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Interruptions in the workplace: A case study to reduce their effects

Edward R. Sykes*

School of Applied Computing and Engineering Sciences, Sheridan Institute, 1430 Trafalgar Rd., Oakville, ON, Canada L6H 2L1

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ABSTRACT

Collaboration is an important aspect for virtually all workplace environments. Workplaces often encourage and foster collaboration in a variety of ways with the purpose to collectively focus the group's attention on a specific problem and solve it as quickly and as efficiently as possible. While collaboration is generally viewed as a positive aspect of the workplace, the negative aspect—interruption—cannot be ignored. Interruptions are an important research area of human–computer interaction and with the growth of pervasive or ubiquitous computing on the rise, the number of interruptions we experience on a daily basis is also growing. It is for these reasons that interruption is and will continue to be a key issue in workplaces.

This report presents the findings of a qualitative research project which explored interruptions in a mid-size software development company based in Ontario, Canada. The purpose of this research was to identify the types of interruptions (both on- and off-task) that occur during typical office software related activities, explore the contextual characteristics surrounding these interruptions, and identify methodologies that could be used to reduce the cost of interruptions and increase employee effectiveness and satisfaction.

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1. Introduction

Collaboration within the workplace involves leveraging the collective strength of individuals within a company to address strategic and tactical business issues. It is an important aspect in many workplace environments to ensure that the business remains competitive and successful (Booher & Innes, 1999). However, the balance between workplaces wanting their staff to collaborate and the cost of interruption is a difficult question with which workplaces struggle (Bettencourt, Brewer, Rogers-Croak, & Miller, 1992). This problem is becoming even more acute given the current economic crisis in which companies are exploring ways to increase productivity while reducing internal costs (Marques, 2010).

Interruptions in the context of collaborations can have considerable consequences (Lottridge, 2006). For instance, consider the seemingly simple task of running a small meeting. Before the actual meeting takes place, various preconditions must have been satisfied, such as establishing the date, time, location, deciding who should be involved, and the modality (in-person, or virtual presence). During this organizational stage, numerous interruptions may have occurred (email exchanges and notifications, telephone calls, instant messenger messages, calendar scheduler notifications, etc.). When the actual collaboration occurs, a series of other interruptions may have occurred. Subsequent to the meeting, a series of follow-up interruptions may have occurred as well.

Many workplaces foster collaboration in a variety of ways by hosting conference rooms, discussion rooms, providing video-conferencing facilities, and encouraging informal drop-by-your-office meetings (Bettencourt et al., 1992). Despite the fact that there may be differences between how companies motivate and support employees to collaborate, the purpose is virtually always the same—to collectively focus the group's attention on a specific problem and solve it as quickly and efficiently as possible (Mandler, 1964).

On one hand it is important to foster collaboration, yet on the other it is important to manage interruptions to attempt to reduce the number of them and reduce the negative effects of interruptions (Solingen, Berghout, & Latum, 1998). While collaboration is generally viewed as a positive aspect in the workplace, the negative aspect—interruption—cannot be ignored. Interruptions are a central research area of Human–Computer Interaction (HCI) and with the growth of pervasive or ubiquitous computing on the rise, the number of interruptions we experience on a daily basis is also growing (McFarlane, 1997). It is for these reasons that interruption is and will continue to be a key issue in HCI research and research involving workplace practices.

The research conducted in this project was a qualitative study which explored interruptions in a mid-size software development company based on Ontario, Canada. The purpose of the research was to identify:

* Corresponding author. Tel.: +1 905 845 9430x2490; fax: +1 905 815 4035.
E-mail address: ed.sykes@sheridanc.on.ca

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1. The types of interruptions (both on- and off-task) that occur during typical office computer-based activities (e.g., Visual Studio development environment, SQL Server query builder, etc.).
2. The characteristics of these interruptions—from the interruption notification modality to the interruption task itself.
3. Methodologies that could be used to reduce the cost of interruption and increase employee effectiveness and satisfaction.

This research provided insight into the very nature of interruptions in this software development workplace environment. It also focused on constructing guidelines that could be fostered by the company to reduce the negative effects and frequency of interruptions while still maintaining a sustainable level of healthy collaboration.

2. Interruption literature review

Interruptions happen for a multitude of reasons. The purpose of an interruption could be to answering a telephone, respond to an instant message notification, or to address a colleague when she comes by your office. Regardless of the purpose of the interruption, there are four known strategies for managing interruption: (a) immediate, (b) scheduled, (c) negotiated, and (d) mediated (Allen, Guinn, & Horvitz, 1999; McFarlane, 2002).

The *immediate* interruption strategy involves interrupting the person immediately regardless of what they are doing in a way that insists that the user immediately stop what they are currently working on and respond to the interruption. The *scheduled* strategy involves restricting the agents' interruptions to a prearranged schedule, such as, send a meeting notification 15 min before it starts. The *negotiated* interruption strategy would have the agent announce their need to interrupt and then support a negotiation with the person. This approach gives the user full control over how to deal with the interruption—when or even at all. For example, many email clients have a popup indicating receipt of a new mail message or small icon in the Task pane indicating the same. These indicators make the user aware and let them choose when to deal with the email message. The fourth strategy, called *mediated*, involves agents indirectly interrupting and requesting interaction through a broker like a Smartphone. The Smartphone would then determine when and how the agents would be allowed to interrupt the user.

A case study conducted by Solingen at a software development company identified three types of interrupts: personal visits, telephone calls and emails (Solingen et al., 1998). They discovered that personal visits and telephone calls caused 90% of all interrupts and email caused the rest (Solingen et al., 1998). The results showed the effort spent on interrupts required an average of 20 min for each occurrence, including the time spent handling the interruption task, and that each developer receives between three and five interrupts per day. Approximately 1.5 h per day of the developer's time was consumed on dealing with interruptions (Solingen et al., 1998).

The following section discusses the following issues surrounding the topic of interruptions: (a) tasks and task boundaries, (b) attention and attentional draw, (c) cognitive load, cost of interruption and resumption lag, and (d) multi-tasking. This list is sufficiently inclusive since it is an established framework that is used by HCI interruption researchers (Gluck, Bunt, & McGrenere, 2007; Hodgetts & Jones, 2007; Mandler, 1964; McFarlane, 2002; McFarlane & Latorella, 2002; Preece et al., 1994; Xiao, Stasko, & Catrambone, 2004).

2.1. Tasks and task boundaries

As humans, we are generally very good at negotiating when is an appropriate time to interrupt another person (Mandler, 1964, 1975). For instance, consider a typical office environment in which you are interested in asking a colleague a question. Contextual awareness of your colleague's task, other office activities, the person's facial cues and body language are all used, albeit possibly subconsciously, in your assessment and ultimate decision in determining if this is an appropriate time to interrupt him/her or to leave him/her to their current task. However, and fortunately for interruption researchers, in many situations, there are some obvious times during a person's activities when it is an ideal moment to interrupt a person or not. For instance, continuing the previous example, suppose you observe your colleague is busy on the phone, or you hear a conversation. Naturally, you decide to wait until s/he is off the phone or the conversational noise level stops. For computer based tasks, task breakpoints can be identified by the interrupter based on the following criterion: attention to the current task, criticality of the current task, and current stage within the task (Gievska & Sibert, 2005).

Unfortunately, computers and computer systems with interruption mediators are not as sophisticated as people's reasoning abilities. Task and interruption researchers are interested in acquiring contextual information surrounding the task so that the timing of the interruption and the information presented will be of the utmost benefit to the user at that time (Iqbal & Bailey, 2007). In many situations if it is possible to defer an interruption to a task breakpoint (or task boundary), the inconvenience to the user by responding to the interruption is significantly reduced (Iqbal & Bailey, 2007). In these situations, the resumption lag is much less for the user than if the interruption occurred during the task (Horvitz, Koch, & Apacible, 2004). In one interruption mediator system, a set of microphones is placed throughout the office to monitor conversational noise levels. These microphones in combination with an eye tracking system that monitors where the user is currently focusing his/her attention is used to provide the contextual data to the interruption mediator (Horvitz, Kadie, Paek, & Hovel, 2003). In this system, if the user turns his/her head away from the computer to talk to a colleague standing at his/her office doorway, then the system notes that the user is essentially disengaged with the current task and any message should be deferred until the user returns his/her focus to the computer (Horvitz et al., 2003). Similarly, the microphones are used to provide input to the system as to whether other people are in the office or if the user is on the phone (Horvitz et al., 2004).

2.2. Attention and attentional draw

By far the most popular form of interruption that computer users encounter on a day-to-day basis is email notifications and instant messenger client pop-up messages (Gievska, Lindeman, & Sibert, 2005; Horvitz & Apacible, 2003; Iqbal & Bailey, 2007). For the content of the interruption to be presented to the user, the user must first acknowledge the interruption—in other words the user must be attentive to the interruption notification.

The process by which an interruption notification method attracts the user's attention is called *attentional draw* (Gluck et al., 2007). A number of computer-based interruption systems have been developed that vary the degree of attentional draw based on the importance of the message (Gluck et al., 2007). Consider an email client presenting a message of high-priority appearing in the center of the user's screen which requires the user to acknowledge the message versus a low (or normal) priority message that would appear in a less obstructive location (say, the bottom right area of the user's screen) and then fade away automatically after 10 s. In

this section a discussion of attention and attentional draw research is presented (Horvitz et al., 2003). In order for an interruption to be meaningful, the user must pay attention to the interruption and the content it discloses. Furthermore, depending on the user's level of attention, level of distraction, and working environment an interruption message may not even be noticed (Horvitz & Apacible, 2003).

Associated with interruption research is determining the best way in which to present a message to the user—this is the topic called attentional draw. A study conducted by Gluck et al. (2007) examined matching attentional draw with the utility of the interruption message (Gluck et al., 2007). This study had the following design guidelines (Gluck et al., 2007):

1. to increase the positive perception of interruptions (i.e., from a psychological computer-human interface perspective);
2. to match the interruption's notification method (i.e., the attentional draw) to the utility of the content of the interruption;
3. to perform an empirical investigation to examine the effects of matching attentional draw of notification to interruption utility in terms of annoyance, perceived benefit, workload, and performance (Gluck et al., 2007).

The findings of this research show that when the utility of the interruption is known to the user, interfaces that change the attentional draw based on utility result in decreased annoyance and increased perception of benefit compared to interfaces that use an unchanging level of attentional draw (Gluck et al., 2007).

2.3. Cognitive load, cost of interruption and resumption lag

Another aspect relating to tasks, attentional and attentional draw is the assessment of the cognitive load placed on the user while performing a task (Allen et al., 1999; Gievska & Sibert, 2004; Gluck et al., 2007; Horvitz & Apacible, 2003; Iqbal & Bailey, 2005). This section relies on the following definitions. **Cognitive load** is an indicator of the degree of working memory utilized when the user is performing a task (Yin & Chen, 2007). The **Cost of Interruption** (COI) is a subjective measure of price a user would pay to remain undisturbed while working on a computer-based task (Horvitz & Apacible, 2003; Horvitz et al., 2004). The COI may include various kinds of alerts disrupting a user in different contexts (Horvitz & Apacible, 2003; Horvitz et al., 2004). The COI has been used as an assessment tool for several decades in decision analysis in various fields (Horvitz et al., 2004). Horvitz' definition for the expected COI is: $\sum_j p(S_j|E)X(D_i, S_j)$, where C is the cost to be inferred of the user being interrupted by different types of disruptions D conditioned on being in states, S, $C(D_i, S_j)$ (Horvitz et al., 2004). **Resumption Lag** (RL) is defined as the time required to resume the primary task after completing the interrupting task (Iqbal & Bailey, 2005). RL can be measured as the time from closing the interrupting task to the first keyboard or mouse action in the primary task in direction of the task goal (Iqbal & Bailey, 2005). The COI can be indirectly measured from the RL (Horvitz et al., 2004; Iqbal & Bailey, 2007). A greater RL implies a greater COI (Horvitz & Apacible, 2003).

There is a strong correlation between cognitive load and the cost of interruption (Baylor & Yanghee, 2005; Gievska et al., 2005; Iqbal & Bailey, 2005). Thus, it is important to assess the cognitive load on the user while s/he is performing a task in order to decide whether or not to interrupt the user (Gievska & Sibert, 2004; Gluck et al., 2007; Iqbal & Bailey, 2005).

Researchers have shown that if a user is interrupted during a high cognitive load task by being forced to switch tasks (e.g., to read a message, talk with a colleague, or to perform the interruption task), then the cost of interruption can be very high (Baylor & Yanghee, 2005; Gievska et al., 2005; Iqbal & Bailey, 2005). There is a strong correlation between cognitive load and the cost of interruption (Baylor & Yanghee, 2005; Gievska et al., 2005; Iqbal & Bailey, 2005). Furthermore, studies have also shown that human work efficiency drops significantly in noisy environments because of the negative effects on concentration (Zaheeruddin & Garima, 2006).

2.4. Multi-tasking

Computer users often multitask (Iqbal & Horvitz, 2007). Due to the fact that there are so many applications available to computer users, the degree of multitasking has significantly increased in the last 30 years (Bannon, Cypher, Greenspan, & Monty, 1983). It is common for users to run a word processor, browser, instant messenger, email, and calendar all at the same time (Horvitz et al., 2003). Unfortunately, multitasking has downfalls:

1. *Multitasking is less efficient*. This is because multitasking is resource intense. Like a computer system, the CPU can be assigned and unassigned tasks by using the Program Control Block which houses all the pertinent information regarding a task. For a computer system to swap tasks requires time and resources. For a human to switch tasks is even more involved and costly. This is due to the fact that the mental requirement and sometimes physical requirement can be very high. For instance, consider a user moving paper documents to the file cabinet to make room to work on documents from another file folder. The person must then mentally try to remember the state s/he was in before the job was suspended. Depending on various factors this may take quite some time (Newell, 1990; Salomon, Perkins, & Globerson, 1991). For computer based tasks, the analogy applies. The cost of interruption in computer multitasking can be very high since the user must change state for the new task, and then switch back again (Griffiths et al., 2004).
2. *Multitasking is more complicated*. From the previous example it shows that for a user to change tasks and at a later time change back again requires a degree of overhead in terms of management and mental awareness of the state of each task prior to its suspension. From a psychological perspective, researchers have shown that users who multitask extensively have felt additional stress and are more likely to make errors (Griffiths et al., 2004; Regian, 1997; Salomon et al., 1991). Thus, at a minimum, computer based task switching is more involved and complicated.
3. *Multitasking can be self-directed*. Another user characteristic associated with multitasking is that it is often self-directed, that is, it is an innate property of the user to perform more than one task at a time. In other words, the user has a choice to switch a task or to remain focused on the current task. However, there are situations where task switching is imposed on the user such as alerts, message notifications, etc., which is a one of the areas of investigation in this research.

Regardless, multitasking is here to stay and appears to be growing steadily among computer users around the world (Horvitz, 1999; Iqbal & Bailey, 2007; Kapoor & Picard, 2005; Microsoft, 2007; Preece et al., 1994). Architects for interruption systems must recognize this aspect of user behaviour in designing new systems.

2.5. Interruption literature—guideline summary

The main points from the previous discussion on interruption in the workplace are summarized below and serve as the fundamental framework for the addressing the research goals:

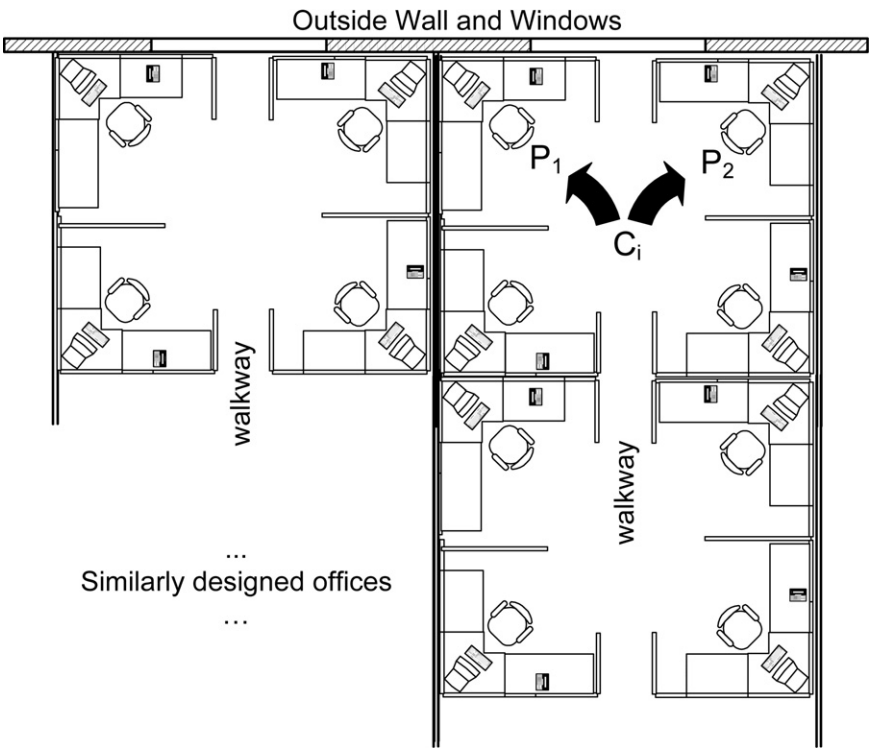


Fig. 1. Office workplace layout.

1. Recognize that there is a cost associated with every interruption and after the interruption is addressed, there is a cost associated with resuming the original task (Gievska et al., 2005).
2. Task boundaries should be observed and used to guide decision-making for interruption points (Hodgetts & Jones, 2007; Solingen et al., 1998).
3. For high cognitive load tasks the cost of interruption is high. In these situations, it is best to wait until the task is complete or the user reaches a task boundary (Adamczyk & Bailey, 2004).
4. Wherever possible the potential for office distractions should be reduced. For example, a cluttered desk with stacks of paper or walls with numerous posters should be avoided (Horvitz et al., 2003).
5. Notification awareness methods should be congruent with the significance of the message (Mandler, 1964).
6. Interruptions can influence the personal state, specifically the negative emotions, such as, irritation, or frustration (Mandler, 1975).
7. Office noise, such as voices from colleague's discussions, one-sided telephone conversations, computer equipment, etc. should be minimized as much as possible (Horvitz et al., 2003).

3. Method

The purpose of this research was to identify the types of interruptions that occur during office software related activities, explore the contextual features surrounding these interruptions, and identify techniques that could be used to reduce the negative impact of interruptions. This section discusses the method that was car-

Table 1
Methodologies for data collection (adapted from: Frías-Martínez et al., 2004; McFarlane, 2002).

	Accuracy of details captured of the interruption scenario	Non-intrusiveness to the participant	Ease of data collection	Ease of data analysis	Setup time
Video recording (participant's computer screen)	√	××	√	×	××
Video recording (participant's face, head, and shoulders)	√	××	√	×	××
Event logger (keyboard, mouse, active applications, etc.)	√√√	√√	√√√	√	×
Remote desktop/VNC	√√√√	√√√	√√√	√	×
Researcher observation	√	√	√√	√	√√√
Survey	×	√√	√	√	√

Legend: (√√√√) (extremely suitable), (√√√) (very suitable), (√√) (suitable), (√) (slightly suitable), (×) (sliightly unsuitable), (××) (unsuitable), (×××) (very unsuitable), (××××) (extremely unsuitable).

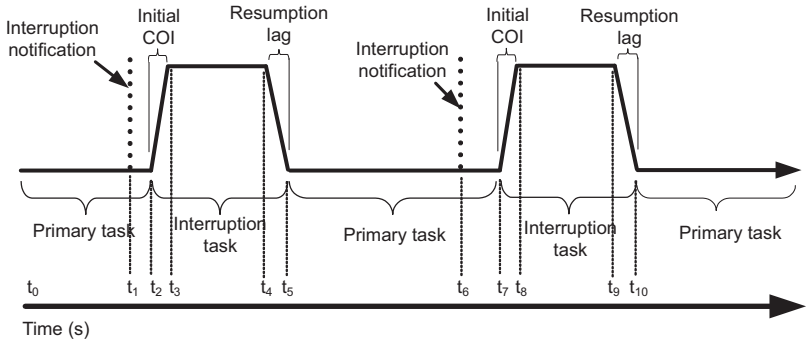


Fig. 2. Sample interruption timing scenario—alternating states between primary and interruption tasks.

ried out for this research. In this section, the following topics are discussed:

- Office layout,
- Data collection technique,
- Types of interruptions,
- Measures,
- Selection process for participants, and
- Procedure.

3.1. Office layout

Each cubical in the workplace is approximately 7′(width) × 8′ (length) × 4.5’ (height), equipped with a computer, telephone and standard office materials. The office layout is presented in Fig. 1. The figure shows two participants (P_1 and P_2) and a Colleague, C_i interacting with the respective participant. The walkways are quite long (approximately 25 m) off which are many similar cubical offices.

3.2. Data collection technique

A number of data collection techniques were reviewed to determine the most suitable method for this research. The techniques selected for consideration have been used for similar research studies (Jackson, Dawson, & Wilson, 2003).

There are several ways in which the details of office interruptions could have been recorded. One way would be to record the employees at their desk, carrying out various activities and capturing the information by using a video recorder. Another possibility would be to have an actual person watching the employee at their desk from a distance. While this approach has bias since other employees may not drop by the participant’s office as often as without the researcher present or perhaps the way in which the participant performs his/her work may be different with the researcher present (Patton, 2002). However, through random observations and unobtrusive observational techniques, this approach can be quite satisfactory (Patton, 2002).

The last option considered was to use computer software to monitor the employee (e.g., VNC, Windows Remote Desktop, etc.). Table 1 presents the characteristics of different data collection techniques along five criteria. The criteria are based on (Frías-Martínez, Magoulas, Chen, & Macredie, 2004):

1. Accuracy of details captured of the interruption scenario;
2. The degree of non-intrusiveness to the participant;
3. Ease of data collection, including the management and storage of the data;
4. Ease of data analysis;
5. Setup time.

Table 1 shows the pros and cons of the selected data collection methodologies were identified and ranked using guidelines from the literature (see: Frías-Martínez et al., 2004; Jonassen, 1994; Kahneman, 1973; McFarlane, 2002). The company deemed the video recording method inappropriate, as it would be too intrusive for employees to their daily activities. It was decided that detailed researcher observational note-taking with a digital stopwatch was the most appropriate method for this research and ensured company compliance. This approach offers rich contextual information to be collected during office interruptions.

3.3. Types of interruptions

Several different types of interruptions were of interest in this research. During the researcher observations, the type of interruption and rich contextual information was recorded. The types of interruptions observed were the following:

1. telephone,
2. Instant Messenger, and updating system notifications (e.g., Windows update, Adobe, Java, etc.),
3. email notifications,
4. colleague initiated discussion in the participant’s office, and
5. distractions (e.g., surrounding office noises, such as, fans, doors, people walking by, nearby conversations, nearby washroom, etc.).

3.4. Measures

The measures for this research included:

1. Interruption details (time, type, and contextual information).
2. The cost of the interruption (time, perceived irritation/disturbance to the participant), and
3. The resumption lag time.

Fig. 2 illustrates a sample interruption timing scenario. The figure shows the primary task and interleaving interruption tasks, the interruption notification, the cost of interruption and resumption lag times.

The data collected was confidential and agreements between the researcher and the company were established to protect the company’s core business and the participants involved in the study. The following conditions were strictly adhered:

1. All information collected on participant activities would only be viewed by the researcher, who carried out the research in cooperation with the company.
2. A non-disclosure agreement was signed by the researcher with the company.

Table 2
Observations of participant: P_1.

Interruption	Previous/primary task	Type of interruption	Initial cost of interruption	Time spent on the interruption task	Resumption lag time
int_1					
int_2					
...					
int_i					
...					
int_n					

Table 3
Number of interruptions encountered by Technical Leads and Senior Developers level participants during an 8-h work day.

Type of interruption	Average number of interruptions	Average interruption length
Colleague	40 (range: 24–56)	2.8 h (range: 1.6–4)
Messenger	9 (range: 8–10)	0.5 h (range: 0.13–0.8)
Email	52 (range: 32–72)	1.8 h (range: 1.6–2.0)
Telephone	20 (range: 8–32)	0.7 h (range: 0.6–0.8)
Total	121	5.7 h

Table 4
Number of interruptions encountered by Staff and Associate level participants during an 8-h work day.

Type of interruption	Average number of interruptions	Average interruption length
Colleague	12 (range: 8–16)	60 min (range: 24–96)
Messenger	4 (range: 0–8)	1.2 min (range: 0–24)
Email	8 (range: 0–16)	12 min (range: 0–24)
Telephone	0	0 min
Total	24	73.3 min

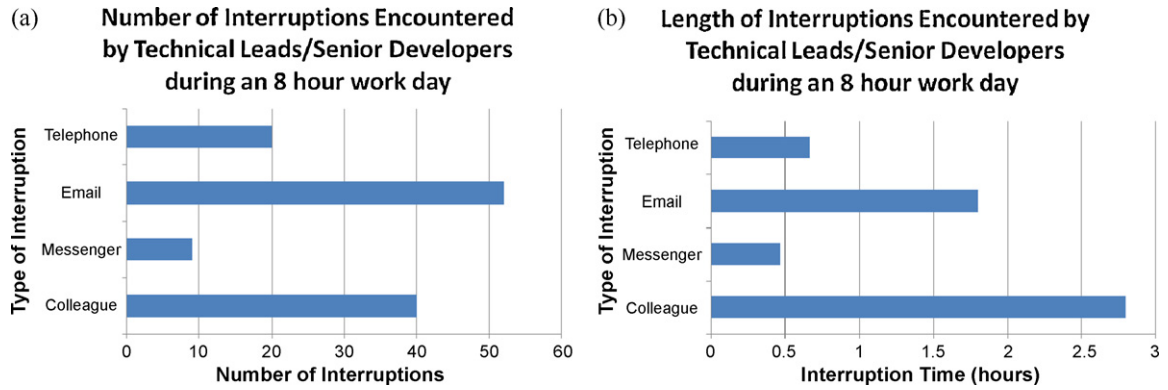


Fig. 3. (a) Breakdown of the times spent in serving different types of interruptions at the Technical Lead/Senior Developer level and (b) the length of these interruptions during an 8-h work day.

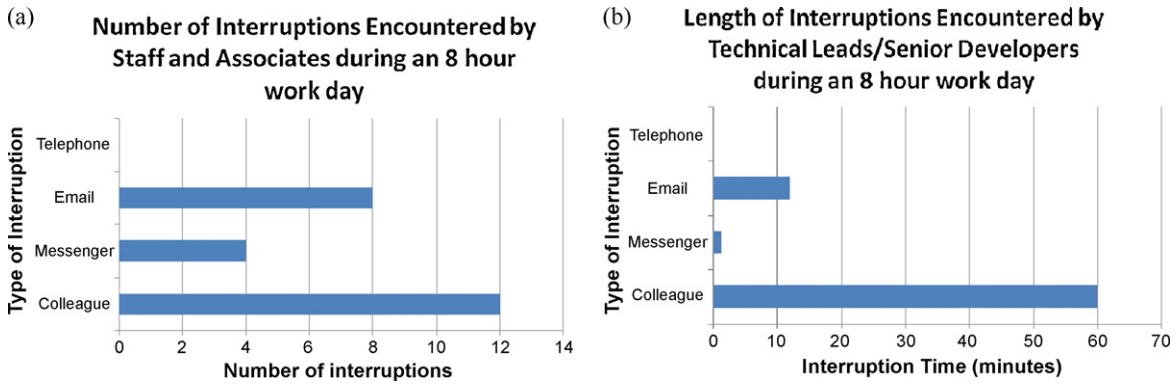


Fig. 4. (a) Breakdown of the times spent in serving different types of interruptions at the Associate/Staff level and (b) the length of these interruptions during an 8-h work day.

3. The results would be disclosed to the company as overall totals, averages and general observations—no individually identifiable information would be supplied to the company.
4. The results would be used to benefit the company as a whole, including all its employees.

3.5. Selection process for participants

An open invitation was sent all employees in the software development group. In this company four different positions (levels) were represented in the research study. One or more employees from each of these positions were invited to participate. The response rate was 86%, indicating the employees invited had a distinct interest in participating in the study. These positions were (most senior listed at the top):

1. *Technical Lead*. This position involves being a software project manager for 1–2 projects each involving 3–5 Staff and Associate level personnel.
2. *Senior Developer*. A senior developer has several years of software development experience on at least three different projects. This position involves working on a project with the Technical Lead and with Staff and Associate level colleagues.
3. *Staff*. This position involves working on projects with a Senior Developer and a Technical Lead. Staff level personnel work closely with Associate level colleagues.
4. *Associate*. This is an entry level position. An Associate works with Staff on a regular basis and reports to a Senior Developer.

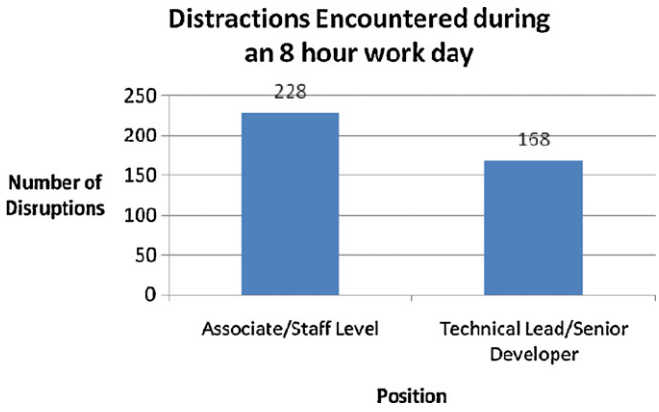
Four employees volunteered to participant in the case study from all position levels of the company. Although the results obtained are only relevant to this software company, a degree of generalizablilty onto other software and information technology companies with similar office design and layout in Canada and the United States is within reason.

3.6. Procedure

The following procedure was followed in this case study:

1. *Briefing*. The researcher briefed the participants about the purpose of the study, the type of information that will be collected and remind the participant about his/her rights (e.g., withdraw from the study at any time without giving reason, etc.).
2. *Signing of Consent Form*. Once all the participant's questions about the study were answered, s/he signed the consent form.
3. *Scheduling*. The researcher arranged suitable times with the participants to ensure they were not in meetings or performing functions atypical from their daily activities.
4. *Observations*. Numerous 1–2-h observational visits were performed for each of the participants. The researcher sat outside of the participant's office as unobtrusively as possible so as to minimize the interference with the daily work functions in the company. The number of observations was sufficient to rule out bias in the form of participant behaviour different. The sessions spanned several months which ensured that an accurate representation of the types of interruptions that that participant was experiencing was a true reflection of his/her typical daily work. The details of interruptions were recorded and timed using a digital stopwatch. Table 2 shows the data collection sheet used.
5. *Closing*. The researcher asked the participant for clarification if appropriate and thanked the participant for their time and involvement in the study.

Table 5
Number of distractions encountered by all positions involved in the study during an 8-h work day.



4. Findings—results of observations and monitoring interruptions

This section discusses the results of this research. The first section discusses the quantitative findings for the participants in the study. The information is presented as a summary including the number and types of interruptions, and the average time spent on the interruption. The second section presents a qualitative synopsis of the contextual setting and rich details around which these office interruptions took place. In this section, a summary is presented that involved reflecting on the researcher's observation notes and identifying themes that emerged.

4.1. Quantitative findings

This section presents a summary of the objective data collected and analysed. The number and length of interruptions encountered by the Technical Leads and Senior Developers was much higher than the other positions in the company. For instance, during 1-h observation sessions, the total number of interruptions at the Technical Lead/Senior Developer level was over 6 times more than the Associate and Staff level encountered. The length of interruptions for all interruption types was also significantly higher. For instance, interruptions at the Technical Lead/Senior Developer level were over 4 times longer than at the Associate and Staff level.

Aggregated data extrapolated over a typical 8-h work day translates into over 120 interruptions per day for Technical Lead/Senior Developers and accounts for 5.7 h of time working on interruption tasks. This translates into over 71% of their daily activity is spent on dealing with interruptions.

Tables 3 and 4 show summaries of the different types of interruptions, the length of interruptions and the ranges for both within a typical 8-h work day for Technical Lead/Senior Developers and Associate/Staff participants, respectively.

Figs. 3 and 4 illustrate the allotment of time serving different types of interruptions for a 1-h session for the Technical Lead/Senior Developer and the Associate/Staff level.

The number of distractions was also recorded. In this research, a distraction is defined as an event that influences the participant's performance on the current task from an observer's perspective. The distractions that were most prevalent in this study were nearby conversations, doors opening/closing, people walking by the participant's office, colleague's music, and other typical office noises (e.g., chairs moving, colleague talking on the phone, etc.). The results are shown in Table 5.

4.2. Quantitative findings

This section provides an unbiased summary of the interruptions and rich contextual information that was present at the workplace. The following themes emerged from the observation sessions:

1. A large number of interruptions occurred primarily from colleagues walking up to the participant's office and interrupting him/her.
2. Distractions are a significant issue in the workplace since noises and voices carry so well in the environment. Furthermore, the offices are relatively small and tightly integrated so:
   a. A large number of conversations can be easily heard in this open environment;
   b. The number of employees that are influenced (or at least can hear these conversations) is high.
3. A number of employees use ear buds or headphones to listen to music to drown out the distractions around them.
4. Reinforcing the quantitative findings, it was immediately obvious that there was a huge difference in the number and length of interruptions between the Technical Lead/Senior Developer and the Associate/Staff levels. A significantly higher number of interruptions occurred at the Technical Lead/Senior Developer level. However, perhaps due to the location of the Associate/Staff level participants, the amount of distractions they experienced were higher than the Technical Lead/Senior Developer level participants.
5. The majority of the interruptions at all levels were business related on-task activities.

These issues illustrate that the environment is one in which numerous disruptions and distractions may occur that affect the employee's effectiveness and their overall satisfaction. Some participants showed signs of frustration and irritation when several interruptions occurred in succession. These interruptions undoubtedly negatively affected the employee's effectiveness and their overall satisfaction. This was confirmed with two of the Technical Lead/Senior Developer personnel after the researcher observation sessions were completed. They said they were "overwhelmed at times and unable to concentrate on specific project tasks" because of a stream of interruptions that kept them from working on what they were intending to work on.

However, the overall impression is that most employees are content and enjoy the stimulating work environment. It was also observed that the employees appear to be performing their tasks successfully.

5. Recommendations for reducing interruption effects

This section presents two areas that may be explored by any similar office environment to reduce interruption effects. The first area focuses on computer-based interruptions and presents several guidelines to reduce interruptions. The second area presents guidelines for all other types of interruptions that occur outside of the realm of human computer interaction.

5.1. Reduction of computer-based interruptions

The following methods may be used as guidelines for reducing the interrupt effect of computer-based interruptions.

1. *Email—customize the settings*. Many email clients have customizable settings for the notification method of incoming email messages. In Microsoft Outlook the default is a popup that appears for 10 s and then slowly disappears. For some employees where high concentration is required for long (1/2 h or more) periods of time, it may be beneficial for these notifications to be turned off.
2. *Email Messages—keep them short and sweet*. Encourage the use of short email messages. Some employees use a verbose style of email messages. However, researchers have found that the use of one line email messages reduces the interruption time for both author and recipient (Jackson et al., 2003).
3. *Instant messaging—only if necessary*. Instant messenger clients should be used in the workplace if the employee's computer-based tasks are of low or moderate cognitive load and the tasks have numerous natural breakpoints (Cameron & Webster, 2005; Gievska et al., 2005; O'Donnell & Eggemeier, 1986). For example, in this research study, instant messaging was prohibited in the workplace.
4. *Self-imposed task switches*. In computer based tasks it is common to perform a series of task switches (i.e., self-directed interruptions) while working on the goal of the primary task (Gievska et al., 2005). In many office environments, it is not uncommon for users to have numerous applications running at the same time (Hart & Staveland, 1988; Jambon, 1996). For example, in this research study, participants would regularly have open the following applications: a browser (with multiple tabs), a simple text editor, Microsoft Outlook, Microsoft Visual Studio, SQL editor, and reference documents open (e.g., pdf, Microsoft Word, etc.). In one instant it was observed that 12 different applications were running on a participant's system.

The main reason for task switching behaviours is related to the task, and the screen size and resolution. For tasks that involve numerous data streams it is necessary to have multiple applications running at the same time. However, educating people on how to make best use of the screen real estate and specific features of the operating system in terms of placement of windows for easier access to information, will increase productivity and minimize self-imposed task switches (Horvitz et al., 2003; Rieber, 2005). It may be advantageous for specific employees to use larger displays and/or connect multiple displays to facilitate ease of access to information s/he needs to perform the primary task. This in turn may result in increased work productivity (Rieber, 2005).

5.2. Reduction of other interruptions and distraction remediation methods

1. *Physical Workplace Environment—well designed and structured*. It is important to design and structure the workplace so that distractions and unintentional interruptions are reduced where possible. For example, in this research study, some offices were missing division barriers. As a result, employees from one office can see, while sitting, across to other offices and colleagues which fosters distractions and unplanned interruptions.
2. *High traffic areas—be aware of their impact*. High traffic areas such as, walkways, front entrances, photocopy rooms, and intersections all pose a potential to cause disruptions in the workplace. In and around these areas, perhaps sound absorbing walls could be mounted to reduce the overall noise in the office. Alternatively, perhaps the location of personnel or office equipment could be relocated to provide different pathways which may alleviate some of the office noise and potential interruptions (Patton, 2002).
3. *Ear buds/Headphones*. The use of ear buds/headphones certainly blocks out the various conversations and other office noises, however, it should not be overlooked as a band-aid solution to the root problem.
4. "*Back in 10 minutes*". At the risk of appearing anti-collegial, it may be reasonable to place "Do not Disturb" (or equivalent) signs in

the offices of developers/programmers working on high cognitive load activities. The cost of interruption can be enormous for someone deep in thought while solving a critical problem. The use of these signs has had significant gains in user performance and satisfaction (Solingen et al., 1998).

5. *Quiet Meeting Rooms*. Assign separate working rooms for critical staff working on tight timelines. All of the participants involved in this study were programmers or software developers by trade. Their desired view of an efficient work day is a set of 2-h uninterruptible blocks in which high cognitive load software development may be performed. In contrast, their day typically is divided into small chunks of time which makes is extremely difficult to resume high cognitive tasks and achieve the same level of productivity. By assigning key personnel to different offices in which uninterruptible blocks of time could be allocated employee productivity and satisfaction may be increased (Furnham & Bradley, 1997; Solingen et al., 1998).

   To maintain and foster the richness of the collegial collaboration in the workplace, designated meeting rooms could be created and positioned in opportune locations within the office environment. In this way, healthy collaboration is fostered, and costly disruptions and distracting external conversations are avoided.
6. *Background Music*. The use of ambient background office music may offset the conversational noise and normalize the disruptions in the office (Furnham & Bradley, 1997).
7. *Educate employees*. Educate employees about the number of interrupts that are occurring at all levels in the organization. In Solingen's research, educating employees about the negative effects of interrupts led to a reduction of interruptions by 30% (Solingen et al., 1998). Additionally, educating employees about the nature of interrupts will have benefits. Discuss the types and length of interruptions that are occurring in the workplace.

   Through communication and education all employees should understand the impact of interruptions in the workplace. Before a person embarks on initiating an interruption with a colleague, s/he should ask themselves:
   a. "Is this a critical question that requires a personal communication (i.e., for me to walk to the colleague's office and interrupt him/her)?" How involved is the issue? How long do I think it may take? Should I book a meeting room to minimize disruption to neighbouring colleagues?
   b. "Is the issue something that can be deferred until a more suitable time?" (e.g., outside of the programmer's 2-h development block).
   c. "What is the most appropriate communication medium to resolve this problem?" The level of impact to interruption is inversely proportional to the colleague's response time to the issue. In decreasing order of impact to interruption they are: (a) colleague initiated discussion in the participant's office, (b) telephone, Skype or equivalent, (c) instant messaging, and (d) email (Solingen et al., 1998).
8. *Office Organization and Restructuring*. While possibly interpreted as covert, from an objective perspective there would be value in installing several dB meters throughout the workplace since then it would be possible to determine if loud and quiet zones exist and the extent of noise within these areas. The findings may reveal significant differences between zones and provide justification to relocate employees so that the noise is more evenly distributed throughout the office. Consistent background noise has been shown to be much less disruptive than noises that occur randomly or abruptly (Gievska et al., 2005; Hart & Staveland, 1988; O'Reilly & Munakata, 2000). For instance the traffic flow of colleagues to the top left and right offices in Fig. 1 was very obvious during observation sessions. Perhaps separating P_1 and P_2 may result in less congestion and distribute the conversational noise more evenly.

6. Conclusion and guidelines for reducing workplace interruptions

Collaboration is an important part of many workplace environments. This research focused on identifying the types of interruptions that occur during typical office related activities in a mid-size software development company based in Canada. This study also included exploring the contextual characteristics surrounding these interruptions, and identified methodologies that could be used to reduce the cost of interruptions and increase employee effectiveness and satisfaction.

The main quantitative findings show that the Technical Lead/Senior Developer employees are spending a significant portion of their time serving interruptions—over 6 times the number encountered by their Associate/Staff colleagues. The interruptions that are most costly in terms of time are colleagues walking into the employee's office and discussing a problem. The second most significant quantitative finding is that the number of distractions is significant in this workplace. This has led to a series of recommendations that will enable the software company to make decisions regarding employee effectiveness and to foster a more satisfying work environment by reducing interruption effects. The researcher offered these recommendations to the company to maintain and encourage the rich collaboration in this company while recognizing methods to reduce the negative effects of interruptions. The recommendations would allow more effective and efficient use of computer and software systems, and office resources. The goal is to strike a healthy balance between collaboration and the interruption effects, and employee satisfaction and productivity. The recommendations given are based only on the experience of the software company and therefore can only be considered to be applicable to that company. However, informal enquiries of other companies indicate that the experience at this software company is not unique. As a result, it is reasonable to suggest that these recommendations may benefit these other companies too.

The principle findings of this research suggest that companies should be cognizant of the type and number of interruptions that are occurring within the workplace environment and should attempt to reduce the number and negative effects of interruptions. Companies may find the set of recommended guidelines presented in this paper helpful in satisfying this goal and to increase employee satisfaction and effectiveness.

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Edward R. Sykes is a Professor of Computer Science in the Faculty of Applied Computing and Engineering Sciences at Sheridan, a SHARCNET College Research Chair, and an Adjunct Assistant Professor of Computer Science in the Department of Computing and Software at McMaster University. Dr. Sykes holds a Ph.D. from Brock University in Cognition and Learning, with an emphasis on machine learning algorithms. His Ph.D. work involved designing, developing, and evaluating the Java Intelligent Tutoring System, which focused on a unique e-learning tutoring system. Dr. Sykes has a strong research background in human computer interaction (HCI), mobile application design and development, machine learning algorithms, and visualization. Dr. Sykes was involved in the development of Sheridan's "IC3D Game" that received world recognition at the 2010 Winter Olympics in Vancouver. Dr. Sykes has nearly 20 years of teaching experience at Sheridan and has taught undergraduate and graduate-level courses at McMaster University and Brock University. He has supervised hundreds of undergraduate and graduate level students in capstone research projects.