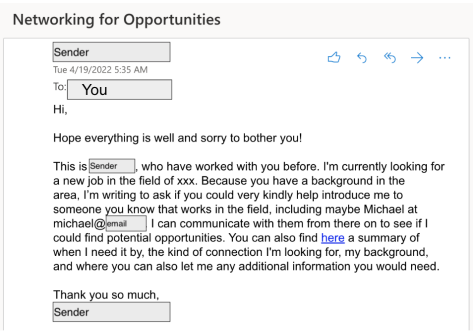
Study protocol. Each workshop was 60 minutes long and was driven by slides that present sample collaborative scenarios to participants and propose follow-up questions about their current practices under each scenario. Based on the survey results, we built three example scenarios for our workshop around two of the most common collaborative task, event scheduling and networking:

- **Scheduling Scenario 1**: A team member uses a personal calendar and when sharing her availability, she chooses to send a list of her free slots as bulleted plain text (Fig. 1a).
- **Scheduling Scenario 2**: A team member uses a third-party platform—YouCanBookMe[2]—to track her appointments. The platform displays her availability in a calendar-like form where others can directly sign up for an available block and receive an auto-generated email for the appointment. Therefore, they decided to send through email (Fig. 1c) the link to her YouCanBookMe page (Fig. 1d) to schedule a meeting .
- **Making introduction Scenario**: A colleague finds it overwhelming to send all the relevant information in the email body including when they want to be connected, their resume, as well as a list of people or companies they'd like to be connected to. Therefore, they decide

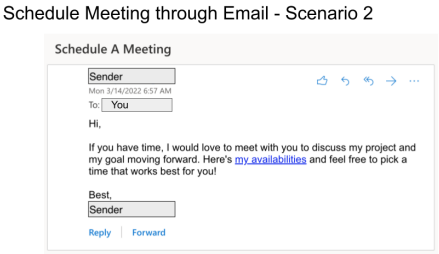
[2]https://youcanbook.me/



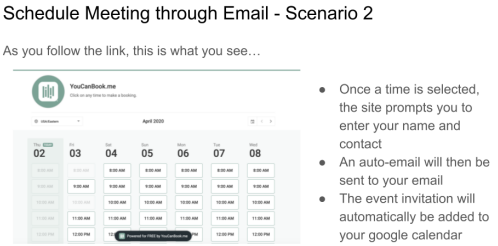
(a) Scheduling scenario 1



(b) Making-introduction scenario



(c) Scheduling scenario 2: Email message



(d) Scheduling scenario 2: Website that are linked

Fig. 1. Slides presented to workshop participants for demonstrating scenario

to use a third-party request management tool that organizes all task related information on one site, which they believe will help both her and the participant to track the status of the networking progress (Fig. 1b)

Upon being presented with each scenario, participants were asked to each walk through the series of actions they would normally take to complete the task. Following this, inspired by [4], we instructed participants to place a sticky note on a *comfort board* to indicate their perceived level of 'usefulness' and 'easy to use' regarding the task completion process and the form in which availability is shared in the situation (e.g., Fig. 2). 'Usefulness' here refers to the amount of useful information that one could receive from how the availability was presented: whether it provides exactly what one needs, lacks crucial elements, or introduces redundant distractions. 'Easy to use', on the other dimension, refers to the level of simplicity and intuitiveness of interaction required to complete the task given the way availability is shared. Participants were asked to write down brief reasoning for the position they chose. After taking positions on the board, participants engaged in facilitated discussions to elaborate on their sentiments towards and the potential challenges faced in completing each scenario.

The university's Institutional Review Board (IRB) reviewed and exempted both our workshop study as well as the randomized user study described in Section 5. Our organization requires all research personnel who conduct human subjects research to complete human subjects protection training using the online CITI course.

Participants. We recruited participants via posting on mailing lists of a private university and word-of-mouth. Each interviewee was compensated $20 for their time and the session lasts 1 hour. In total, 11 (9 females, 2 males) participants were recruited and assigned to each group of 3-4 participants. Participants' ages range from 26 to 62 (mean age=35) and occupations were administrative assistants, client and corporate relations coordinators, digital media strategist, graduate students, and professors.

3.2 Results

At the conclusion of sessions, relative positions of sticky notes (visual comfort board) were manually translated for each participant. The comments written on sticky notes and made verbally during conversation were transcribed into a spreadsheet, on which we later conducted an open-coding protocol to identify concepts and categories. Through multiple iterations along with periodic discussions with the rest of the research team, the coding led to 27 codes, from which the following major themes were selected. To yield concepts and themes, the authors discussed the codes through multiple iterations.

In this section, we delve into key themes from our workshop sessions, which collectively reveal two insights about how cross-boundary teams manage group decisions without established norms and fixed roles. Additionally, we explore desired features identified by participants to address current challenges and potential new tools.

3.2.1 Group norms. Cross-boundary groups, being newly formed, lack established group norms, making coordination challenging. Consequently, communicating the advantages of adopting new

Table 1. Information of interview participants. While participants have varied reaction (excited, willing, not willing or irked) to being introduced to new coordination tools, it is universal among participants that they would not express their reaction to others about how they feel about introduced to new tools and "go along" with the tools.

Occupation	Age	Willingness to learn and introduce new coordination tools
Administrative Assistant	27	Not willing to learn new tools
Administrative Assistant	35	Willing to learn new tools
Administrative Assistant	50	Irked when introduced new tools
Client Relations Coordinator	27	Excited to learn new tools but not want to force other people to use it
Client Relations Coordinator	31	Willing to learn new tools
Digital Media Strategist	28	Willing to learn new tools
Financial Administrative Assistant	62	Willing to learn new tools
Graduate Student	26	Not willing to learn new tools
Graduate Student	27	Excited to learn new tools and introduce to others
Graduate Student	35	Willing to learn new tools
Professor	34	Irked when introduced new tools

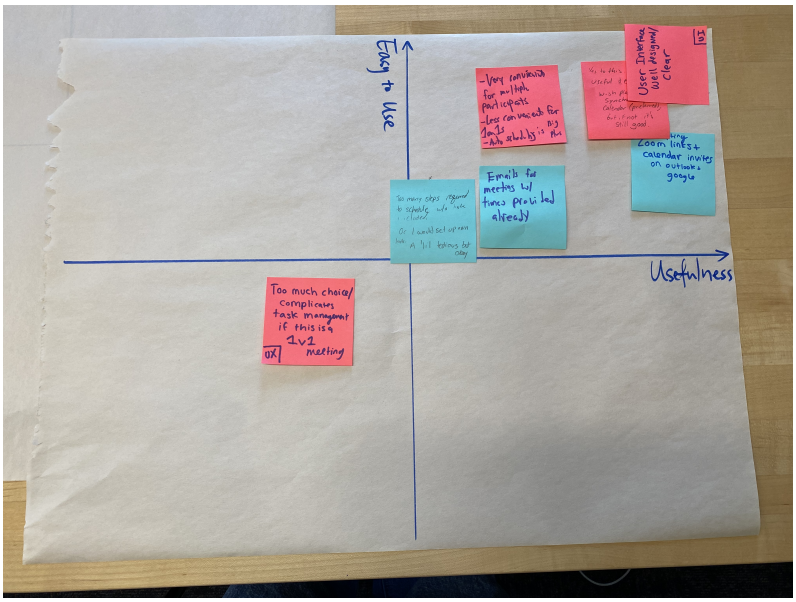


Fig. 2. Sticky notes on the comfort board placed by one group during their workshop study.

tools becomes more complex. Members may hesitate, fearing societal judgment, and may scrutinize those promoting groupware systems for decision-making. Further elaboration on this issue follows in subsequent paragraphs.

Prioritizing social acceptance over efficiency in choosing tools. Based on the sticky notes position on the comfort boards, 7 out of 11 participants had identified sharing availability using YouCanBookMe to be more easy-to-use and offer more useful information. These 7 participants placed their sticky notes in the YouCanBookMe scenario at a greater position on both 'easy to use' and 'usefulness' scales compared to their notes for the plain text version. Some of their comments read *"Easier to schedule. I just have to find a time in my calendar & select it in theirs. Then everything else happens automatically"*. Other comments include *"reduces back and forth [in email writing]"*.

However, participants expressed ideal preferences for a tool like YouCanBookMe but harbored realistic doubts about its adoption. Even those who favored YouCanBookMe acknowledged that they feel inadequate not only asking someone else to use these centralized tools but also getting asked to use the tools. Participants expressed their sentiments towards receiving links or other *"fancy"* tools that are different from their go-to tools for the task. For example, one participant commented, *"I just say when I took a look at these [links] my step one is: I'll be judging the person, "Oh look at how fancy you are""* Another participant added, *"I wouldn't reply with a Calendly. I feel it's not nice."*. A participant who described themselves as *"a big fan"* of productivity tools often uses Trello for personal organization. Even though they were enthusiastically explaining *"it's really great for collaboration"*, they would be more cautious of suggesting using a new tool for coordination, especially to people who they hadn't coordinated much before: *"our team as a whole doesn't use tools like Trello so I wouldn't try to get [people outside of my team] on board with it."*

The reasoning behind negative sentiment towards adopting centralized tools is summarized into two aspects; first, participants felt that they are making others to do more work. A participant argued that *"It does feel kind of like ... you're offloading work from the sender onto the receiver."*

Second, they worried that introducing such tool in the middle of coordination might come across other people who already contributed to the conversation. For example, if one suggests to use When2meet when others have already shared availability, it might look like others' responses are ignored. In other words, they wanted to make sure that they are not accidentally overwriting other people's contributions to coordination.

Elevated concerns regarding social acceptance contributed to participants displaying inefficient coordination behaviors. Within group dynamics, individuals often refrained from advocating for their preferred tools and instead invested extra effort in consolidating information from various individual tools. This underscores a key insight in cross-boundary collaboration: when making decisions about collaborative technology, the challenge lies in minimizing the imposition of changing work habits on participants.

Cross-channel coordination makes group-decision demanding. The above finding leads to a situation where members in casual groups avoid requesting compromises, resulting in diverse forms of contributions when organizing and coordinating group decision tasks. In all three groups, participants raised concerns about cross-channel coordination challenges, which currently require both mental and physical efforts to overcome.

As the participants described for scheduling tasks, when receiving availability in different forms (e.g., a list of availability, links to their public calendar) from different members, *"it takes time to switch between [their] email and [my] calendars. They're all in the same browsers [so I] have to switch tabs so that... can be annoying"*. Some participants pull the email or shared calendar up in another window and resize it to view side by side with their own. Others utilize another separate monitor screen to view multiple windows of calendars at the same time. Participants indicated that all these actions are "tedious" and repetitive; opening up in new tabs, dragging the tabs to view in a new window, then resizing and positioning carefully to compare the content are all time-consuming and jarring actions to perform on a laptop.

Moreover, this difficulty drastically rises as the number of people are involved in the scheduling increases. One participant noted, *"I usually struggle with scheduling especially when we're doing user studies [where] I have to schedule a lot of things."* Others also mentioned the challenge when there's many parallel and potentially conflicting parts in a task. For example, when there's a list of people participants need to meet 1-1 but each with location preference and availability shared in separate threads and various forms, it becomes hard to track the status and compare across the sub parts to make sure the meeting times don't conflict. Therefore, participants yearned for tools to mitigate the challenge of cross-channel coordination especially at scale as discussed in the following paragraph.

People turn to tools that can capture moving parts of coordination. Our participants, even though they tend to judge about receiving information in a new tool as discussed earlier, pointed out that when the task involves multiple people, tools become attractive: *"So I think ... initially I thought I was turned off by ... a link, instead of just having the time given to you right there, however, tools like this (YouCanBookMe) is much better if there's multiple people in the meeting ... who are also going to input their times.* In terms of wishful features, participants demonstrated great interest in the wishful tool that could bring together different views on one sight: *"I actually like this idea of I can see my calendar [and] see their calendar, at the same time"*. Others proposed that *"what might have been more useful is Like two slides side by side, so you can see all their information and then respond to it"*.

3.2.2 Members' roles. Similarly with group norms, cross-boundary groups were often formed without specific members' roles. To get the coordination tasks done, we found that members in cross-boundary groups organically take on roles.

Coordination procedure naturally inherit roles of leader and bystander. Our study delineates a distinct pattern of roles within cross-boundary team coordination tasks. Participants' shared experiences across various scenarios highlight the emergence of two primary roles: the leader, who willingly takes on the role of convenor, investing additional effort in gathering responses and overseeing progress, and the bystander, contributing minimally in sharing their own input.

These roles can be dedicated in some scenarios. One of our participants who works as a corporate relations coordinator described how they would facilitate meeting scheduling with different companies: *"if [I'm] working with foreign entities, defense companies...or other companies...[who] are not using zoom.us, some will use zoom.gov or... Webex, we have our own portfolio...to remember [their preferences]"*. Due to the nature of his job, this participant takes the role of a leader and would have to do the extra work to remember and adjust to the ways that his clients, the bystanders, would prefer.

However, in more casual groups and tasks, these roles can also naturally evolve from personalities and social expectations. For example, organizing a group lunch was mentioned by many of our participants where *"there [first] has to be someone who initiates[s]"*, then *"someone constantly checking"* on responses. After others all responded, *"someone needs to be 'Ok, so what's happening'"* to start moving it forward and collect everyone's responses. As described by participants, there can be multiple leaders at different stages of a group task and they can be multiple different members. In addition, in cases where a member of the team would like to schedule a meeting with everyone, it feels like asking for a favor. Our participants in the position of the requester, who wants to initiate the meeting, naturally would put in the effort to *"text someone on Whatsapp, texting the other on messenger, or email all"* to make sure others can be reached in the way they prefer. While in the position of receiving these requests, our participants preferred doing minimal work and expressed concern against *"offloading the work that's supposed to be on requesters"* if they had to do extra coordinating work. This also echoed the social judgment in Section 3.2.1 in terms of under what situation the judgment is most likely to occur.

In these cases, group organization often occurs informally, driven by individual personalities or social expectations. Some members naturally assume more responsibilities in coordinating responses. Traditional collaboration tools that enforce fixed roles for each member can pose challenges in adapting to this organic leader and bystander dynamic.

3.3 Summary

3.3.1 Implications. The research highlights challenges in coordinating cross-boundary groups, particularly due to the lack of established group norms. This gap complicates the introduction of new coordination tools, not because of their complexity, but due to societal judgments surrounding their adoption. Despite recognizing the efficiency of tools like YouCanBookMe, participants often prioritize social acceptance over efficiency, leading to suboptimal coordination practices. Challenges also arise in cross-channel coordination, where toggling between various channels becomes cumbersome. However, there is a clear appetite for tools that can consolidate varied forms of information and simplify coordination. The study also observes the organic emergence of roles within these groups, primarily as leaders and bystanders. These roles, influenced by individual personalities and societal expectations, suggest that traditional collaboration tools with fixed roles might struggle to accommodate these dynamic, informal structures.

3.3.2 Design requirements. Our findings inform design requirements for CollaboRanger. Central to our findings is the understanding that cross-boundary teams prioritize tools that empower them to make group decisions efficiently, without the burden of drastically altering existing work habits or imposing new methodologies on members (R1). This speaks to a need for adaptability

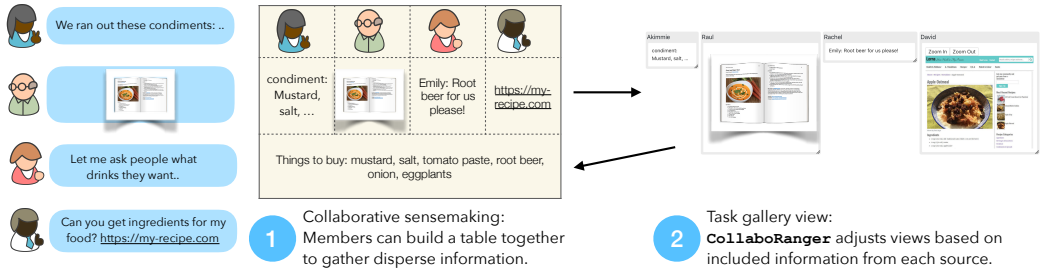


Fig. 3. The CollaboRanger workflow for helping groups to make group decisions using information from personal tools: (1) Group members engage in a table building process to gather information from different tools (2) Through automatic view adjustment, they can see all the interfaces in one view

and intuitive design. Moreover, in the ever-shifting landscape of teamwork, it's imperative that the tool's interface be fluid and flexible. Members should be able to effortlessly identify, assume, and even transition between different roles based on the task's demands or their individual preferences (R2).

4 COLLABORANGER: A COORDINATION SYSTEM FOR AIDING CROSS-BOUNDARY GROUPS WITH DIFFERENT TOOL PREFERENCES

Building on our findings of our workshop results, we developed CollaboRanger. We discuss interface components of CollaboRanger (Fig. 3) and how they meet the requirements of the group-decision making process of cross-boundary teams.

4.1 Building Collaborative Sensemaking Objects

CollaboRanger provides tables as a means to build a shared mental representation of information exchanged in their group conversation about coordination. We chose a collaborative-editable table as the representation, as a table is widely and universally used for sensemaking in various contexts. Hence, using familiar representation can invite conversation participants to contribute to the collaborative sensemaking process. This satisfies the design requirements for flexible switch of roles in cross-boundary teams (R2). In any point of conversation, any participant can create a table and employ it to gather information dispersed throughout or outside of conversation. For each cell, participants can select snippets of information using one of the following interface components (Fig. 4):

Gathering information from messages. CollaboRanger can present a pop-up window of the current conversation where the user can select texts or attachments exchanged in the conversation. This allows users to gather and categorize essential information that sometimes disperse in different messages in the conversation. Once they select information, the collected snippet embed hyperlinks, so users can refer to the part of the conversation where the snippet is from. Users can also import cell information from other cells in other tables from that pop-up, so users can re-use the information that is already captured.

Gathering information from contacts who are not in the conversation. This interface is used when users try to acquire information from the 3rd party who are not in the current conversation or separate the conversation to get this particular information. CollaboRanger users can link a separate conversation that links to a cell in the table. As there are new messages in the conversation thread, CollaboRanger displays the messages in the cell.

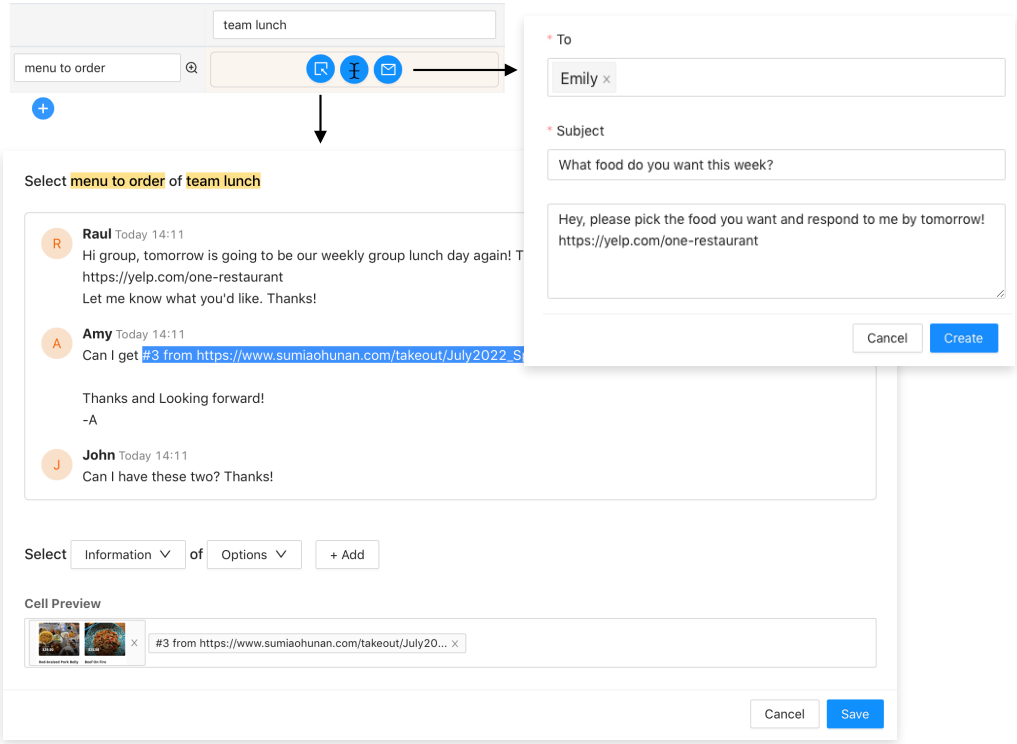


Fig. 4. Interface for collecting information to each cell

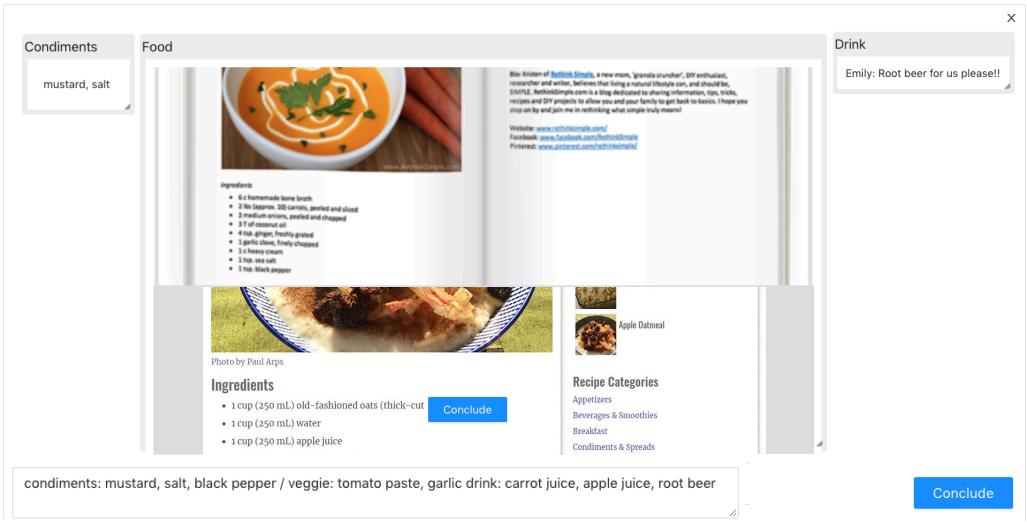


Fig. 5. Task-Gallery view interface: Users can see all the information in one sight. CollaboRanger detects the contents of each cell and automatically adjusts the size of each cell to fit all the cells in one sight.

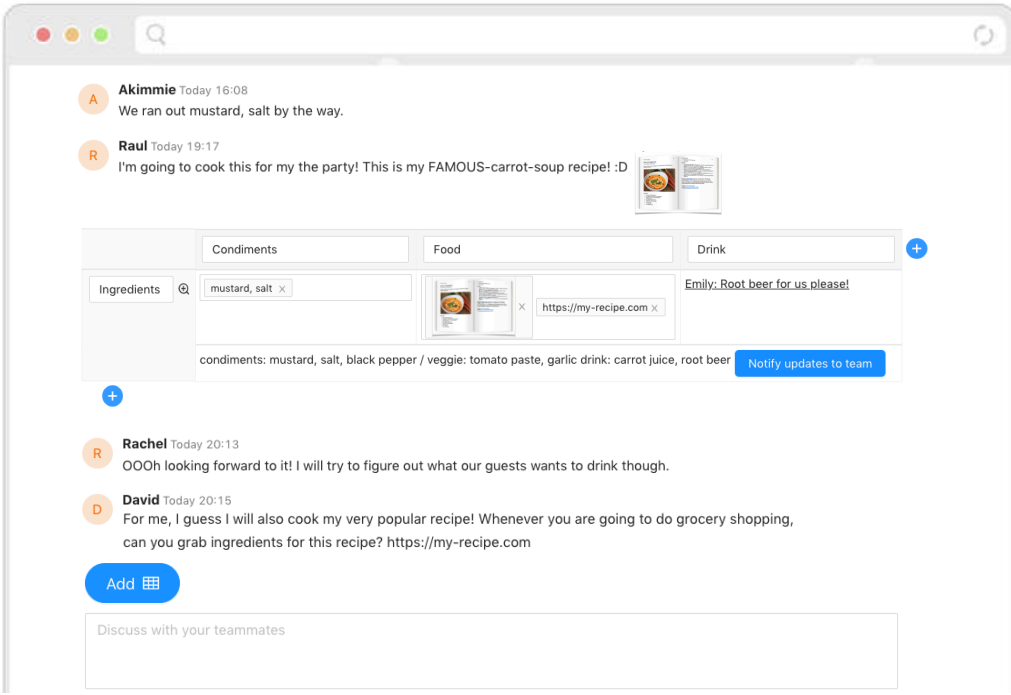


Fig. 6. CollaboRanger interface: during the group conversation, participants can contribute to the collaborative table to make sense of information from personal tools

4.2 Aggregating Information from Different Information Sources

As highlighted in our workshop study, due to different tools used by individuals in cross-boundary teams, they had to handle information from cross-channels (R1). In the process of switching and aggregating different information, they felt that the process is mentally demanding and prone to make mistakes. Hence, it is important to provide support aggregation of information from different sources of information. To satisfy the requirement, CollaboRanger provides a task-gallery view (Fig. 5); once users fill out the cells in a row, users can see all the information in one sight. CollaboRanger detects the contents of each cell and automatically adjusts the size of each cell to fit all the cells in one sight. Such placement of all the relevant information in one place helps users to navigate information and conduct tasks [52]. If users adjust or resize any cell contents, the adjustment is preserved.

For each row, participants can summarize information shared across each attribute in a row, which is presented as a merged row in the interface (Fig. 6 & 7). Users can write down a summary in the CollaboRanger interface. This way, without having each user going through information, one of the group participants can contribute finding common grounds on the attribute. The visualization serves as a useful temporal summary for not only newcomers, but also longer group tasks, as well as its effects on accountability and engagement across natural roles. CollaboRanger can also help users to notify the summary with other users by clicking the notifying button, which then will auto-complete the message in the CollaboRanger thread.

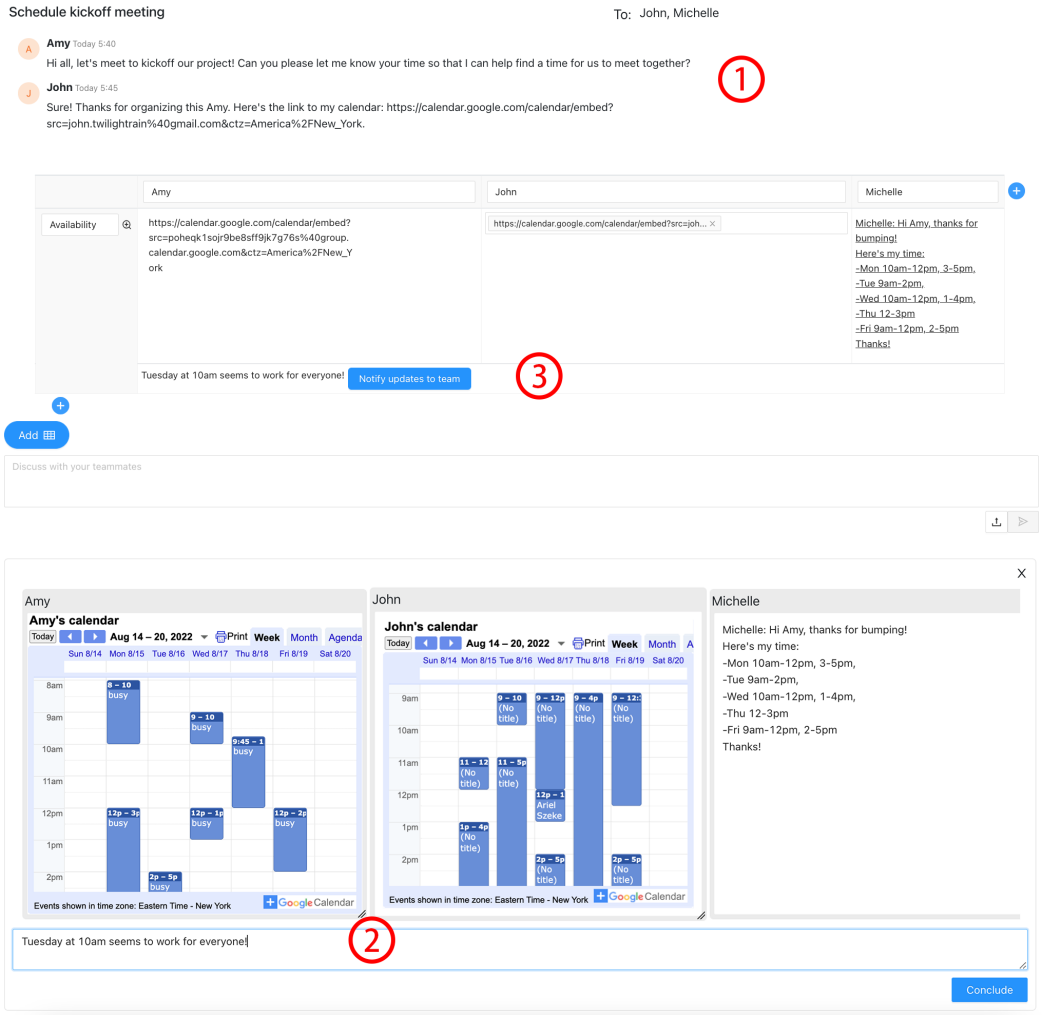


Fig. 7. The workflow for meeting scheduling. (1) Users directly share availability and can organize them into tables for better comparison. (2) A coordinator views all responses and concludes on a time. (3) They update the final decision to the team.

Implementation. CollaboRanger is a React application with Ant Design[3] and Firebase Firestore. It also uses Gmail API to read and send email messages.

4.3 Use Cases

4.3.1 Group Scheduling: Finding Commonalities across Responses. CollaboRanger can facilitate group scheduling across multiple forms of availability (e.g. text, image, Google Calendar link, or Calendly.com link) shared by group members within one site. Group scheduling or event scheduling in general is ranked the top frequent activity that occurs in daily working settings as according to our pre-workshop survey. However, it is the group leaders' job, either appointed or naturally

[3]https://ant.design/

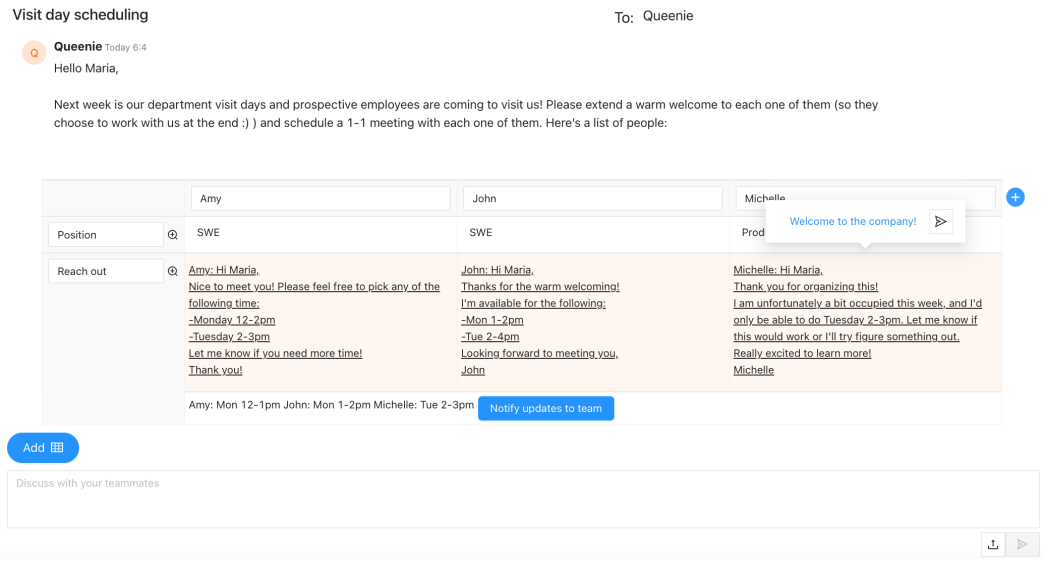


Fig. 8. Users can simultaneously track and compare across several individual sub-threads of a main task. Coordinator can reply individually to each thread directly from the table with the summary feature as a hint.

evolved, to coordinate everyone's time and find a common time to meet together. CollaboRanger can make this coordination process easier especially when the availability is shared in various forms by letting coordinators directly view the responses in resizable panels next to each other horizontally and display the web page content if a link is included. Fig. 7 illustrates the workflow. Leaders can create a table to collect all attendees' availability with attendees on column, "Availability" as the attribute to compare across, and time shared by each person in their corresponding cells. In this example, Amy is trying to schedule a time to meet together with John and Michelle, where John directly shares his calendar link while Amy had to bump Michelle individually for her schedule. Amy inputs her own Google calendar link and selects from John's response to put into the table cell. To conclude on a time to meet, Amy opens the gallery view for "Availability" to compare everyone's schedule and writes down the time she finds to work for everyone. She finally updates everyone with the decided time by bumping another message using the "Notify updates to team" button and sending.

4.3.2 Hybrid Visit-day Organizing: Parallel Sub-tasks Managing. CollaboRanger allows users to easily manage and work across parallel sub-tasks at a higher level by embedding sub-conversation threads into a table. Such a feature is integral to large scale collaborative tasks that involve multiple parts as the parallel sub-tasks may often conflict or influence the progress of each other. Take for example that Maria is working at a company and there's a visiting week coming up for the company where potential future colleagues are going to visit the office. Maria's work admin asks her to schedule and give a 1-1 tour for each of the three potential colleagues for her department, Amy, John, Michelle. The admin creates and sends to Maria a table of visitors that she needs to follow up with confirmation time individually. Maria uses the cell for each visitor to send out individual messages and compare across all visitors' responded time preference to decide when to meet them so there's no conflict (shown in Fig. 8). Once she's done with her decision, she confirms with all visitors in each individual thread.

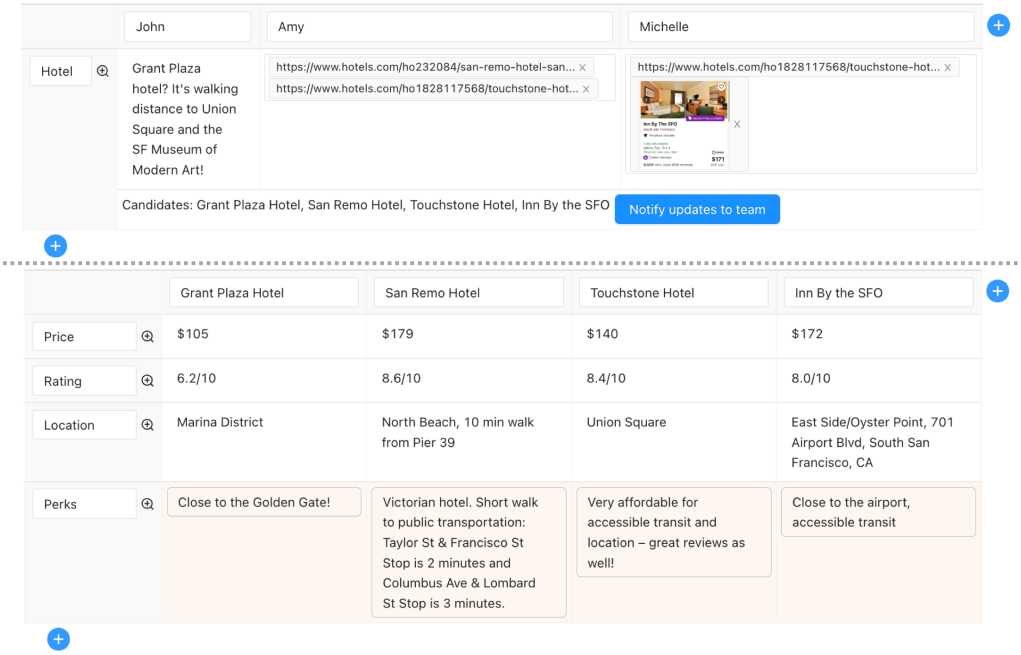


Fig. 9. (Top) Table to collect hotel suggestions of each member and aggregate a candidate list. (Bottom) A second table comparing corresponding amenities across candidate hotels generated from the first table.

4.3.3 Group Decisions: Preference Gathering and Trade-off Comparison. CollaboRanger facilitates group decision-making involving multiple steps by using the collaborative table with different purposes for each decision to make. Apart from the previous two use cases where the table can be used to view calendars, it can also be extended to collect other forms of group member preferences or to compare trade-offs of several options with multiple attributes to help the group to reach a final choice. Fig. 9 demonstrates an example scenario. In the example, Amy, John, and Michelle are going on a trip to NYC and they are looking at hotels to stay in. They first use a table to collect hotel suggestions by group members and aggregate them into a list of candidates to make sure that everyone's preferences are being addressed. Then they use a second table to compare between the hotel candidates based on amenities that the group members care about. Further discussion revolves around the second table until they reach a final consensus. The first table guides users to consider and build from all members' opinions while the second table aids users to compare trade-offs among the potential candidate choices.

5 SYSTEM EVALUATION

We conducted lab and deployment studies to see how CollaboRanger affects users' experience in coordinating different formats of information in ephemeral teams. In this study, participants were given several group tasks involving processing various forms of information and were asked to perform each coordination.

5.1 Study Design

Tasks. The primary tasks were to lead and collaborate in group coordination tasks with various purposes. The purpose of the tasks included scheduling a group meeting, scheduling multiple 1-1

meetings for a department visit day, and hotel picking for the group's trip planning. These tasks were widely used among prior studies for evaluating novel groupware systems [35, 36]. These tasks were instantiations of "decision-making" task in the McGrath's Task Circumplex Model [40] and as such required team members to share personal opinions in various forms and engage in discussion and coordination to arrive at a solution.

Study protocol. To explore how CollaboRanger may change the experience in coordinating different forms of information shared in ephemeral teams, we conducted a within-subjects study. We chose email as the messaging system for the control version since email is most commonly used channels for ephemeral teams [41]. Participants were informed that they can use other collaborative tools of their choice with email. The order in which they conducted the control and experiment version was randomized. The procedures were as follows:

(1) Task introduction: Each participant was invited to a session on the day to start the study, where they received a brief tutorial on how to use CollaboRanger and tried it out on a sample task (making a shopping list). We also introduced them to the last task they would conduct over the next two days. Participants attending the tutorial on the same were grouped together to conduct the trip-planning task.
(2) Group-scheduling task (maximum 15 minutes, x2): A group was trying to meet together for an hour and participants were asked to reach out to other members, ask for their availability, and help schedule a time for the group meeting. A Google calendar was given to each participant as his or her own schedule and the other three imaginary members shared their availability in different forms, ranging from bulleted plain text, google calendar link, to Calendly.com[4] link. Like prior work [36], the responses from the rest of the users in the group were pre-programmed and sent automatically once the participants sent the message. If a participant can't finish the task in 15 minutes, we stop them and record the completion time as 15 minutes.
(3) Visit-day-organizing task (maximum 15 minutes, x2): The participant acted as an employee at a company where there was a visit day event coming up. Each participant was assigned by the work admin to reach out to the three visitors individually, send them warm welcomes, and schedule a 60-min 1-1 meeting with each of them in the coming week.
(4) Trip planning task (over three days, x2): The group of participants spent two days engaging in a collaborative hotel-picking. The second round of the task using the other treatment began when the group wrapped up with the task using the first interface by reaching an agreement of what hotel to pick. In the control condition, the group was asked to plan a trip to and pick a hotel in New York City, while the experimental condition picked a hotel for San Francisco. Each member shared a few hotel suggestions from their preferred hotel-booking website by sharing different mediums such as links and screenshots of the website, and explaining their brief reasons. Then the group engaged in discussion regarding candidates based on everyone's preferences and compared the hotel amenities to collectively pick one. Specifically for the experimental condition, group members were asked to create a list of hotel candidates using CollaboRanger table based on everyone's suggestions. How exactly the tables should be structured was not specified and was up to the participants to decide.
(5) Exit interview & survey (30 minutes): At the end of the study, participants engaged in a 30-min exit interview and survey focused on understanding their experience and eliciting feedback on our system. The interview was semi-structured and guided by a list of questions attached in the Appendix. Similar to workshop study, the first author conducted axial coding

[4]https://calendly.com/

of the interview transcripts with an open-coding protocol. The authors then discussed and refined the codes.

Participants. We posted a recruitment blob on the mailing list of a private university. In addition, participants in our workshop study were invited to this study. As a result, one of the previous participants took this study as well. Each participant was compensated $40 per person for their time (for an effective pay of $16/hour). In total, 23 participants responded to the recruitment email. We assigned them to one of 5 groups by the order of the responses. Two people dropped out after signing up (remaining 10 females, 9 males, 2 prefer not to say). Participants' ages range from 19 to 60+ and occupations included vice president of a company, research associate, software engineer, mechanical engineer, designer, undergraduate students, graduate students, and client relations coordinator.

5.2 Measures

We used the following measures to compare the experiences. The measures were applied to usage logs of the system and self-reported data via an exit-survey and exit-interview.

5.2.1 Completion time. To measure how fast the users can finish tasks under different treatments, we measured time to complete the lab-study tasks (i.e. scheduling task and visit-day task). We did not measure the time for the deployment task (i.e. trip-planning task) as the task was open-ended and did not have answers or outcomes.

5.2.2 Perceived workload. For the exit-survey, participants rated on a scale of 7 (1=definitely disagree, 7=definitely agree) in each condition, if they thought their team were able to make an informed decision and if they were able to compare trade-offs between the different suggested hotel options. Participants also filled out a NASA-TLX survey [24] on their experience with their overall experience using CollaboRanger. We omitted the question about physical demand as our tasks were not relevant to the metric. The questionnaire for the exit-survey is attached in the Appendix.

5.2.3 Group interaction. The conversation logs during the collaboration tasks were analyzed using the linguistic dictionary Linguistic Inquiry and Word Count (LIWC) [49]. Qualitative results through exit-interviews were also accompanied to understand group interaction.

5.3 Study Results

When in the control condition, three teams utilized collaborative editing documents or spreadsheets. Here, we describe their feedback and performance with both. Using CollaboRanger, participants created situated tables to compare responses across different options. We ran a two-sided paired t-test to compare completion time in the control and the experiment condition (Fig. 10). We analyzed responses of the exit survey using a mixed effect model (Table 3).

CollaboRanger lets users more easily collect and compare across responses made by their own preferred tools. Users were able to more efficiently conduct coordination tasks across multiple format of information using CollaboRanger than the control condition. In the group-scheduling task and visit-day-organizing task, we measured the amount of time taken to complete each task in both the control and experiment conditions. Specifically as shown in Fig. 10, we found from the measured completion time that when using CollaboRanger, users were significantly faster ($\overline{x}$=3.9) in the group-scheduling task (p<.01, Fig. 10) than when using the control interface ($\overline{x}$=6.6). They are marginally faster ($\overline{x}$=4.8) in the visit-day-organizing task (p<.1, Fig. 10.right) than when in the control condition ($\overline{x}$=6.3). Users believe that the gallery view cuts redundant steps from their normal practice to manually create a similar effect. In the control condition, they had to go back and forth remembering information across multiple windows or even threads in

Table 2. Comparison of messages exchanged in different conditions for the trip-planning task. When participants used CollaboRanger first, they tended to have similar amounts of total word counts. However, for the opposite cases, there tended to be drastic decreases in word counts when they used CollaboRanger.

	Group 1		Group 2		Group 3	
	CollaboRanger	control	CollaboRanger	control	CollaboRanger	control
# of messages	13	12	14	7	11	9
Total word counts	264	235	265	266	464	314

(a) Groups exposed to the control condition first

	Group 4		Group 5	
	CollaboRanger	control	CollaboRanger	control
# of messages	12	13	11	9
Total word counts	265	502	133	280

(b) Groups exposed to the CollaboRanger condition first

the visit-day-organizing task where multiple individual threads were involved. It became easy for them to forget comparisons already being made and would have to recheck. To mitigate such challenges, some participants even open up personal notes or Google doc to write down their thinking process. When using CollaboRanger, however, participants commented, *"I can write down the times I'm comparing using the summary textbox and ... cross things out if it doesn't work for everyone"*. CollaboRanger helps them to track their thoughts. One of the participants mentioned that the table-making process was *"tedious"*, but it had *"the great paid-off"*. They sought automatic response extraction using NLP techniques for better user experience.

In addition, users felt that, coordinating information from different tools overall using CollaboRanger compared to the control, it was significantly less hard to achieve a more successful result in accomplishing the task they were asked to do (Table 3). Specifically, users found CollaboRanger to be *"more convenient"* as they can *"have the options side by side [and] look at [their] notes for each of the different options all in a singular place without having to scroll (along long conversation threads) or switch tabs"*. CollaboRanger also felt less mentally demanding as it offloaded the memorization that users would have to do when working across multiple channels linked to by the responses. One participant described his mental stress using the control interface: *"I had to open three different emails or calendars and I had to try to remember when I was scheduling times. I had to try to remember when everyone was free."*. When using CollaboRanger, however, *"even doing multiple things, the information is already sorted out for me in one screen (so it) required much less mental bandwidth."*

CollaboRanger also led groups to make more informed and effective decisions (Table 3) and was influential in the way users coordinate. CollaboRanger not only facilitates coordination, it even noticeably influences the groups' behaviors. As analyzing the conversation behavior for the trip planning task in both conditions (Table 2), we discovered that teams who start with CollaboRanger first preserve the same pattern of conversation whereas groups who did the control condition first were greatly impacted by CollaboRanger. In fact, one of the groups, which conducted the experimental version first, adopted from CollaboRanger the table concept to create a collaborative-editing spreadsheet later on for their control condition. Participants remarked that they found themselves constantly referring to the original conversation and the table in the process. Hence, even the spreadsheet and CollaboRanger provide similar visual organization, in CollaboRanger the referring was easier as both conversation and tables can be viewed in one interface, and helped them understand the context within the conversation.

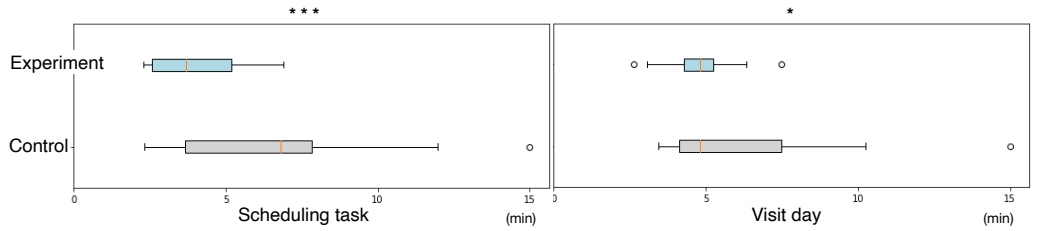


Fig. 10. Completion time of scheduling task (Left) and visit-day-organizing task (Right) in both conditions. Participants were significantly faster at the scheduling task and marginally faster at the visit-day-organizing task when using CollaboRanger (p < .01 ***, p < . 05 **, p < .1 *)

Table 3. Results of self-rating by study participants. They are analyzed using a mixed effects model with random effects for teams and participants fit by maximum likelihood. As a result, there are significant differences between different treatments (control and experiment) in all attributes (p < .01 ***, p < . 05 **, p < .1 *)

Metrics	Informed decision		Trade-off comparison		Mentally demanding	
Fixed effects	(Intercept)	Treatment	(Intercept)	Treatment	(Intercept)	Treatment
Coefficient	5.59 ***	0.94 ***	5.00 ***	1.53 ***	4.35 ***	-2.18 ***
p-value	<.01	<.01	<.001	<.01	<.01	<.01

Metrics	Hard work		Stressed		Successfulness	
Fixed effects	(Intercept)	Treatment	(Intercept)	Treatment	(Intercept)	Treatment
Coefficient	4.24 ***	-1.88 ***	3.59 ***	-1.82 ***	6.24 ***	0.41 **
p-value	<.01	<.01	<.01	<.01	<.01	.03

Natural group leaders lead with less stress and bystanders stay more informed with less effort using CollaboRanger. Users participating in the trip planning tasks as ephemeral groups indeed organically and dynamically took on the role of leaders and bystanders, echoing our workshop findings. As our participants described in the exit interview, throughout the two versions of trip planning tasks, leaders differed from task to task and there were also multiple leaders during different parts of the coordination process within each task.

Among those who identified themselves as a leader in some parts of the decision making process, users felt they were less stressed in coordinating responses and moving things forward (Table. 3). A leader said, *"When I was making that table with all the amenities, I could just pick their URLs and and I can go to the URL viewer mode (gallery view) and open all of them."* By seeing all the amenities and summarizing them in another row, they thought *"it was definitely easier to process and address everyone's response here"*. Another user mentioned that they were "so stressed" when they were conducting the task using the control, because they worried that they accidentally forgot to include some responses from some users in their team.

Users also felt more comfortable leading the progress as making the CollaboRanger table could also act as acknowledging others' responses and contributions. One leader said, *"It feels actually more comfortable in this case as leaders normally have to take on extra responsibility for what they say"* as explained by one user. Another leader said that filling out the table is like a better version of emoji in chatting interfaces. They explain that it is not only acknowledging each participant's response but also helping to sensemake everyone's responses.

Lastly, organizing responses using the collaborative table made it easier for natural leaders to keep track of the teammates making sure everyone had their input. *"I don't have to dig into the long threads of messages and usually things get easily missed"*. Specifically, based on the tables participants created, two of the groups used the sub-thread feature to bump for responses and they found it convenient having the response going right into the cell. One leader even created a third table bumping individually and collecting everyone's final choice to address and better visualize potential consensus across all members' opinions.

Among those who described themselves to be more like a bystander in some cases, users didn't feel overwhelmed by the "fancy" table created by leaders as they might have judged others according to our previous workshop participants when being presented YouCanBookMe. They thought the table structure made it clear enough of what it meant. Furthermore, bystanders even appreciated the table for helping them keep up with the progress. Specifically, users felt it required less effort from people who are not organizing and CollaboRanger made the conclusion very visible with the summary feature. For some bystanders who joined in late for sharing suggestions and for discussion when other members have already moved to started to win on some choices, they just *"looked at the table at what they're talking about and it made sense."* On the contrary, participants argued that this would be hard to achieve using the control interface or even other online chats such as *"even if people add [bulleted list], we kind of get lost in the sea of text"*.

Moreover, even given the natural roles of leaders and bystanders, groups using CollaboRanger were in general more engaged in conversation and experienced more equal roles among members. Through analyzing the discussion thread using LIWC, we discovered that teams when using CollaboRanger had an increase in use of *you* (p=.03) to address each other. This was echoed by users feedback during exit interviews where they thought the sub-thread feature in the table made it easier to address and track individual group members. Furthermore, there were also more *social* words (p=.007) and *informal* words (p=.06) used when discussing on CollaboRanger, indicating that group members were more socially connected with each other on CollaboRanger [34]. This was surprising as even bystanders started to engage more. One participant describing herself to be more of a bystander in both trip planning tasks expressed that, once someone in the group had strong preference or the majority seemed to agree, they tend to trust and follow with their choice. However, they felt that the table their group made and organized by members seemed to more *"equalize"* the opinion of all members even if it might be a minority idea, promoting her to still make her input.

CollaboRanger helps users to stay informed when the task spans a longer period. By preserving the structured information and relevant summary made, *"when going back and trying to refresh the memory ... A few days later, it was definitely much easier in CollaboRanger"*. When asked to submit a brief write-up for the final hotel decisions and the reason why it was picked over the others, users were able to come up with a more detailed explanation in much shorter time when answering about the decision made using CollaboRanger, regardless of the order of the task. Users even came up with other use cases in which they would find CollaboRanger supportive when discussing their experience using the tool. *"I would imagine it to be useful in scenarios when I'm reaching out to a lot of people for job referrals and I want to make sure to keep track of our conversation to be able to come back easier."* as one user commented.

6 DISCUSSION

We presented a workshop study focusing on coordinating tool preference in cross-boundary teams. Then, we provided empirical findings using design concepts resulting from the workshop. Our design was inspired by previous literature regarding individual differences in task management, gap between personal tools and group tools, sense-making system as well as our workshop study.

Here, we also share the potential of having structured interpretation of conversation as a way to increase social acceptance for cross-boundary group coordination tools and tighter connection between personal tool preference for information sharing and easier group coordination.

6.1 Design Implications for Social Coordination Systems

While some people prefer highly structured information, especially for coordinators (leaders) who are responsible for bringing everything together, others prefer the momentum-building free-form of communication and would feel overwhelmed and shed away by overly-structured tools. From our workshop study, this was among reasons why individuals would tend to judge new tools shared by others. Difference in preference for how structured information should be presented therefore hinders the adoption of new tools. A careful balance between the two would mean less adoption barrier for both as it eases the job for coordinators while allowing smooth communication between all members. Previous works [8, 36] decided to hide the coordination tool from the bystander class. This finding contributes insights in that, unlike neither in-organization or personal tool adoption explored by previous literature, tool choices of cross-boundary teams are less studied and we discovered that cross-boundary teams sacrifice efficiency for social acceptance in group coordination.

In our user study, we allowed visibility to the coordination features for all members yet observed that both coordinators (leaders) and regular participants (bystander) felt comfortable and benefited from the additional features when they used CollaboRanger. By building another level of structured, yet familiar, interpretation (e.g., table) directly sourcing from participants' responses, individuals felt the synthesized information, though structured, to be more closely tight to original opinions and were intuitive and easy to parse through with little or no learning curve. Having the table displayed within the free-form discussion channel and being able to view responses on one site even if they link to other web pages, both coordinators (leaders) and regular participants (bystanders) also found it more straightforward in terms of how to contribute to the group sensemaking, what decision or conclusion have been made, as well as the reasons why.

In addition, while veering away from free-from conversation ought to make conversation being more rigid and brittle, however, contrary to the well-known belief [16], we found that users were able to engage in more social conversation when they use CollaboRanger in our user study. Similar findings were also observed in prior systems to add semantics and structure conversation [48, 65]; users of the systems try to be more mindful about other users and helpful to the group collaboration. We believe that this is possible because the systems help users sensemake the conversation and allows users to have the mental capacity to be more social. Additionally, the visualizations facilitated by our table interface could be a significant factor in promoting social behavior, aligning with insights from prior research [7]. As a matter-of-fact, our users felt the same coordination tasks were less mentally demanding when they use CollaboRanger.

Taken together, we envision that structural, familiar and universal representation of conversation while embedding all relevant information on one site can overcome various barriers in adopting new coordination tools and facilitate social coordination for cross-boundary groups.

Our work suggests implication for collaborative tool designers. Collaborative tools should be mindful and expect that different people might have different tool preferences or have go-to tools that they have been using. Instead of allowing only a unified form of responses, such tools should accept various forms of responses. Currently, the tools assume each user being responsible for sharing and converting their own information; the future tool can leave it up to cross-boundary team members to organically figure out who will take over the conversion. Our work also implies that it is a promising social-bond-building exercise.

A practical implication from our research is for people to pay more attention to personal tool preference. In cross-boundary teams, it is possible that some people might feel comfortable taking initiatives and suggest using a fancy tool to get over the coordination burden. One important findings from our study is that underlying annoyance exists. This might be easy to ignore or hard to recognize because people tend to not disclose the feeling [14]. Even within a workshop session, participants often remark to the others' comment who were not happy about being told to use a new tool: *"Oh, I never thought that way."* Hence, a takeaway is that acknowledging the spectrum of comfort to a new tool, and that one might not like to adopt new tools even if others do.

6.2 Opportunities for Discussion to Evolve around Different Level of Coordination

The empirical findings of our work suggests implications for designing team process in cross-boundary teams. To aid information synthesis and preserve such results in coordination tasks, we chose to support the summary feature in CollaboRanger. When designing its functionality, we made the design choice for the summary to span the entire row for comparison across all columns, give coordinators the choice of whether to notify the team with a separate message, and only allow the notification to be sent once. The rationale behind our decision was to guide users to use a separate table for each decision or conclusion to make so that there's no confusion of which new updates result from which table. There can be many other alternatives to the design of intermediate note-taking and presenting conclusions made. In fact, participants from our user study mention the need for more flexible and dynamic discussion regarding different levels of details during coordination. We envision that CollaboRanger can provide opportunities of better tracking discussions evolving around different coordination levels. For example, instead of supporting the summary feature more like a "statement", we can imagine that allowing conversation to happen for the comparison across the options would allow all members to hop on discussing what the conclusion should be, making it more like a collaborative consensus than one person's say. Furthermore, supporting comments for each cell in the table may also bring benefits as participants can address specific concerns without always having to flood the messaging channel.

6.3 Limitations & Future Work

One notable limitation, which could pose a potential threat to external validity, is our user study's relatively small sample size, comprising only 23 participants. Furthermore, although CollaboRanger targets tool coordination, which is a universal problem in group tasks, our workshop study and user study are highly based on populations from academia. We attempted to draw our insight from participants of different team and occupation natures, such as coordinator for client and corporate relations, students at school, and few engineers or designers working in industries. This modest participant pool may restrict the generalizability of our findings to a broader population. It still remains as a future work to see if our findings expand to other populations. We next aim to deploy our system on a larger level in different backgrounds and examine how our system situates for various cross-boundary groups.

CollaboRanger also has limited scalability. The current version of CollaboRanger is only applicable to *small* cross-boundary teams. As future work to improve scalabilty of CollaboRanger, we can incorporate several methods. First, inspired by prior work [8, 36], we can use crowdsourcing to extract information from a large number of responses. To aggregate information, CollaboRanger can guide crowdworkers to recursively summarize responses [56].

We also plan to support more visual aid for interacting with the table to improve the coordination and decision making process. As some of our users suggested in the exit interview, people found it tedious to manually fill out table cells. The future work can make this process more efficient by employing NLP techniques and automatically extract based on query of table rows and columns,

which later can be confirmed and polished by users. They also argued that with more visual aids than just the summary feature would make the distribution of preference more visible when narrowing down on the options to reach a conclusion. Therefore, we next aim to explore more simpler yet dynamic interactions with the table to promote even easier engagement and visualize group reactions towards the information being compared. This could include giving a title for each table so that users are aware of one dedicated goal they are reaching, adding simple reaction to each cell for users to voice more specific opinions and visualize opinion distribution, and supporting transposing of the table when listing of comparison gets long and when users prefer viewing it vertically.

In addition, we envision different methods of contributions by conversation participants, which will allow different levels of engagement from leader and bystander users. Currently, CollaboRanger only allows two types of contribution: filling out table cells and summarizing information. On top of these, CollaboRanger can also support real-time annotation on the notable messages using emoji or tagging, which is a far less time-consuming task than existing CollaboRanger contributions. Prior work in annotating group interactions found that the annotating activity improves group sensemaking [50, 65]. Taken together, having different levels of contribution to the sensemaking process will make the group coordination more efficient and allow a flexible level of engagement by users.

7 CONCLUSION

We explore the challenges and opportunities in cross-boundary groups without having participants compromise the form in which they choose to share their contributions. In our need-finding workshop study, we found that in cross-boundary groups, individuals prioritize social acceptance over efficiency in choosing tools to use which raises great challenges having to coordinate across multiple channels. In addition, organically developed roles of leaders and bystanders among cross-boundary groups makes group tool adaptation even harder. To address these challenges, we designed CollaboRanger as a coordination tool to facilitate at scale easy collection and visual comparison across multiple forms of responses and allow both leaders and bystanders to flexibly engage. Our user study revealed that CollaboRanger fares well as a group coordination tool that enables users to coordinate more easily and efficiently while all roles of the group are more comfortable and successful at what they want to accomplish. We hope that findings from our studies can inform future researchers on how they design CSCW applications for cross-boundary teams.

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A INITIAL LIST OF TASK CATEGORIES FOR PRE-WORKSHOP SURVEY

(1) What are you asked to do from the colleagues via email or messaging apps (e.g., slack)? Select all that apply and add to "Others" anything that's not included.
   - Code related: e.g. fix bugs, add features, migrate data, verify code, etc.
   - Scheduling meetings, rescheduling and sending reminders
   - Prepare documents by deadline
   - Approvals: e.g. sign a document
   - Provide feedback on projects, ideas, etc.
   - Review a conference paper
   - Recommendations: e.g. how to design user studies, list of relevant papers, etc.
   - Asking for letters: e.g. recommendation letters, department letters
   - To participate in user study: e.g. fill out a survey, fill out a form

(2) What do you often ask your colleagues to do via email or messaging apps (e.g., slack)? Select all that apply and add to "Others" anything that 's not included.
   - Code related: e.g. fix bugs, add features, migrate data, verify code, etc.
   - Scheduling meetings, rescheduling and sending reminders
   - Prepare documents by deadline
   - Approvals: e.g. sign a document
   - Provide feedback on projects, ideas, etc.
   - Review a conference paper
   - Recommendations: e.g. how to design user studies, list of relevant papers, etc.
   - Asking for letters: e.g. recommendation letters, department letters
   - To participate in user study: e.g. fill out a survey, fill out a form
   - Can you help me with my computer problem (to IS&T)?

(3) What is your occupation?
   - Undergraduate student
   - Graduate student
   - Postdoctoral researcher
   - Professor
   - Management
   - Employee at a research institute
   - Employee at a company
   - Other (Please specify:)

(4) If you fill out "Other" option, please provide your email for the potential reward ($20 amazon giftcard)

B EXIT-SURVEY QUESTIONNAIRE

Questions are on the scale of 7 (1=definitely disagree, 7=definitely agree). The questions are repeated for CollaboRanger and tools that they used in their control condition.

- Using [the tool], my team members and I are able to make an informed decision.
- Using [the tool], my team members and I were able to compare trade-off between the options.
- How mentally demanding was making group decisions using [the tool]?
- How successful were you in accomplishing what you were asked to do using [the tool]?
- How hard did you have to work to accomplish your level of performance when using [the tool]?
- How insecure, discouraged, irritated, stressed, and annoyed were you when you are doing tasks using [the tool]?

C EXIT INTERVIEW QUESTIONS FOR USER STUDY

(1) Please open your email thread for your team's NYC trip planning. Please write a brief explanation of what hotel your team picked and the reason why.
(2) Please open the CollaboRanger thread for your team's SF trip planning. Please write a brief explanation of what hotel your team picked and the reason why.
(3) Can you compare the experience of planning a trip using email vs. CollaboRanger?
(4) Overall, please describe your experience using CollaboRanger.
(5) For the scheduling and visit day organizing task in our tutorial session, you were able to finish much faster using CollaboRanger than when you use email. What do you think the reason is?
(6) Are you normally leading to get through the decision, or let someone else lead you when coordinating something with others?
    - (if leader) With CollaboRanger, are you able to lead and make your team progress like you would?
    - (if bystander) With CollaboRanger, are you able to see your team leader's contribution and make sense of information?
(7) Are there scenarios in which you'd use one over the other when coordinating contributions?
(8) How willing to engage (to actively coordinate and drive decision-making) were you when using CollaboRanger and when using email for each task?
(9) Would you, and in what scenarios, continue to use CollaboRanger for task coordination in the future?
    - if yes, why? what did you like about it?
    - if no, why? what's stopping you from using it?