Traces: A Flexible, Open-Source Activity Tracker for Workplace Studies

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Abstract
Despite increasing use of sensors to track many everyday activities, workplace studies routinely rely on manual methods of data collection such as diary studies and shadowing. While rich in many respects, these methods are tedious, prone to bias, and limit the detail and volume of data that can be collected. This paper presents Traces, open-source software for passively capturing detailed activity histories on computers running OS X. We describe the design and features of Traces including its modularity, ability to continuously record weeks of screen activity, and support for experience sampling. We describe two studies in which we used Traces to observe everyday work activity at a scale and level of detail difficult to achieve with self-report or shadowing.

Author Keywords
activity histories; workplace studies; activity tracker

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

Introduction
Passive sensors are increasingly being used to track rhythms of personal life reflected in physical activity, finances, and location [3, 6]. Despite the growing

measurement of personal activities, studies of everyday work routinely rely on manual methods of data collection such as diary studies and shadowing. While providing useful data, these methods have significant limitations. Self-report is prone to bias as participants may try to look overly productive, give researchers the "right" answers, or simply forget to record data during busy periods. And although shadowing can provide rich contextual data, it is prone to the Hawthorne effect and difficult to conduct with many participants for extended durations.

Passive sensors enable observation of everyday work at a scale and level of detail difficult to achieve with manual methods. Wearable badges have been used for decades to study the workplace and smartphones, tablets, and activity trackers are increasingly used for data collection. While these methods provide insight into the *How* of work (e.g., who talked to who for how long), they stop short of articulating *What* is being accomplished or *Why*. We still have very little idea what people actually do at work.

Recording phone and computer use can provide detailed data about work processes, but has not been widely practiced. Although software logging is a pervasive practice, it is often done with a focus on debugging or on studying software usage, not studying work. Moreover, in many cases such recording software is tailored for specific purposes and it is challenging to build and maintain a generic recording infrastructure. Commercial tools like Morae[1] enable detailed recording but are difficult to incorporate with other methods that put data in context, such as experience sampling. And very few tools are freely available or open-source. Finally, privacy issues involved in tracking sensitive and proprietary information are significant concerns.

We present Traces[2], open-source software for capturing rich activity histories on computers running OS X. Traces supports recording various types of information (i.e., app and window use, clicks, keystrokes, screenshots) and, its modular design enables extension for more detailed recording of specific activities like writing. Moreover, the software supports experience sampling to augment passively recorded data with people's own descriptions of what they are doing.

Traces is designed as a data capture tool for researchers seeking to better understand everyday work. We present two studies in which we used Traces, along with post-recording interviews, to observe work activity in-the-wild at a scale and level of detail difficult to achieve with self-report or shadowing. Moreover, by adding appropriate visualization facilities, we believe Traces can be used not only by researchers, but also by people who want to reflect on and resume past work.

Related Work

Studying and supporting everyday work is a central aim of HCI research. Early studies used manual methods such as self-report [11] and shadowing to observe work habits and these methods are still widely used, partially due to the richness of contextual data they provide. Notably, Mark et al. used shadowing in their study of fragmented work [7] and Czerwinski et al. examined task switching with a diary study [1].

[1] https://www.techsmith.com/morae.html

[2] https://github.com/activityhistory/traces

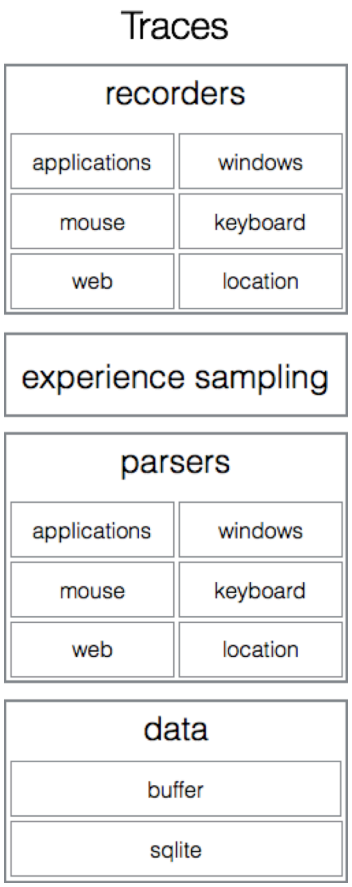

Figure 1: Traces is built on a modular architecture that separates recording data to a buffer, experience sampling, and parsing buffered data to an SQLite database.

Passive sensors have been used to track workplace dynamics since at least the early 1990's with the introduction of Active Badge systems at Olivetti, Xerox PARC, Xerox euroPARC, and MIT [15]. Recent advances in sensor, battery, networking, and storage technologies have further enabled passive and badges to study patterns of communication [10] or using tablets to track noise, light, and air quality along with people's self-reported mood and activities [9]. However, data provided by these sensors typically lack the context that manual studies provide.

Logging phone and computer use provides another lens for looking at work activity that mixes detailed passive measurement with context about the work being accomplished. Numerous activity loggers have been developed for Linux, OS X, and Windows to study aspects of work such as interruption and window management [8, 14]. But few of these are widely shared or open source. As a consequence researchers must develop their own recorders or buy commercial ones.

Finally, any form of observing or logging of work activity can raise significant privacy concerns [2]. One way to mitigate these concerns is for the recording to directly benefit users by, for example, automatically generating a timesheet or digital lab notebook [5, 13].

Traces Activity Tracker

Traces is an open-source tracker that can be extended to provide direct benefits to users. It employs an OS X daemon to capture a detailed history of computer activity. Separate modules track application and window use, websites visited, keyboard activity, mouse activity, and clipboard contents. This modularity allows aspects of tracking to be turned on or off depending on the study or participants' concerns for privacy. Moreover, new modules may be added for detailed tracking of interactions of interest, such as participants' use of their web-browser or word processor. Traces' core logic is written in Python, allowing it to be extended to other operating systems in the future, and listens to OS X's system events using PyObjc[3] bindings. Traces can also take periodic screenshots, triggered by a timer or user activity such as clicking or typing.

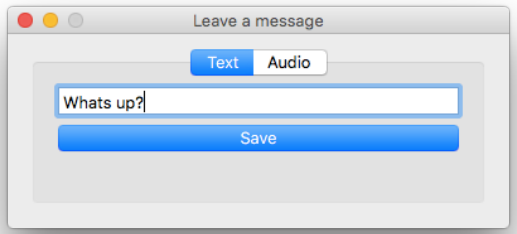

Figure 2: Traces supports several forms of experience sampling including textual and audio responses.

In addition to passive tracking, Traces can ask for user input via experience sampling (Figure 2). Traces currently supports periodic textual and audio experience samples but can be extended for more complex sampling schemes. For example, in one study (described below) we asked participants for a short textual note about what they were doing periodically throughout the day. At the end of each day, we used a sampling debrief window to capture detailed audio

[3] http://pythonhosted.org/pyobjc/

descriptions of what the participants recalled about previously sampled moments. This two-part sampling enabled us to capture rich descriptions of work activities without significantly interrupting the participant while they were working.

We designed Traces to be less obtrusive by reducing its use of system resources and providing facilities for preserving privacy. Traces first saves all activity data to a log file, and only parses those logs to an SQLite database periodically, currently every 15 seconds. This delay not only reduces the frequency we access the database, but also lets Traces clean and compress the data before saving. Moreover, Traces records periodic screenshots rather than full video since the overhead of continuous video recording can impact computationally intensive applications. We also gave users the ability to delete recent history (much like deleting web history) in case they inadvertently recorded sensitive or private information.

Example Studies using Traces

Traces has enabled us to study real world activity at a scale and level of detail difficult to achieve with manual methods. Here we detail two studies in which we have used Traces.

Study 1: Resumption Methods

In our first study we sought to understand how people resume complex work, as when coming back to it after a weekend or from attending a conference. While we had studied interruption and resumption of complex activities in the lab, we sought to understand how resumption happens "in the wild" on self-motivated projects. We had ten participants record their computer activity for two weeks as they worked on activities such as poster design, web development, or dissertation writing. This pervasive, long-term recording let us observe resumption whenever and wherever it happened (e.g., at 11 pm at home). We also believe using Traces reduced the Hawthorne effect since, by the second week of recording, several participants reported significantly less awareness of and concern about recording.

Figure 3: Participants were able to use Chronoviz visualizations of their Traces data quickly find moments when they were resuming complex work. Chronoviz let users review a timelapse of their screenshots, their keystrokes per minute (green line) and their experience samples (red bars).

Using Chronoviz (Figure 3), a tool our lab developed for visualizing video and other time-based data [4], participants were able to review their recorded data and provide descriptions about what they were doing as

they resumed work. Augmenting the interviews with Traces data enabled us to match rich contextual descriptions with detailed data about the dynamics of the resumption.

Study 2: Desktop Thumbnails

In a second study, we asked if reviewing small thumbnail images of prior desktop arrangements could help people recall details about past work such as what they were working on and intended to do next. [12]. Again, we had participants record their computer activity for two weeks but this time made more use of Traces' experience sampling functionality. Every 15 minutes we asked participants for a quick textual note about what they were doing at that moment. At the end of each day of recording, we asked participants to review screenshots and textual notes from a few of these sampled moments and provide an audio description of everything they remembered about the moment. This two-step sampling provided a detailed account of the sampled moments without overly disrupting participants while they were working. Comparing these end-of-day descriptions with descriptions of the same moments cued by viewing various thumbnails of their activity a week after recording helped us test the effectiveness of various thumbnails in cuing episodic memory for computing events.

Conclusion & Future Work

Despite increasing use of sensors to track everyday life activities, workplace studies routinely rely on manual methods of data collection. Those studies that do leverage passive sensor-based recording often focus on the dynamics of work (How) rather than capturing rich situated detail about the work itself (What and Why). Logging computer activity has potential to capture both passive measurements and context but raises significant privacy concerns and requires a robust recording infrastructure that will not interfere with participant's ongoing work activities.

In this paper we presented Traces, open-source software for passively capturing detailed activity histories on computers running OS X. Traces' modular design supports flexible recording and extension both for more detailed tracking and to provide visualizations that may benefit both researchers and end users. Through two studies we demonstrated how Traces can be used to observe everyday work activity at a scale and level of detail difficult to achieve with self-report or shadowing.

Future work will extend Traces in a number of directions including recording tailored for specific activities such as writing, visualizing recorded data to assist and encourage reflection, and exploring how to mitigate privacy concerns through enhanced transparency about what Traces records and facilities for managing recorded data.

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