Characterizing and Predicting Email Deferral Behavior

Bahareh Sarrafzadeh*
University of Waterloo
Waterloo, Canada
bsarrafz@uwaterloo.ca

Ahmed Hassan Awadallah, Christopher H. Lin, Chia-Jung Lee, Milad Shokouhi, Susan T. Dumais
Microsoft
Redmond, WA, USA
{hassanam,christol,cjlee,milads,sdumais}@microsoft.com

ABSTRACT

Email triage involves going through *unhandled* emails and deciding what to do with them. This familiar process can become increasingly challenging as the number of unhandled email grows. During a triage session, users commonly *defer* handling emails that they cannot immediately deal with to later. These deferred emails, are often related to tasks that are postponed until the user has more time or the right information to deal with them. In this paper, through qualitative interviews and a large-scale log analysis, we study when and what *enterprise* email users tend to defer. We found that users are more likely to defer emails when handling them involves replying, reading carefully, or clicking on links and attachments. We also learned that the decision to defer emails depends on many factors such as user's workload and the importance of the sender.

Our qualitative results suggested that deferring is very common, and our quantitative log analysis confirms that 12% of triage sessions and 16% of daily active users had at least one deferred email on weekdays. We also discuss several *deferral strategies* such as marking emails as unread and flagging that are reported by our interviewees, and illustrate how such patterns can be also observed in user logs.

Inspired by the characteristics of deferred emails and contextual factors involved in deciding if an email should be deferred, we train a classifier for predicting whether a recently triaged email is actually deferred. Our experimental results suggests that deferral can be classified with modest effectiveness. Overall, our work provides novel insights about how users handle their emails and how deferral can be modeled.

KEYWORDS

Email Management, Triage, Deferral, Users Behavior Modeling

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1 INTRODUCTION

Email is one of the most popular online activities and remains a major tool for communication and collaboration. It is estimated that 269 billion emails were sent and received per day in 2017 [26], and studies show that information workers tend to spend up to 28% of their time reading and answering email [5].

Email usage has significantly evolved beyond *communication* to encompass other areas like *task management*, *archiving*, etc. Mackay [19] presented one of the earliest studies examining how email was being used for more than just communication, a phenomenon often referred to as "email overload" [31]. Since then many researchers [3, 7, 13, 31] have studied the close tie between people's tasks and their email practices. Venolia and Gupta [28] then consolidated these findings into five areas of email activity: flow, triage, task management, archive, and retrieve.

Email *triage* is the process of going through unhandled email and deciding what to do with it. Email triage can quickly become a serious problem for users as the number of unhandled emails grows. During a Triage session, users commonly defer emails until later to manage overflow[25]. Email *deferral* is directly related to task management, and occurs because people have insufficient time to take an immediate action or they need to gather information before they can act on a message [3, 30]. Dabbish et al. [6] showed that people defer responding to 37% of messages that need a reply. Similarly, in a sample of the logs of a popular email client we analyzed, we found that while around 10% of all messages receive a Reply, a ReplyAll or a Forward action; 26% of these actions are taken at a later time (not immediately following the first read) indicating the significance of deferral.

The fact that a user defers an email does not imply that the message is less important. A deferred email could be very important and therefore requires careful examination and a well crafted reply. Alternatively, it could be not important enough to warrant immediate attention. Deferral could also be a result of other factors unrelated to the message such as the current user workload and the device she is currently using. For example, a common scenario for deferral involves the increasing use of mobile devices for day-to-day task management. Not only does triage play a more prominent role on mobile devices, users also need to accomplish it more quickly because of the short, intermittent nature of mobile interactions [20]. Past research on smart phone use suggests that mobile users primarily identify what emails to delete and to handle immediately, and defer handling most messages until they reach a larger device [23].

Understanding email deferral characteristics, strategies and motivations could help develop new experiences to empower people to get tasks done more efficiently. In this paper, we present a detailed study of email deferral. We employ a *mixed methods* approach where we combine qualitative and quantitative analysis to better characterize deferral in email. We present a large-scale log analysis of forty thousand anonymized users of a popular commercial email client. We complement the log analysis with a qualitative study where we perform

interviews to gain more insights into the motivation for the observed user behavior. Inspired by the insights we develop from characterizing email deferral, we define a prediction task to support email deferral using features of the email message, user workload and behavioral logs. We also discuss the implications of this work on designing email clients to help users be more efficient with managing their mailboxes.

Previous research has mostly focused on email organization and management [25, 28, 30]. However, to the best of our knowledge, understanding why people defer emails and what strategies they use to go back to them have received much less attention. In particular, we focus on the following research questions: How is deferral defined and perceived by users? [**RQ1**] How common is deferral? [**RQ2**] What motivations are behind deferral? [**RQ3**] What factors impact deferral for an email? [**RQ4**] What strategies are employed for deferral? [**RQ5**]

To address these questions, and as our first contribution, we conduct a qualitative study, using interviews, to understand why and how people defer messages and what affects their decision (Section 2). As our second contribution, we then present a detailed analysis of email deferral by performing a large-scale log study of email interactions of thousands of users (Section 3), that largely supports the trends observed in our qualitative interviews. Inspired by our qualitative and quantitative learnings, we define the task of predicting email deferral from user interaction logs and describe a model for identifying deferred messages using a large number of features (Section 4). Next in Section 5, we discuss the implications of our study on designing email clients. Finally, we provide an overview of the most related work in Section 6, before we conclude the paper in Section 7.

2 DEFINING EMAIL DEFERRAL

Siu et al [25] used a day long in-situ shadowing study, and observed that users explicitly mark emails for later action (e.g. mark messages as "Unread", leave message windows opened on the desktop, etc.). However previous literature has little information on how often users postpone required actions within their inbox during the day, what are the motivations behind this behavior and what strategies are used for revisiting these deferred messages, choosing instead to focus on other aspects of use such as triage or task management. Furthermore, there is no consensus on a formal definition for deferral, and little understanding on how it can be inferred from the user actions. To address these gaps, we conducted a qualitative study through a series of in-person interviews. The interview data helped us understand how deferral is perceived by enterprise workers, highlighted the motivations behind deferral and the strategies that are employed to facilitate getting back to deferred messages.

2.1 Interview

We recruited 15 participants (4 female), all above 18, with a very diverse set of roles within Microsoft, ranging from product managers and researchers to software developers and interns. Interviews were scheduled for 30 minutes in the participant's office where they had access to their mailbox during the interview. All participants used Microsoft Outlook on a daily basis and some of them used other email clients as well. Part of the interview was conducted as a contextual inquiry, where the participants were asked to look through their mailbox and share some information about any emails that they had received on the day of interview and *had to leave for later to deal with.*[1] We were mostly interested in learning about what those emails were about, what was the participant required to do in order to take care of that email, what was the relationship between the sender and the participants, whether there were multiple recipients on the emails, why did they decide to leave it for later to deal with, what would "dealing with" involve when the participant does go back to the email, how soon they are planning to do so, and finally whether they employed any strategies to facilitate this revisit.

For the remainder of the interview, the participants were asked a variety of questions, such as how many emails they receive per day, what kind of email management strategies they usually employ (e.g. whether they use many folders, have a clean inbox, have many unread emails, etc.), how often they leave emails that they have seen for later to deal with, and how they decide whether they should deal with an email right away or leave it for later. We also asked them to think about the actions they take on a deferred email at the time they go back to take care of it.

Interviews were all transcribed and analyzed using affinity diagramming. Data was initially clustered using open coding producing 16 clusters. Clusters were then analyzed using axial coding to identify overall themes in the data. We found that saturation for our qualitative data occurred approximately after 10 participants, no new clusters of information were identified. However, we continued to cluster interview data for the remaining participants, particularly attuned to data that might expand our clusters or add nuance to our analysis. These clusters resulted in three broad themes, namely: deferral is common; factors that impact deferral; and revisiting deferred emails. We describe more details about these themes in the next two subsections.

2.2 Main Findings

Our interviews confirmed that deferral is common, and all our participants reported that they frequently defer some emails. *"I usually have many meetings during the day and so I just quickly look at the emails to see if it needs anything from my side, then leave it for later. This happens for half of my emails I would say."* [P4]; *"several times a day"* [P2, P11]; *"at least 1 or 2 emails everyday"* [P9];

Participants discussed a wide range of characteristics regarding the emails they deferred as well as other factors that impact their decision to defer emails during triage sessions. These factors can be grouped into 5 main classes, ordered by prominence as: (1) How much time or effort does handling this email require? (2) Who is the sender? (3) How many recipients are on the thread? (4) What is the user's workload and context? and (5) What is the urgency of the email message?.

Time & effort. The amount of time or effort needed for handling an email was identified as the primary factor influencing the decision to defer an email to a later time. Different characteristics of the email were used to estimate the required time or effort at the time an email was first seen by the participant: Do I know the answer? [P7, P11, P13] Does it require any task to be done? [P4, P12] What is the complexity level involved? [P11] Does it require context switching? [P4, P11, P13] Can I handle it independently? [P1, P11]

Sender. The sender of an email and the relationship between the sender and the recipient was another factor influencing deferral. Participants mentioned different notions of 'importance' for a sender:

[1] The participants were asked not to share any confidential information and use general terms to describe the content of those emails.

based on the projects they are affiliated with [P9, P11]; based on their organizational rank [P2, P11, P12] or based on their proximity [P11, P12]. Time zone of the sender could also lead a recipient to prioritize handling the email in two different ways: *"If I receive emails that I know it's like 3-4 pm their time, I try to answer those first because then they can move on with their day before work hours are over.* [P10]; *"And the ones that I'm the only recipient then I usually try to answer as fast as possible. unless I know that the other person is sleeping right now.* [P6]

Finally "Intended Responsiveness Image" emerged as another factor that some of the participants considered while deciding how quickly they need to respond to an email that they just saw. As identified by Tyler and Tang [27], users often maintain and cultivate a responsiveness image for projecting expectations about their email response. *"There are times that the relationship between me as the recipient and the sender is such that I don't want to respond right away. Sometimes it's because the sender is not very important and sometimes it's because I don't want to come across as too available"!* [P2]

Recipients. Having multiple recipients on the thread commonly led to a delay in handling the email for two different reasons: If there is an overlap in knowledge and ability in handling the email a recipient might choose not to act knowing other recipients can also take care of it [P6, P9]. Different participants mentioned the need to be able to identify whether or not *they* are expected to handle the email: Can I immediately tell if *I* need to take care of it? [P7, P13]; Am I explicitly mentioned? [P12, P13]; Am I on the To line or the CC line? [P7, P12]. Another related case was active email threads with multiple recipients on them: *"there are many cases with those threads where multiple people have already responded and I should read it for a while to see who said what."* [P9];

Workload. The context and workload of the user was identified as an external factor impacting the deferral decisions at the time of first visit to an email. The context of a user involved the workload (e.g. number of pending tasks, number of unhandled emails), current task at hand (e.g. coding, attending a meeting), their whereabout (e.g. at office, at home, in transit) and access to resources (e.g. having access to a large screen, having their planner handy, etc). *"I use conditional formatting to know which emails I am on the To line vs CC line and if the email mentions me. So the issue is not identifying those emails, the main problem is when I don't have time to deal with them. e.g. running into a meeting. So I have to flag them and remember to go back to my flagged emails later."*[P4]; *"generally it's because I have something else on my plate right now that should be finished first before I have time for handling the email."* [P13].

Urgency. we learned that the urgency of an email was perceived in at least two different ways: urgency for the recipient of the email versus that for the sender. For both notions the participants would evaluate the urgency of an email based on (a) whether a deadline is specified in the email, and (b) if there is a deadline for the task / project with which this email is affiliated. *"[How soon I revisit deferred emails] would depend on their urgency. I keep that in mind as scrolling past them and thinking they won't need that just yet."*[P7]; *"I would rather read all of them and then start working on them than start working on the ones that I have already read; because something that could be five emails down could have a one hour deadline, whereas something that just came in may have a one day deadline."* [P12].

2.3 Characterizing Revisits

Based on the qualitative data that we collected, there are three main aspects to revisiting deferred emails: *how*, *when*, and *what*. The first aspect (how) is about strategies employed by users for deferral. The second aspect (when) is related to factors that influence the time of revisit. Finally, the third aspect (what) is regarding the actions taken by users when handling their revisited deferred emails.

Deferral strategies (How). Deferral Strategies seem to be affected by the users' email management attitudes and behaviors. Previous studies have demonstrated the different strategies employed by email users to manage messages. Whittaker and Sidner [31] classified users into frequent filers, spring cleaners, and no-filers, which was later extended by other classifications ([14, 17]). Similarly in our study we identified a connection between the choice of deferral strategy and the user's general inbox management attitude. For example, *zero-inbox*[2] users and filers who frequently move emails out of their inbox do use their inbox as a TODO list and leave their pending deferred emails in the inbox as a reminder to go back to them. *Zero-unread* users who actively try to minimize the number of unread emails in their inbox do use *MarkAsUnread* as a strategy to facilitate finding the pending emails to go back to them. Although *flags* were used by a variety of users types, it was perceived differently by pilers, zero-inbox or zero-unread users. While pilers seemed to use flag as a way to remember about pending items that are usually mixed with many other unread emails in the inbox, zero-inbox or zero-unread users usually apply flags to indicate an important or urgent email. Some participants used a mix of email functionalities to mark pending emails that require a response while others used external tools such as OneNote, Planner, Calendar, etc. to plan for and schedule their pending tasks that were corresponding to their pending emails. *"So my general strategy [during Triage] is I flag emails that need a response. If a task needs to be done I add it to my schedule as a block in my calendar."* [P4].

Scheduling (When). Participants often took a variety of factors into account to determine the time to go back to a deferred emails. Two main factors were common across all participants: (1) estimating the amount of time, prerequisites and resources required to handle that email, and (2) finding the best available time slot in their schedule to handle that email. Focusing on the prerequisites of handling an email, participants talked about a variety of such requirements including whether or not they need to consult with a colleague [P10, P11], what sub-tasks handling this email involves [P9, P12] and where they should be to handle this email [P8, P13].

Even after the user has determined the time and the prerequisites to handle an email or the tasks associated with it, finding the right time to do it turned out to be a different process that involves optimizing two different variables: (a) minimizing context switch, and (b) minimizing the number of time slots to be assigned to handling a single email. *"a lot of people find that most of their energy is spent switching gears and so if you want to minimize the amount of gear switching then every time you flag something for later you should indicate what kind of later it is. "* [P13]. *"So when I have 30 minutes I want to devote it to something longer. [...] and then for easy tasks I'm gonna do it when I have five minutes and I won't do it when I have 30 minutes."* [P12].

Handling deferred emails (What). As mentioned earlier, one of the interview questions was about the actions participants take when they go back to a deferred email. We collected responses for both the

[2]https://www.goodreads.com/book/show/8660916-inbox-zero

specific emails that were deferred on the day of the interview as well as the more general discussions regarding the past deferral cases. The *need to respond* was identified as the *most common action* users take when they revisit deferred emails: *"[the main reason for deferral] is just that I wanna think about this a little bit, so I let it roll at the back of my mind to see how I should respond to this."* [P2]; *" basically going back to emails almost always involves responding."* [P6]; *yeah if it's unread it's because I need to do something with it. And when I go back to it I pick up the conversation thread and reply."* [P5].

While all participants talked about "response" as the most common action they take for their pending emails, this response is not always a "Reply" action on the deferred email; composing a new message or a face-to-face or phone conversation were also mentioned as ways to follow up and resolve a deferred case. *" it's definitely a case that I choose not to respond [to a deferred email] if it becomes more urgent for that person then they email me back or come to my office and get things resolved more efficiently."* [P7]; *"if it's something that says hey we need to organize something I don't need to respond to that email. I just set it up and then [...] I start a new thread saying that."* [P12].

We also recorded a few scenarios where the user needed to defer an email to be able to read it for a extended period of time. The most common scenario with *long read* involved active threads of emails with multiple recipients on them. Some of these cases would still result in a reply to the thread, while sometimes the user just needed to stay informed.

2.4 Summary

In our qualitative study, we directly investigated each of the research questions outlined early in this paper. Our interview questions were designed to minimize priming the participants with our definition or specifications of deferral. To this end, we referred to the concept of deferral as "emails that are seen but were left for later to be dealt with.", while the terms "later", "dealt with" and the reasons behind this behavior was open to interpretation by the participant. Participants differed in their perception of what "later" means for a deferral case. The majority of participants considered a message left for a day as deferral. Short term deferrals were also common among participants; especially when they were specifically asked about them. We also learned that in almost all cases of deferral, the user intention is to return to an email and *complete the task*. That often involved taking a strong action like replying to the email. Therefore, we define an email as deferred after being read for the first time if:

> the user deliberately postpones completing the task related to it to later (RQ1).

Our interviews confirmed that deferral is common and was reported by all fifteen participants in our study (RQ2). We learned that users defer emails mostly due to lack of sufficient time for handling emails and related tasks that may involve synthesis and collecting resources (RQ3). Indeed, deferral was mentioned as an effective time and task management technique for reducing context switching. Our participants pointed out several factors that influence their decision about deferring an email, including the time and effort, sender importance, number of recipients and previous emails on the thread, their workload at the time of reading the email for the first time, and urgency of the email (RQ4). We discovered that users apply various strategies to stay on top of their deferred emails and tasks (RQ5). Marking emails as unread after reading, came up as of the most common strategies, which confirms previous related findings [25]. Creating dedicated folders, or transferring tasks to external tools, such as note taking tools, were preferred by some of the participants, although they were not as common.

In the next section, we revisit the same questions through a different lens, by characterizing deferrals in the user action logs of a commercial email provider.

3 CHARACTERIZING EMAIL DEFERRAL

Our detailed in-person interviews highlighted several interesting aspects of why and what emails are deferred. However, obviously our findings, based on 15 interviewees, should not be extrapolated to all users. Therefore, as in the previous section, we study the research questions described in introduction, but this time quantitatively based on user action logs.[3]

We analyzed a sample of the anonymized email logs from users of a major commercial Web email client (Outlook) over a two weeks period from May 6, 2018 to May 19, 2018. The email Web client can be used on both desktop and mobile with multiple browsers. Our sample consists of forty thousand active users who performed about 3 million actions during the two weeks period. Our sample included emails from enterprise users only. The logs do not contain the text of the email message, email headers or email search queries. The email log contains actions performed against messages with timestamps and other metadata. We limit our analysis to *active* users by excluding any user that interacts with less than 1% of received email in the two week period.

3.1 Deferral in Email Logs (RQ1-2)

In the previous section, and based on our qualitative study, we defined an email as deferred when "the user deliberately postpones completing the task related to it to later" (RQ1). To quantify how often deferral can be observed in email action logs (RQ2), we first need to adopt a definition that can be measured based on traces of recorded user actions. To achieve this we have to identify what signals can be considered as proxy for *task completion* and *later*. To address the former, we decided to focus entirely on three *strong actions*: Reply, ReplyAll, and Forward, which were frequently mentioned by our interviewees as the main unhandled tasks related to their deferred emails. To set the threshold for what qualifies as later, we were again inspired by the responses from our interviewees who suggested that they would get back to their deferred emails later in the day.

Therefore, we limit our focus to emails on which a strong action is observed only in *sessions* after the initial read session. While session boundaries are well studied and relatively well understood in some related areas such as Web search [16], there is very little work on how they should be defined for email triage. Following the work on session segmentation in Web search, We segmented our logs into session based on a threshold on the time of inactivity between actions. Following Narang et al. [21], we use 10 minutes of inactivity as our threshold.[4] Based on this definition, and using our sample of email logs, we found that 16% of active users defer at least one message per day (excluding weekends), 3% of all messages get deferred, and that deferral happens in at least 12% of triage sessions. Overall, deferral is indeed common based on both qualitative interview data and quantitative email logs (RQ2).

[3] Please note that (RQ3) cannot be studied using action logs and hence is not explored here.

[4] It is worth noting that the focus of Narang et al. [21] paper was on email search. We explored a few other thresholds in our preliminary experiments and observed little difference. Hence, we left further investigations for future work.

3.2 Factors Impacting Deferral (RQ4)

We learned from our interviews the decision to defer an email can be impacted by several factors such as the properties of the email (e.g. sender, receiver) and the workload of the user. We investigate these factors using log analysis here.

Properties of deferred emails. Using our qualitative data we identified four main characteristics of messages that usually lead to deferral: (1) time & effort (2) urgency (3) sender, and (4) recipients. Among these, the first two are best inferred from email content, such as subject and body, to which we had no direct access in our logs. We could however run text classifiers blindly on the body of emails to detect whether an email is requesting any action (isActionRequest) from the recipient(s), and whether the email content is requesting a reply (isReplyRequest) [32]. We use these two signals as a proxy for "the amount of work required" to handle an email. We did not however have any indication of *urgency* of messages available in our dataset. We also used algorithmically computed metadata about the sender (i.e. Human vs. machine-generated (*isHuman*), whether the sender is important based on historical interaction features (*isImportantSender*) and whether the sender has sent any emails to the recipient(s) in the past (*isKnownSender*). We also used the number of recipients (#recipients).

Table 1 presents the distribution of these features given the type of message. It can be observed that Non-Deferred messages tend to have double number of recipients on average (*recipients*), and contain noticeably fewer number of action or reply requests (proxy for effort) than Deferred messages. Furthermore, a Non-Deferred message is less likely to be from a human or important sender and more likely to be from a known sender.

The Impact of workload on deferral. The workload of a user can be estimated using a large set of factors including the projects they are involved with, the meetings they have to attend or prepare for, the number of emails they receive and hence need to triage, etc. Since we do not have access to a comprehensive context of the user, we use two factors to estimate the workload of a user at the time she is attending to her mailbox: (1) number of unhandled messages that she received in her inbox since the last time she visited her mailbox and (2) number of meetings or appointments the user has on her calendar during the time of receiving emails.

Such features may be helpful because what users are doing may affect how they interact with their email. For example, as mentioned by many of our participants, they tend to defer more emails if they are in a meeting when they first read the email. For every message, we look at the hour and day of the initial read of that message and include counts of the total number of meetings at that time using the user's calendar data.

Figure 1 illustrates the relationship between the workload of the user in terms of number of unhandled emails and the probability of deferring a message. The horizontal line indicates the baseline deferral probability regardless of the workload of the user. The trends are consistent with our qualitative findings and confirm that users are more likely to defer a message when dealing with higher workload. Similar trends – omitted here for brevity – were observed when number of meetings is considered as proxy for workload. For instance probability of deferral increases from about 3% to 4% as the number of meetings on user's calendar almost monotonically grows from 1 to 5.

3.3 Deferral strategies (RQ5)

Our qualitative findings showed users employed a variety of strategies to manage their deferred emails. While inferring high-level

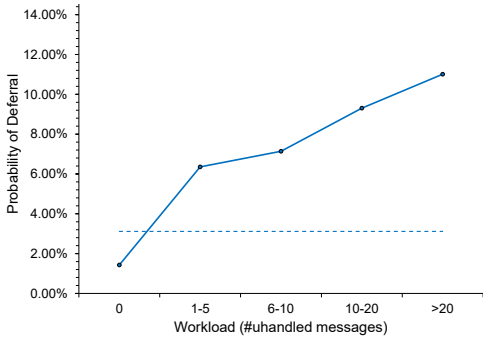

Figure 1: The probability of deferring an email based on the workload of the user measured by the #unhandeled emails

management strategies from actions logs is a challenging task, actions such as Flag and MarkAsUnread were commonly mentioned as deferral strategies (*deferralStrategy*), whereas Move was mostly used for archiving a non-deferred message or filing a deferred message when it was no longer pending (*filingStrategy*). We used our action logs to compare the probability of observing these actions given the message type (i.e. Deferred vs. Non-Deferred).

Table 3 includes these conditional probabilities for these actions along with other actions for completeness. We compute standard error confidence intervals for all probabilities in Tables 2-3 via bootstrapping, and find that all differences are statistically significant with $p < 0.05$. Looking at *Flag* and *MarkAsUnread* columns we see that they are indeed more likely to be observed for Deferred messages than Non-Deferred ones, which partially validates RQ5. However, *Move* seems to be used on Deferred messages more frequently which is in contrast to our qualitative findings – a discrepancy we return to later in this section.

In order to further investigate RQ5, we look at the distribution of actions in read and revisit sessions separately. The motivation behind this analysis is that the intent of the user at the time of first read is indeed different from the time she goes back to a message at a later time. While the intent to defer a message takes place at the time of first read, the intent to take care of a pending message takes place at the time of revisit and can similarly impact the distribution of user's actions. This hypothesis is supported by our qualitative data as users seemed to exhibit different behavior at the time of the first reading of a message (e.g. *deferralStrategy*) and the time they revisit that message (e.g. *filingStrategy*). In order to investigate the differences between read and revisit activities, we split our distributions of actions into first read and first revisit sessions.

Table 2 summarizes the probability of observing different actions in read and revisit sessions and contrast them between Deferred and Non-Deferred messages. While it is still evident that *Flag* and *MarkAsUnread* are more likely to be seen for Deferred messages, we can see that they are indeed used as deferral strategies at the time of reading these messages. Additionally, looking at the read sessions of Deferred and Non-Deferred messages, we see a significant difference in the likelihood of observing these two actions which is consistent with our qualitative findings for Q5 (*deferralStrategy*).

Another interesting observation is the distribution of the *Move* action. At the time of reading a message with the intention of deferral, observing the *Move* action is the least likely, whereas users are more likely to move a message at the read time than the revisit time if they

Table 1: Comparing the properties of deferred and non-deferred emails based on the meta-data and contents of messages.

Type	#recipients	#actionRequests	#replyRequest	isHuman	isKnownSender	isImportantSender
Deferred	3.899	0.075	0.200	0.849	0.604	0.469
Non-Deferred	7.010	0.034	0.100	0.744	0.723	0.403

Table 2: Probability of observing a given action on an email (deferred vs. non-deferred), and first read vs. revisit sessions.

Type	Delete	Flag	FlagComplete	LinkClicked	MarkAsUnread	Move	OpenedAnAttachment
Deferred-Read	0.004	0.021	0.001	0.017	0.038	0.015	0.139
Deferred-Revisit	0.054	0.005	0.011	0.014	0.008	0.086	0.096
Non-Deferred-Read	0.121	0.007	0.003	0.034	0.008	0.060	0.087
Non-Deferred-Revisit	0.054	0.003	0.003	0.008	0.004	0.0300	0.027

Table 3: Probability of observing a given action on an email given its type (deferred vs. non-deferred) .

Type	Delete	Flag	FlagComplete	LinkClicked	MarkAsUnread	Move	OpenedAnAttachment
Deferred	0.108	0.036	0.021	0.032	0.053	0.161	0.239
Non-Deferred	0.171	0.009	0.006	0.039	0.011	0.090	0.103

are not intending to defer acting on it. Furthermore, *Move* at the time of revisit for a deferred message seems to be an indicator of "being done acting on that message and hence the message is no longer pending". This behavior was also observed among our participants and more specifically for the Filers who tend to move emails out of their Inbox as soon as they are done handling them (*filingStrategy*), and explains the discrepancy observed earlier in this section.

3.4 Deferral vs. Reply

Given that all deferred emails in our dataset are associated with a strong action, it is important to verify how they are different from other replied-to emails, and confirm if there is anything unique about deferred emails.

Interestingly, we observed that replied-to emails are much more similar to Non-deferred emails in terms of their action probability distribution, but their metadata and other properties are closer to Deferred emails. For instance, the probability of *MarkAsUnread* is 0.013 for replied-to emails (compared to 0.011 and 0.032 respectively for Non-Deferred and Deferred as shown in Table 3). In contrast, the average number of recipients for replied-to emails is 3.497 (compared to 7.010 and 3.899 respectively for Non-Deferred Deferred emails, as presented in Table 1).We observed consistent trends for other actions and properties and exclude them here for brevity.

One way to explain this is that message properties may be good indicators of whether the user will take a strong action (e.g. Reply) on the message or not (as was also investigated in Yang et al. [32]). However, they may not be a strong indicator of determining whether the strong action will be taken immediately or deferred for later.

4 DEFERRAL PREDICTION PROBLEMS

We now present our experiments for predicting deferral. The ability to accurately predict whether an email is deferred has the potential of significantly improving the email experience. For example, email clients could use such a model to remind users about emails that they have deferred or even forgotten about, reducing the amount of effort they need to spend to re-find emails and the chance of them missing to act on important emails.

Since we do not have access to ground truth labels, we focus on emails that have been marked as unread or flagged (the strongest signal of deferral that we have) and predict whether the user will return to them or not. More specifically, we predict whether a message that has been marked as unread or flagged will receive a strong action (Reply, ReplyAll, Forward) in a session after the session containing the email's initial read. We choose to only predict revisits with strong actions (as opposed to all revisits) because our qualitative study shows that almost all deferred emails contain strong actions in the revisit.

Note that the problem we tackle here differs from Reply prediction, because of the element of time. We do not build a model to simply predict whether a user will reply to an email *at any time*. Instead, we build a model to predict whether a user will return to an email and and take a strong action on it *at a later time*. Our problem formulation allows us to use signals from the email's initial read session in order to help in the prediction. For example, a flag on the email could be a strong signal that the email will be returned to.

Labels & features. We first filter the sample of email logs we use in our quantitative analysis to include only those emails marked as unread and flagged, resulting in a dataset containing 10,551 emails. We label messages as positive when they contain strong actions in a session after the initial read session. For our first experiment, we remove messages that contain strong actions in the initial read session because we do not consider these emails as deferred. We will return to consider these excluded examples in the following experiment in Section 4.2.

We use a large number of features spanning different categories (see Table 4). **Action Features** include counts of user actions (e.g. Reply, Move, etc.) that occurred during the initial read session for that message. We also include **Message Features** like the length of the email body (in number of words), number of recipients and several features characterizing the sender of the message. **User Features** represent general user characteristics like the size of their mailbox (as a proxy for the amount of email messages they need to handle). We use four buckets to represent the number of emails they received in total in the entire dataset (<10, 10-24, 25-99, ≥ 100). We also use a feature to describe their triage behavior (whether they are a Zero Inboxer, a Zero Unreader, or a Piler [31]). We have shown earlier that the user workload is an important factor when she decides whether to defer a message or handle it immediately. Hence, we also included **Workload Features** to represent the user's workload in terms of messages they need to handle and meetings they have. Finally since the time of first seeing the message may have an impact on how a user handles it, we include several **Temporal Features** characterizing the time

Table 4: Features used for deferral prediction.

Name	Description
Action Features	
NumRespone	Num. of responses (Reply, ReplyAll, Forward)
NumFlag	Num. of flag actions (Flag, FlagComplete)
NumMarkUnRead	Num. of MarkAsUnread actions
NumOpenAtt	Num. of OpenAnAttachment actions
NumLinkClK	Num. of LinkClicked actions
NumMove	Num. of Move actions
NumDelete	Num. of Delete actions
NumSearch	Num. of times retrieved in search
Message Features	
UniqueBodyLength	length of the body of the email
isBulkMessage	Is email sent to a dist. list?
isInThread	Is email part of a thread?
numRecipients	number of recipients in the email
isHuman	Is sender a human (vs. machine-generated)?
isSenderFromSameOrg	Is sender from the same org?
isKnownSender	Is sender known (sent emails before)?
isImportantSender	Is the sender important (previous interactions)
User Features	
MailboxSize	Num. of receieived emails in the dataset
ManagementStyle	Piler, ZeroInbox or ZeroUnread[31]
Workload Features	
NumMessages	num. of unhandled messages
NumMessagesSLTS	- since last traige session
NumMeetings	total num. of meetings
NumMeetingsOrg	- organized by the user
TimeBusy	percent. of time user is busy
TimeFree	percent. of time user is free
TimeTentative	percent. of time user is tentative
TimeOOO	percent. of time user is out of office
Time Features	
HourOfDay	Hour of the day of first read
DayOfWeek	Day of the week of first read
DayOfMonth	Day of the month of first read
Month	Month of first read

of the first read of the message (e.g. hour of the day, day of the week, etc.). A full list of features and their description is listed in Table 4.

4.1 Experimental setup and results

We randomly split our dataset into a training set containing 80% of the emails and a test set containing 20% of the emails. Then, we perform 5-fold cross validation using the training set to select hyperparameters for the LightGBM classifier [18] (an implementation of gradient boosted trees). During training, we weight positive examples 10 times more than negative examples because about 14% of the examples are positive.

We compare our model against a simple baseline, which predicts as positive every message that has been marked as unread or flagged. Experiment 1 in Table 5 shows that using the strongest deferral signals available to predict deferral results in surprisingly low precision and F1, suggesting that users often do not go back to messages they explicitly mark. We also see that our model is able to double precision and increase F1 by over 50% compared to the baseline, showing that many additional signals are necessary to significantly improve prediction. For insight, we look at the features that have the highest Gini importance (Mean Decrease in Impurity)[18] as output by the LightGBM classifier and find that the length of the body and the number of unhandled messages are the two most important features. This result is not surprising. The importance of the length of the email is bolstered by the conclusions from our qualitative study, which showed that users consider how long responding to an email will take when deciding whether to respond or not. And the importance of the number of unhandled messages is intuitive, since users may tend to defer more emails if they have more emails to attend to.

Table 5: Experiment 1: predicting whether a message marked as unread or flagged will contain a strong action in a later session Experiment 2: limiting the prediction to only those messages that contain strong actions Experiment 3: expanding the sample of messages from Experiment 2 to include messages not marked as unread and not flagged. Precision, and recall are denoted by P and R respectively.

	Experiment 1			Experiment 2			Experiment 3		
	P	R	F1	P	R	F1	P	R	F1
Our Model	0.25	0.65	0.36	0.51	0.91	0.66	0.25	0.95	0.40
Baseline	0.14	1.00	0.24	0.41	1.00	0.58	0.41	0.06	0.10

4.2 Predicting Deferral or Strong Action?

We have shown that our model can reasonably make a compound two-part prediction: whether a user will return to an email *and* perform a strong action on it. However, it is possible that our model is simply predicting whether a user will perform a strong action, since we excluded those emails with strong actions in the same session. We next investigate whether the act of deferral can be separated out from the act of replying or forwarding.

We build a model to predict whether a user will return to an email after first read *given* that they have performed a strong action on it at any time. In other words, we consider only those emails with strong actions, and predict those whose strong actions occur only in sessions later than the initial read session. By only considering emails with strong actions, we reduce the size of our dataset to 3339 messages. Needless to say that this prediction problem cannot be applied in practice, because we are trying to predict deferral after it has already happened. For this prediction problem, we exclude from the features the counts of strong actions, because these directly indicate the label. We set up our experiment exactly as before. Experiment 2 in Table 5 shows that our model is only able to increase F1 over the baseline by about 12%. We conclude that *given* an email with a strong action, a mark as unread or flag signal is a strong signal that the email has been deferred, so the additional signals in our model are not that useful. However, note that our dataset only contains those messages that have been marked as unread or flagged (we made this restriction earlier for the practical prediction task). This restriction unfairly causes the baseline to have perfect recall, by definition.

Experiment 3 in Table 5 shows that when we remove this restriction so that our dataset also includes messages not flagged and not marked as unread, our model is able to increase F1 over the baseline by almost 300%, which suggests that our model is able predict whether a user will return to an email *given* that the email contains a strong action. This result shows that our improvement in Experiment 1 is not just simple reply prediction.

5 DISCUSSION & DESIGN IMPLICATIONS

An overarching theme that emerged during our qualitative study was that while there has been a significant shift towards the centrality of email clients for task management, effective inbox management is still one of the main challenges facing enterprise workers who constantly deal with email overload. One main reason behind this observation is that the design of email clients has not kept up with

the management scenarios it is expected to support. We identified three main areas to support users during their daily inbox management activities: (1) during triage (2) at the time of deferral and (3) while handling deferred emails.

When triaging, many of our participants try to use some of the available functionalities such as conditional formatting of the emails based on the sender, presence of explicit mention, etc. to facilitate the process of identifying emails that require attention. Automatic identification of emails that require attention, are urgent, or are likely to be deferred may have a great impact on managing email overload.

Support for deferring emails was often requested by our participants. Our participants often commented on scenarios where emails can be automatically "snoozed" out of sight and resurfaced later. Many participants also described flags for responses and tasks, being able to specify the amount of time needed to handle emails and support for scheduling a time to revisit emails.

Finally, many of our participants expressed their fear of forgetting about their deferred emails and the need to use external tools due to the lack of client's support for effective task management. Reminders and notifications were envisioned as the most effective way to surface deferred emails. Integrating planners, task extractors, TODO list-generators, and automated support for suggesting the best times to handle deferred emails were also among the most popular functionalities for an intelligent email client.

While prior work (e.g. [25]) had identified *deferral* as a common email flow handling strategy, through in lab studies, to the best of our knowledge this work is the first attempt to formalize *deferral* and how it can be inferred from logs of users actions. While we do replicate the previous design recommendations for enhancing the UI of email clients to leverage task views, scheduling tools, mechanisms for highlighting emails based on different metadata or means for annotating emails, our quantitative findings, based on the logs of thousands of users, highlighted different characteristics of messages (e.g. #recipients, #actionRequests or #replyRequests) as well as deferral strategies (i.e. Flag or MarkAsUnread) that can be used to predict whether or not a read message is deferred. A direct implication of such prediction is designing email clients and intelligent assistants that help users with getting back to their pending messages.

6 RELATED WORK

Previous work has studied several aspects of how people interact with email and how to assist them with email management. Two lines of prior work are especially relevant, one on email management and organization and the other on large-scale log analysis of email interaction. We cover both of them below.

Email organization and management. One line of work on email management focused on understanding activities and workflows in email. Venolia and Gupta [28] identified five major activities surrounding how people use email. In particular, they highlighted two activities: keeping up with the flow of incoming messages, and triaging existing messages and discussed how mail clients could better support these activities. Siu et al. [25] studied email use in the context of everyday work practices. They examined how users interlace email with their day-to-day, ongoing work processes. They demonstrated that subjects use email as a tool for managing moment-to-moment attention and task focus, and built on top of the work by Venolia and Gupta [28] to propose a model of this workflow.

Much of the early research on email focused on how people organized and managed their email. Mackay [19] described a set of interviews that focused on understanding the way professional workers use email. Whittaker and Sidner [31] proposed the concept of email overload to describe the usage of emails beyond communication needs, such as task management and personal archiving. They identified common strategies for handling email overload such as filing, searching, and cleaning. Fisher et al. [10] found similar results in their study of mailboxes at a large tech company. Gwizdka [14] identified two additional email management practices, Cleaners and Keepers, based on clustering responses to a questionnaire about email practices. Grevet et al. [12] revisited these previous findings with a qualitative study of Gmail users and found that email overload was still prevalent in both work and personal settings.

Grbovic et al. [11] showed that, with the increase of email messages over time, users do not use folders and argue that search is an increasingly important alternative to human-generated folders and tags. Several studies have focused on developing effective search systems for email [8, 24]. Dumais et al. [8] found that email was the most commonly retrieved source of personal information (e.g. files, web history, emails, etc.). Horvitz et al [15] described experiments with bounded deferral, a method aimed at reducing the disruptiveness of incoming messages and alerts in return for bounded delays in receiving information. They showed that bounded deferral policies could help with balancing awareness about potentially urgent messages with the cost of interruption.

Earlier work also focused on studying how people triage their email. Neustaedter et al. [22] performed a set of interviews and surveys to understand how people handle email during triage and what email do people decide to handle first. Pierce et al. [23] also studied triage but they focused on mobile use. They showed that triage is a more dominant activity on mobile and that users often triage on mobile and defer their action until they reach a desktop. Perhaps the most relevant to our work in this line is the work of Wainer et al. [29]. They studied how top-level cues, including message importance, organization utility, subject line specificity, curiosity, workload and personal utility, influence attention to email.

Our work is similar to this line of research in that we also study aspects of email management and organization. We examine in greater detail one aspect of email management focused on deferred action on emails and provide in-depth qualitative and quantitative studies to characterize and support users with deferral.

Log-based analysis of email interaction. Large-scale log analysis has been extensively used in the literature to study different aspects of email interactions. Kalman and Ravid [17] conducted a study of email management strategies on thousands of users over a period of 8 months using a popular email web client add-in. They showed that people use a wide variety of strategies to manage their emails, many more than had been identified in earlier studies. Other work focused on using large-scale log analysis to study re-finding in email. Elsweiler et al. [9] studied several email interactions such as sorting, changing views, searching, selecting messages and opening folders. Their work revealed strong relationships between difficulty in re-finding emails and the time lapsed since a message was read, remembering when the sought-after email was sent and remembering other recipients of the email. Whittaker et al. [30] carried out a large-scale study of users using a web-based email client. They investigated different re-finding strategies. They found out that some users create and use complicated folder structures to use them for email retrieval with no improvement in retrieval success. Dumais et al. [8] showed that re-finding previously seen information is a

frequent activity that goes beyond email. However, they showed that email is by far the most common type of information that people re-find in a desktop search application.

Log-based studies have also been used to study email search. Ai et al. [1] examined the actions that people perform on emails after searches and compared re-finding in email search with web search. Narang et al. [21] also examined the activities performed on messages following searches, and how this related to the characteristics of people's mailboxes and email organization strategies.

More recently, Castro et al. [4] studied what actions the users might conduct on received messages by analyzing the actions of a large number of users in Yahoo! Mail. They found out that the most frequent actions are typically read, reply, delete and a sub-type of delete, delete-without-read. Yang et al. [32] studied email reply behavior in enterprise settings. They characterized the influence of various factors such as email content and metadata, historical interaction features and temporal features on email reply behavior. We also develop models to predict whether a recipient will reply to an email and how long it will take to do so

Alrashed et al. [2] studied the lifetime of email messages with a focus on revisiting patterns. They showed that some emails are never revisited, while others are revisited for multiple times. They also showed that some users revisit messages for a variety of reasons including taking an action or for finding location information.

This line of work is related to our study since we also use large-scale log analysis to study email interactions. We build on top of previous work on understanding email triage and re-finding but focus on the act of email deferral. We also augment the log-based analysis with a qualitative study and use the findings of both studies to define a prediction task to help users get back to deferred emails more efficiently.

7 CONCLUSIONS

We sought to understand one important aspect of email triage where people defer taking action on emails after seeing it for the first time. We employed a mixed-methods approach where we combined qualitative analysis, via interviews, and quantitative analysis, via a large-scale log study, to develop a better understanding of why people defer emails, what strategies they employ to do so and how we can provide better support for deferring and getting back to deferred emails.

We found that users are more likely to defer emails that require responding or processing information in an attachment. We also observed that deferred message share common characteristics related to the importance of the sender, the number of recipients and the content of the message. Further, the decision to defer a message depends not only on the message itself but also on other contextual information such as the current workload of the user. Our log analysis revealed several insights about deferral strategies. For example, we showed that Flag and MarkAsUnread are more likely to be observed for deferred than non-deferred messages but are only observed for a limited portion of deferred messages. We used these insights to define a prediction task to assess the feasibility of using machine learning to assist users with their deferral workflows.

Understanding email deferral could have implications on understanding how people interact with their email and designing email clients and intelligent agents to help people with managing and organizing their messages. Our future work will aim to explore applications and user experiences that would better support email deferral.

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