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Researching real-world Web use with Roxy: Collecting observational Web data with informed consent

Ericka Menchen-Trevino

Northwestern University

Chris Karr

Audacious Software LLC

Abstract

Outside of a lab environment, it has been difficult for researchers to collect both behavioral and self-reported Web use data from the same participants. To address this challenge we created Roxy, software that collects real-world Web-use data with participants' informed consent. Roxy gathers Web log data as well as the text and HTML code of each page visited by participants. In this workbench note we describe Roxy's data gathering capabilities and search functions, then illustrate how we used the software in a multimethod study. The use case examines selective exposure to political communication during the November 2010 U.S. general election campaign.

The Internet is an integral part of daily life in the developed world[1]. According to a 2010 survey by the Pew Internet & American Life project, 79 percent of American adults use the Internet, and 66 percent have home broadband (Princeton Survey Research Associates International, 2010). Increasingly, networked technologies are so embedded in routine activities that the technology itself seems to disappear from view (Parks, 2009). In contrast to earlier visions of a separate cyberspace, the Internet is now "the utility of the masses" (Wellman, 2010 p. 20). News consumption, long a routine and even ritualized activity (Carey, 1975), has moved online. A 2010 survey of the U.S. showed that 80 percent of online Americans get news online (Princeton Survey Research Associates International, 2010), while a 2008 survey of the city of Chicago (the site of our[2] research project) showed that 91 percent of online Chicagoans access news on the Web (Mossberger & Tolbert, 2009).

Yet it has been difficult for researchers to combine behavioral and self-report data in socio-political investigations of communication technologies. When we looked for tools to collect real-world Web behavior data for a multi-method project, the software was either not

[1] This software project was possible due to a grant from the Department of Communication Studies at Northwestern University, and the guidance and support of James Ettema. Grants from Northwestern's School of Communication and The Graduate School supported the research case study we describe in this report. The authors would also like to thank Robin Hoecker for her assistance with the abstract.

[2] We use the first person plural throught the article to avoid awkward grammatical constructions, however, the research project that prompted the creation of the software and serves as the case study herein was conceived and executed by Ericka Menchen-Trevino, while the software architect and developer was Chris Karr.

available for use (trade secret software developed for consulting or Web ratings purposes), or not designed to adhere to the ethical principals of informed consent (software designed for workplace employee monitoring or parental control of children). This prompted us to create Roxy, software that runs on a proxy server that can collect real-world Web behavior for a wide variety of research goals while adhering to principals of informed consent.

Researchers have examined the Web's role in political information gathering and political activity using different methods. Many of these studies use nationally representative sample surveys, such as the reports from the Pew Internet & American Life Project and the National Annenberg Election Survey. The disadvantages of surveys that ask participants to report their media use is that respondents have a great deal of difficulty reporting use accurately, and survey estimates are generally far higher than ratings data indicate (Price & Zaller, 1993, Schwarz, 2001). Reporting media use is cognitively difficult, particularly in a rich environment of ubiquitous media. A recent report shows that 46 percent of American adults get news from 4 or more media platforms regularly (Purcell, Rainie, Mitchell, Rosenstiel, & Olmstead, 2010). A recent experimental study was designed to discover the cause of respondent over reporting of news media use on surveys. This study found that "overreporting results from unrealistic demands on respondents' memory, not their motivation to misrepresent or provide superficial answers" (Prior, 2009, p. 893).

Other studies of political information gathering online rely on ratings data from companies such as Nielsen, comScore or Hitwise (for example Hindman, 2009; Tewksbury, 2003). Using this type of data eliminates the problem of respondents' limitations in describing their online behavior, but it creates other challenges. Ratings companies keep the identity of their participants confidential. Investigators who use this data generally do not have the opportunity to

contact the people whose data they are investigating to inquire about their other behaviors and motivations. Often ratings data is provided in aggregate form or limited to pre-determined Web sites and does not provide a comprehensive picture of individual-level browsing. Furthermore, this ratings data does not include an archive of the text and HTML viewed by participants, so the exact content accessed by the individual is often uncertain, particularly on fast-changing news Websites. The software used to collect ratings data is typically treated as a trade secret so it is often unclear exactly how the information is recorded, and some aspects of the participant recruitment process are also opaque. This prevents the methodological transparency needed for research replication.

Other researchers have studied online political behavior in a lab setting (Iyengar & Hahn, 2009; Kim, 2007; Knobloch-Westerwick & Hastall, 2010; Menchen-Trevino & Hargittai, 2011). This approach allows the investigators to combine self-reports and observed behavior in a transparent and replicable manner. The primary drawback of lab-based experiments or observations is that they are different from real-life Web use. Participants are in an unfamiliar location using the lab computer and working under a time constraint, imposed by the researcher or their own schedule. They are often assigned a task they would not ordinarily choose to perform.

Roxy allows investigators to observe and record participants' real-world Web use. Researchers using Roxy have full control over participant recruitment, selection, and the data gathering process. The data collection effort is comparable to survey and lab-based projects. Every research design involves trade-offs. Roxy gives Web researchers another tool with which to tackle such decisions. The basic proxy server technology that Roxy uses is widespread and has

existed for quite a long time. Our application of proxy servers in the research data collection process demonstrates an innovative use of this technology.

Below we discuss our development goals for the software and the technologies we used to reach them, including the refinements we made through testing. Next we describe the user's experience before we detail the researcher's work flow. Finally we describe the study where we collected eight weeks of Roxy data from 41 participants who also completed a series of surveys and an in-person interview to demonstrate Roxy's unique contribution to the dataset.

Development

Roxy is designed to balance the requirements of informed consent and privacy with the need for comprehensive Web-activity data from participants. While Roxy's first deployment focused on online news and political information consumption, we built the software to address a wide variety of Web data collection needs.

Roxy is a Web proxy server. A proxy server is a software program that acts as an intermediary in the exchange of requests and content between a respondent's Web browser and the Internet. When a user's browser is configured to use a proxy server, the browser submits requests for content to the proxy server, and the proxy server fetches the content on the browser's behalf. When the proxy receives the content from the originating source, it returns it to the browser and the browser presents the content to the user. Proxy servers have been used to solve a variety of problems, such as bandwidth optimization, content filtering, and anonymization of Internet traffic.

Proxy servers are a proven infrastructure technology with wide technical support among the many platforms and systems that connect to the Internet. Using a proxy server allowed us to collect rich information while avoiding the logistical challenges of developing, installing, and

supporting custom software on our participants' computers. We provided participants with simple instructions to configure their existing browsers to connect to the Roxy server. After following a few steps to connect to the proxy server, they joined our data collection system without installing any software on their computer.

Since the existing proxy programs are predominately designed to transfer and filter content efficiently, we constructed our own to implement the data collection and provide effective informed consent and privacy protections for our participants. Roxy differs from other proxy packages in the following ways:

- Roxy keeps a full record of the HTML and text content that participants request. This textual content provides the corpus that allowed us to interview participants about the specific content they requested or perform any form of textual analysis. In addition to the text of visited pages, we also collect the URL, the referring page and the date and time of the content access. See Table 1 for sample data.
- Roxy allows participants to specify pages or sites to blacklist from our system. This blacklist is used to protect participants' privacy by allowing them to opt out of our study on a fine-grained level and to be confident that we are not collecting private information like bank account numbers and Web-based e-mail messages.
- Roxy provides participants a mechanism to review their browsing history and remove information after-the-fact. This is an additional tool to protect participant privacy and ensure informed consent.
- Roxy includes a system-wide blacklist that allows researchers to proactively block sites that are not useful to their research using existing blacklists and site

categories. We adapted others' lists to avoid collecting data when participants visited adult sites, banking Web pages, and personal social networks.

- Roxy does not attempt to log any encrypted (HTTPS) content.

In summary, Roxy archives copies of the content that participants request for later analysis, but balances this potentially intrusive activity by giving participants a rich set of tools to review the gathered information, and to exercise control over whether that information becomes part of our dataset. No available proxy server program provided both the tools for rich data collection, as well as robust privacy management features.

We used a variety of technologies to build Roxy. As mentioned above, we did not require participants to install custom software on their own computers, so our efforts focused on building the central proxy server. The core of the server uses the Twisted framework for building Internet applications (Twisted Matrix Labs, 2010). Twisted provided the infrastructure for managing the proxy traffic. We used a MySQL database to store the collected information and operational data like the usernames and passwords used to identify participants (Oracle Corporation, 2010). In addition to MySQL, we also used Apache Solr to index the textual content (The Apache Software Foundation, 2010). Whereas MySQL's text searching and analysis functions are fairly basic, Solr allowed us to efficiently search the large amount of information we collected using a rich query language.

We protected participants' privacy and maintained the highest level of data security by hosting Roxy on its own private dedicated host. Only the Roxy administrators had access to any personal identifiable information. We supplemented the site's privacy protections with a robust set of intrusion detection and access denial tools that prevented unauthorized third parties from accessing the server. These measures included strong firewalls (iptables), intrusion-detection

scanners (Rootkit Hunter), daily log analyses (logwatch), and a file modification watchdog via a secure version control system (Subversion). When Roxy is used in this manner, the data that it captures is secure at all levels. Using Roxy does not expose the participants' Web data to any additional vulnerability beyond what they would encounter in routine Web use. After data collection is complete, the researcher must then store the resulting dataset securely to protect participants from privacy violations.

The participant-facing portions of the server are implemented as a small custom Web application integrated into the Twisted infrastructure. This Web application includes instructions for participants to configure their systems, a testing tool to determine if the setup was successful, and the tools described above for managing privacy. Roxy administrators (the researchers or programmers) use a private administrative site to review how many participants are active at a given moment, as well as search tools to review the data collected, described further below.

When a participant makes a request through the Roxy server, the following flow is used (see Figure 1):

1. The request is checked against a blacklist on the participant's computer specified by Roxy's proxy configuration (PAC) file. If the request matches, the browser does not use the proxy at all (a, b, c).
2. The request is transmitted to the proxy and is tested against the system and user blacklist (d & e). If the participant has not logged into the system, (d) is interrupted with a login dialog and resumes upon successful authentication. A matched request is tagged before being sent to the request manager (f).
3. The request manager fetches the content from the Web (g). If the content is not blacklisted, it is stored in the full-text index (h), and the database (i).

4. The request manager returns the requested content to the participant (j).

{Insert Figure 1 about here}

Refining Roxy

After we completed an initial implementation of the Roxy software, we conducted an internal beta test to evaluate the effectiveness of the system as well as tune the software to handle the larger population of users in our first study. Since most existing proxy server packages simply relay content between the requestor and the content provider, we used this beta testing period to explore the performance ramifications of not just transmitting content, but also storing it. Our suspicion that the computational costs of storing the content would be a performance issue was correct, and we refined our initial implementation to use a multithreaded design where saving retrieved content was delegated to a collection of worker threads.

In addition to raw performance metrics, we also reviewed the content required by a typical Web page view. Web advertising introduced a situation where a single Web page view could request content from tens of third party advertising sites. For example, viewing the source of the Chicago Tribune front-page in January 2011 reveals that content loads from more than ten non-Tribune domains, the majority of them advertisers. Since banner ads, Facebook "like" buttons, and other auxiliary content were not essential to our first study, we elected not to log these requests and proxy them without saving this content to improve performance. This allowed us to accommodate more participants in our study using fixed resources. Similarly, no image or video files were archived based on their relatively lower utility to the study compared to the high resource cost of storing them. Studies with different research goals or funding can customize the software to make different choices.

Originally, advertising blacklists were implemented on the server side, but we discovered that we could conserve server resources using our proxy configuration file (PAC). A PAC file is a small JavaScript file that tells the browser when to use the proxy and when to communicate with the Internet directly. We originally deployed the PAC file to simplify browser configuration, but later began using it as a blacklist to alleviate the load on our server.

Finally, after observing Roxy in the beta test, we discovered that the large amount of text we were archiving during the study was beginning to degrade the performance of our database because extremely large databases perform more slowly. We measured the performance and activity required to begin degrading the server's performance, and implemented a regularly scheduled off-hours maintenance process that would collect and archive each week's data. This process reset the system's database each week so we could continue to provide a responsive experience to our participants, who were sensitive to the slightest delays introduced to their Web-browsing experience. At the conclusion of the study, we reassembled our weekly snapshots into a complete dataset for analysis.

Roxy from a Participant's Perspective

Roxy's user interface is designed to cause participants as little interruption as possible, while still offering them meaningful control over the system. The username and password are saved so users do not have to enter them frequently. Once users select their session type (regular, private, or guest) they are immediately redirected to the page they were requesting before the interruption occurred. This results in a one-click user interaction in most cases, where the one click indicates the participants' choice of session type (see Figure 2).

After a participant has been inactive for more than 30 minutes, Roxy automatically prompts them to re-authenticate. Participants may visit the Roxy login page (Figure 2) at any

time to end their current session and to begin a new session with different privacy preferences. Each of the three session-type buttons display explanations that describe the session types when a participant holds their mouse cursor over an option. This allows users who may not have read or remembered Roxy's participant instructions to understand how to use the tool based only on the login page itself. The explanatory text for the 'Regular Session' button is: "Roxy will record the sites you view, except for any sites you've blacklisted or sites that are secure (start with https and have a 'lock' symbol like banking sites)." The text for the 'Private Session' reads: "Roxy will not record any information about the Web sites you visit in a private sessions. Please use this option sparingly to help the research project. You can blacklist specific sites using the 'History & Blacklist' link on the right." The 'Guest Session' button explains: "If you are not a participant in this research project please use this option so that none of your Web browsing is logged."

{Insert Figure 2 about here}

Participants can also review the data Roxy has collected from them. The 'Browsing History' page shows a chronological list of every page logged, with the option to delete the page from the log, or to blacklist the domain (see Figure 3). A link to the Browsing History page is available on the Roxy login page. Users can also create a personal blacklist of Web sites they do not want Roxy to log.

{Insert Figure 3 about here}

Roxy from the Researcher's Perspective

Roxy has two features available only to administrators, who are generally the researchers. These features are the User Status page and the Data Explorer. The User Status page shows each username and indicates whether or not that participant has ever logged on, if the participant is logged on now, and the date and time of last login if applicable. The Data Explorer allows

researchers to search the full index of content in Roxy (see Figure 4). There are many options for targeting one's search as depicted in Figure 4. The example illustrated in Figures 4 and 5 shows a query that returns results where the word Obama matches in the title field of the page only for the username 'test.' Up to 50 results will be displayed in reverse chronological order according to when 'test' accessed these pages, based on the settings depicted in Figure 4. The Data Explorer is a front-end for Solr search server queries. Researchers who want an even more powerful query can go to the 'Raw Search Interface' and construct queries in Solr syntax directly. The flagging feature in the search results helps researchers who need to go beyond simple text searching to manually indicate interest in relevant results by clicking the 'flag' option in the search results (see Figure 5).

{Insert Figure 4 about here.}

{Insert Figure 5 about here}

Work Flow

Researchers must acquire a sufficiently powerful server for the project they wish to conduct. Participants are very sensitive to delays in their normal Web browsing and if Roxy significantly impacts browsing speed this will jeopardize the research project because it will cause participants to drop out of the study. Consequently, researchers must accurately predict the number of participants in a study, how active those participants are online, and how well the server fits the participant profiles. We suggest pilot testing one's server before launching a project to detect any delays in browsing speed.

While selecting participants for a research project using Roxy, there are a few technical issues to consider. Any Web browser that connects to the Internet and allows the user to configure a proxy can use Roxy; however, not all browsers support proxy servers. The AOL

Web browser and the AT&T mobile network[3], for example, do not support custom proxy configuration. Also, participants must be able to configure their Web browser to use Roxy, so those who browse the Web primarily in tightly-controlled environments like offices will pose a challenge.

After selecting participants and obtaining informed consent, researchers follow this process to deploy Roxy:

1. Create usernames and passwords for the participants.
2. Send the participants instructions on how to connect to Roxy and inform them of their username and password.
3. Verify that the participants have connected by viewing the user status page.
4. (Ongoing) Monitor the server and database performance for hints of a potential overload. Adjust settings as needed. Perform backup and archiving as needed, about once per week.
5. When the study is complete, ask users to remove the proxy setting that connects them to Roxy.

Researchers can search the data during and after data collection using the Data Explorer. Once the data collection is complete, researchers can export the data for analysis in specialized data analysis software packages. An example of the data available for export is provided in Table 1. The fields described in Table 1 include the Request ID (an automatically generated unique identifier), the username, the timestamp which is in YYYY-MM-DDTHH:MM:SS.SSSZ format, the URL, Search terms (derived from the URL field), Referrer (if applicable), Title (derived from the HTML), and the actual HTML code and text of the record (displayed in part).

[3] The iPhone, which at the time of this research project was only available through AT&T, allows users to configure a proxy only for wireless hotspots, but not the AT&T moblie network.

Using Roxy in a Multi-method Research Project

Roxy was designed to collect data for research on the role of technology in selective exposure to political communication. Below, we begin with a brief description of the research project and then discuss some of the preliminary results. We focus on Roxy's unique contributions to the dataset rather than substantive conclusions because the purpose of this workbench note is to demonstrate the analytical potential of Roxy, not to present research findings, which will be discussed in other publications.

Roxy was deployed for this project from September 6th 2010 until November 5th 2010. This time period includes eight weeks of the U.S. general election campaign and three days after the election on November 2nd. There were 41 respondents from the Chicago area who completed the study[4]. During this time, the participants successfully logged 186,296 Web pages to Roxy[5]. They also completed 10 online surveys and, after the election, an in-person interview lasting, on average about 1.5 hours. Participants were paid a total of $70 for completing the study.

The first author took great care in recruiting and selecting participants based on the theoretical concerns of the project. The research design, which will be described in detail in publications about the study's results, required participants with different levels of political

[4] Two respondents who later dropped out of the study used Roxy during most of this time, as well as three test users who were not part of the study, bringing Roxy's user load to a total of 46 people who varied considerably in their amount of Web use. To meet the needs of these users, we rented a dedicated server with the following specifications: 2.4 GHz Xeon server equipped with 3 GB RAM & 500 GB disk drive.

[5] Roxy logged over 360,000 requests. Many requests were components of Web pages, such as advertising, buttons, or widgets.

interest. Given the fairly high respondent burden and the technical requirements for Roxy use, the first author chose to use a quota sample drawn from a pool of recruits who expressed interest in participating by completing an online recruitment survey designed for this study. The recruitment survey was completed 900 times, and 629 qualified for the study by meeting the study's voter registration, age, and web use skill requirements. The quota sample was selected to match the U.S. population's level of political interest[6] and, for the purpose of selecting participants who would be able to use Roxy most of the time, included those who indicated that they owned the computers where they did most of their Web browsing.

The surveys, Roxy data, and the semi-structured interviews worked together to inform the project, since each type of data have different strengths. Before each in-person interview the first author reviewed the participant's Roxy data and survey responses. The first author then assessed the Roxy data by searching for terms related to the mid-term elections, politics, and news in general. For example, searches were performed for local candidate names, as well as national political terms such as "Tea Party" and national political figures like Obama. The first author also reviewed the surveys before the interviews, which contained several open-ended questions, in part to find additional search terms to use in Roxy that were specific to the participant's stated interests. During this process the participant's general pattern of online news access was noted in order to discuss this with the participant during the interview. The first author also used the flag feature in Roxy's search results (Figure 5) to highlight any interesting or puzzling pages and brought her computer with her to the interview to review these flagged pages together with participants as needed during the interview.

[6] This match was based on survey measures of political interest in the American National Election Studies post-election survey of 2008 that were also used in the recruitment survey.

We were not sure how often participants would use Roxy's privacy features. Most participants did choose a private session at least once (28 out of 41), but few did so frequently. Over all 5,784 sessions, the 41 respondents chose a logged session in 91.1 percent of cases. However, the distribution is highly skewed per user (see Figure 6). While 13 participants chose logged (regular) sessions every time, one person chose only 34 percent logged sessions. The individual with the highest rate of private sessions shared her computer with other family members who mistakenly used the private session option instead of the guest session. This mistake did not impact data collection since data was sought from the participant only, not her children. The median among users was 98 percent logged sessions. Five participants used the blacklist feature. As requested, none of the blacklisted sites were news sites, and the list of specific sites blacklisted by a participant was deleted from the study's records after data collection was complete to protect privacy. Participants were very cooperative with the data gathering and used the privacy features judiciously.

{Insert Figure 6 about here}

Roxy's search functionality allowed us to explore political content wherever it was found, not just in sites categorized as news. Others have found important political discussions occurring outside of sites defined as news or politics (Wojcieszak & Mutz, 2009), but studies that consider the political implications of non-political Web site use are rare in part because data that addresses this issue have been difficult to collect. To illustrate the breadth of our data, we explore the range of different Web sites accessed by participants whose title contained the word "Obama." This search had 222 results, 189 of which were unique (duplicates are due to the same participant accessing the same Web page more than once during the study). The pages came from 64 different domains that ranged from the very popular, such as yahoo.com and cnn.com, to

niche sites like motherjones.com or personalfinancebulletin.com, to obscure blogs like Freedom Eden. This breadth allowed us to explore online political discussion and participation more fully in the interviews, using specific examples from participant browsing history.

The detail of Roxy data also facilitates the development of *meaningful* quantitative measures by allowing researchers to examine the actual page content if non-significant findings occur when significant differences were predicted. Initially it seemed reasonable to expect that participants who accessed pages with the term 'Obama' in the title (30 of the 41 participants) would be those who were more interested in politics, as compared to those who did not access any such pages. Most of the search results for 'Obama' in the Web page title field were articles about the president and his policies, such as an article from the New York Times entitled "Obama to Open Offshore Areas to Oil Drilling for First Time." However, this measure does not correlate significantly with the participants' survey measures of interest in government, politics, and elections. Looking more closely at the content of the titles the reasons for this lack of correspondence become clear. For example, one participant accessed a page with the title "Reuse, Renew, Reverse: Michelle Obama's sweater two ways" [7]. Another respondent accessed many pages while searching for the streets that would be closed for an Obama campaign appearance in Chicago. Also, some participants accessed national political news primarily offline via TV, radio, magazines, or talking with others. Of course, the number of times 'Obama' appears in the title field may be a reasonable measure of national news access in a large dataset with hundreds or more participants who get their news primarily online, and more sophisticated

[7] The correlation between those with at least two search results with Obama in the title (n=22) and the survey measure of political interest was also statistically insignificant.

techniques could use the context of the Obama reference, but this simple measure will remain susceptible to the types of errors we see in the individual-level data.

Although issues of informed consent for non-participants prevented us from logging Facebook for this study, the referrer field allowed us to observe cases where participants were referred from Facebook to another Web site. We have logged 978 Web pages from 30 respondents who accessed a Webpage via a link from facebook.com. This informed the interviews, which dealt with political information exposure on Facebook in part. Also, the Roxy data alone show which types of news articles are accessed via Facebook and the spreading of political memes such as, whatthefuckhasobamadonesofar.com, which detailed the president's accomplishments and was accessed by three participants via Facebook.

The first author who interviewed the participants in person was not sure how they would respond to questions based on their browsing log. It was unclear how much detail they would remember or if they realized exactly what was logged. Participants responded well to these questions overall. Although they did not recall the details of their actions in some cases, none of them were surprised about what was logged, demonstrating an effective informed consent process. The interview questions based on the Roxy data were critical in helping participants remember and discuss the context of their behavior. Below is an example of an interview question about a search on a political topic.

> Interviewer: Another … search that you did was looking for the Tea Party's stance on homosexuality.
>
> Participant: … You know, I'm gay so like their stance on it is a big issue to me… I actually remember, now, doing that… I think there was some discussion about … they [the tea party] are very like 'government get out of our lives.' And I'm

like, well I wonder … if they're true libertarians then they're like, … 'people can do whatever they want.' So, I wanted to see like if they had actually made statements about … how they feel about homosexuality.

This type of information about specific behaviors added very useful context for understanding how political information searching occurs in real-world contexts.

The first author also asked participants if they did anything differently online because of the software. This question was asked near the end of the interview that typically lasted about 90 minutes, after rapport had been established and specific examples from the browsing data had been discussed. Most participants indicated that they did not change their browsing behavior significantly once they had established that the software was working as described. The following quote comes from the interview of a 49-year-old male participant.

Interviewer: Do you feel like you did anything differently online because of the software?

Participant: No… With the blocking capabilities, … there's a couple sites that might be embarrassing … but, … I … [blocked them] so…

Interviewer: Did you get a chance to look at the data that it was collecting and that sort of thing or not really?

Participant: I only went and did that once and that was towards the beginning when I wanted to double check to see if um, like the social networking sites and these types of things were being blocked… and then after that, it just seemed unnecessary… because I trusted it.

Several participants said they never checked to see what data the software was collecting and simply continued their normal online routines. A 32-year-old female participant was asked if

she ever looked at her logged data and she said, “No, I just let it go.” Similarly, a 30-year-old female participant indicated, “I completely ignored that it was ever there.”

Although one might suspect that participants simply told the interviewer that their online behavior did not change because they thought that is what she wanted to hear, some did mention that they changed their behavior due to the observation. A 33-year-old participant mentioned that he may have avoided a news site he considered lowbrow, but he also wanted to portray his behavior honestly:

> I was focusing … more heavily on the intelligent stuff [rather] than like the Daily Beast [a website that mixes entertainment with political news]. Then I would go, “Oh, I should go check out the Daily Beast, because I have to be honest about this, I really do look at this.”

We do not know how much he would have accessed the site otherwise, but we see that this participant accessed 77 pages from thedailybeast.com over the course of the study.

Conclusion

The link between researchers and participants has an important ethical dimension. This relationship should be one of mutual trust and respect. When researchers ask participants to use software that monitors their Web use they are asking for a significant amount of trust that it is secure and works in the way the researcher has described. Roxy gives participants full control over their data before and after it is collected to create a reciprocal relationship where participants are both giving and receiving trust. Participants could use their control over their data to harm the research project by deleting information that the researcher might deem useful or interesting. Participants can potentially subvert most, if not all, research methods that rely on

human subjects. It is the responsibility of the researcher to build a mutually beneficial and respectful relationship with participants.

Our case study demonstrates that this type of relationship is achievable in practice with participants, 78 percent of whom were recruited through online advertising, primarily Craigslist. In addition to the relationship of mutual trust built into the software, the first author created an online video of herself describing the research to put a human face on the project for invited participants, and paid part of the compensation in advance to participants who began the study in exchange for their promise to complete the research. Trust and other behavioral norms between participants and researchers may vary considerably among projects or cultures, and researchers who employ observational methods with informed consent should consider this carefully. Furthermore, studies of anonymous Web browsing logs should be compared to findings from studies that use informed consent to log Web data to find out how informed consent may impact browsing logs.

Roxy enabled us to collect a unique dataset that was directly relevant to our research questions. We believe that researchers in many fields of study may benefit from combining real-world Web data with other methods, including library and information scientists, market researchers, and those who do lab-based studies of Web behavior and want to compare the lab with real-world behavior. Roxy could also be used as the only data collection method in research that focuses on general patterns of individual-level Web use.

Most modern Web browsers can use proxy servers. This software provides a way to capture a type of data that was previously inaccessible to many researchers, and can do so on a wide variety of computer platforms. However, if more Web browsing occurs on mobile smart phones in the future, this will present a technical challenge. Roxy is an important first step in

what may be a new type of research software for observing real-life online behavior for social science research purposes.

The development of this tool from concept through launch took less than one year of part-time work by the two authors. We have accomplished a significant amount given our limited resources. We wish to develop Roxy into an even more general and scalable tool for researchers observing Web behavior. Other projects may need more or less data than the study Roxy was originally designed to support, for example, so a simple configuration page that allows researchers choose what data they would like to collect could be developed. Roxy is a data-gathering tool that is not intended to provide full analysis capabilities so we would like to provide a wider variety of export functions to transmit Roxy data to data analysis tools such as qualitative data analysis software, statistical packages, linguistic, textual analysis, and network analysis tools.

We hope to release the Roxy software under an open-source license if we obtain the resources to complete the necessary documentation and modifications to make the software useful to a wide variety of researchers. Current information about Roxy will be available at http://www.roxyproxy.org/. We look forward to collaborating with other researchers and institutions to further develop this unique tool.

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Author note

Ericka Menchen-Trevino

Northwestern University

Ericka Menchen-Trevino is a Ph.D. Candidate in the Media, Technology & Society program in the School of Communication at Northwestern University. She received her M.A. in Communication Studies at the University of Illinois of Chicago, and her B.S. in Anthropology at Loyola University Chicago. Her research interests lie at the intersection of technology studies and political communication.

Chris Karr

Audacious Software LLC.

Chris Karr is an independent ubiquitous computing researcher & consultant. He received his M.A. in the Media Technology & Society program in the School of Communication at Northwestern University, and his B.S. in Computer Science from Princeton University. He is the primary software developer for the Roxy program and is the founder and chief developer at Audacious Software.

Correspondence concerning this article should be addressed to Ericka Menchen-Trevino at pubs@ericka.cc.

Figure and Table Captions

Figure 1: Request flow diagram

Figure 2: Roxy login page[8]

Figure 3: Roxy Browsing History page

Figure 4: Roxy data explorer

Figure 5: Search results from Roxy Data Explorer

Figure 6: Percent of private sessions per user (n=41, 13 never selected a private session)

Table 1: Sample Roxy data

[8] Figure 2 is a partial screen-shot of the Roxy login page. This figure focuses on the login information.

Figure 1

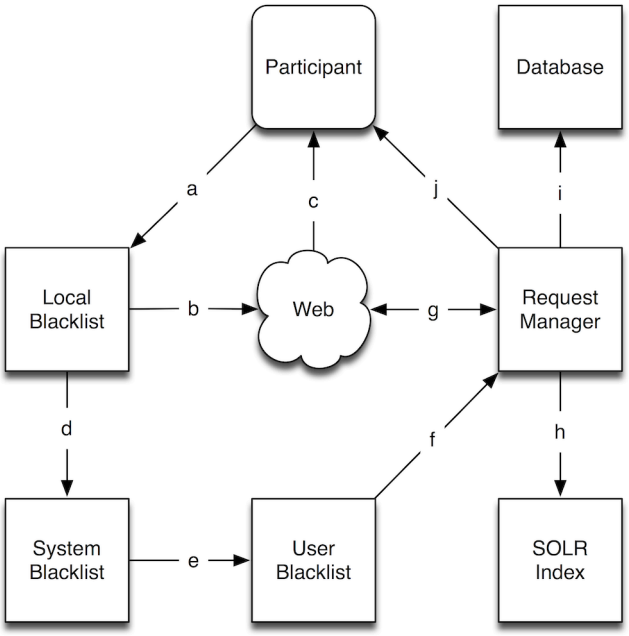

Participant
Database
a
c
j
i
Local Blacklist
b
Web
g
Request Manager
d
f
h
System Blacklist
e
User Blacklist
SOLR Index

Figure 2

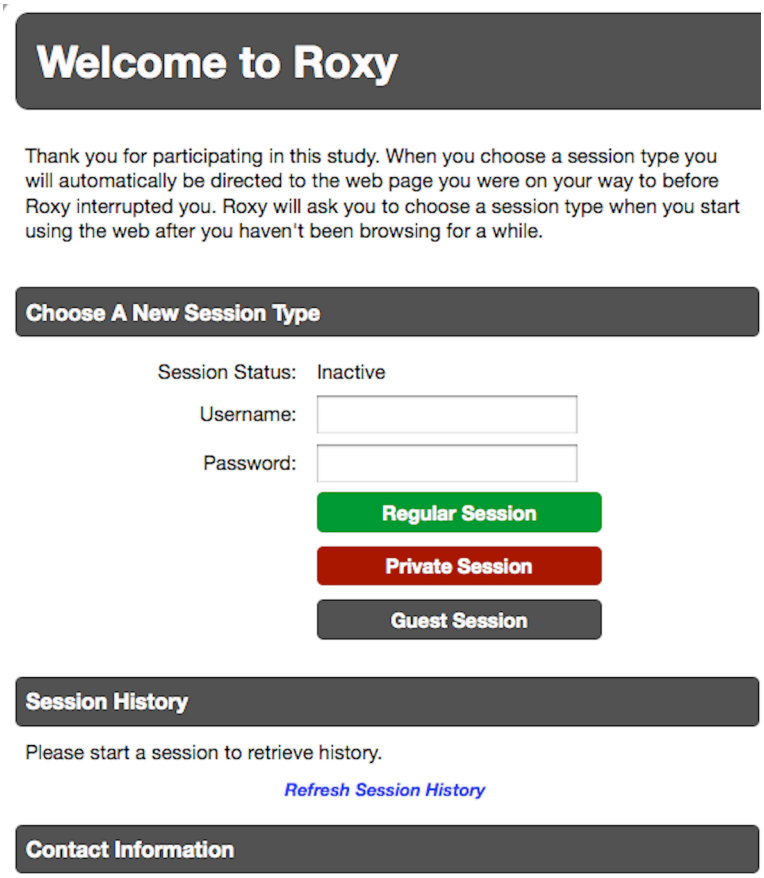

Welcome to Roxy
Thank you for participating in this study. When you choose a session type you will automatically be directed to the web page you were on your way to before Roxy interrupted you. Roxy will ask you to choose a session type when you start using the web after you haven't been browsing for a while.
Choose A New Session Type
Session Status: Inactive
Username:
Password:
Regular Session
Private Session
Guest Session
Session History
Please start a session to retrieve history.
Refresh Session History
Contact Information

Figure 3

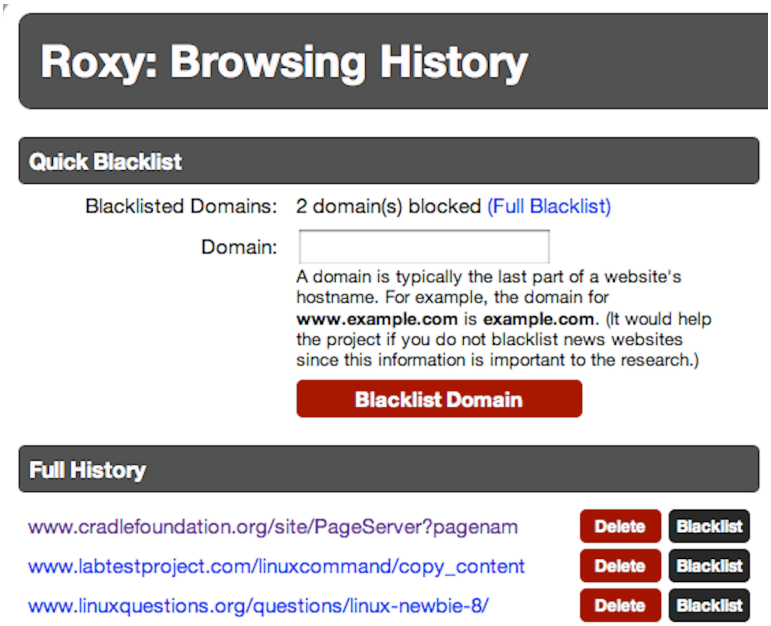

Roxy: Browsing History
Quick Blacklist
Blacklisted Domains: 2 domain(s) blocked (Full Blacklist)
Domain:
A domain is typically the last part of a website's hostname. For example, the domain for www.example.com is example.com. (It would help the project if you do not blacklist news websites since this information is important to the research.)
Blacklist Domain
Full History
www.cradlefoundation.org/site/PageServer?pagenam
Delete
Blacklist
www.labtestproject.com/linuxcommand/copy_content
Delete
Blacklist
www.linuxquestions.org/questions/linux-newbie-8/
Delete
Blacklist

Figure 4

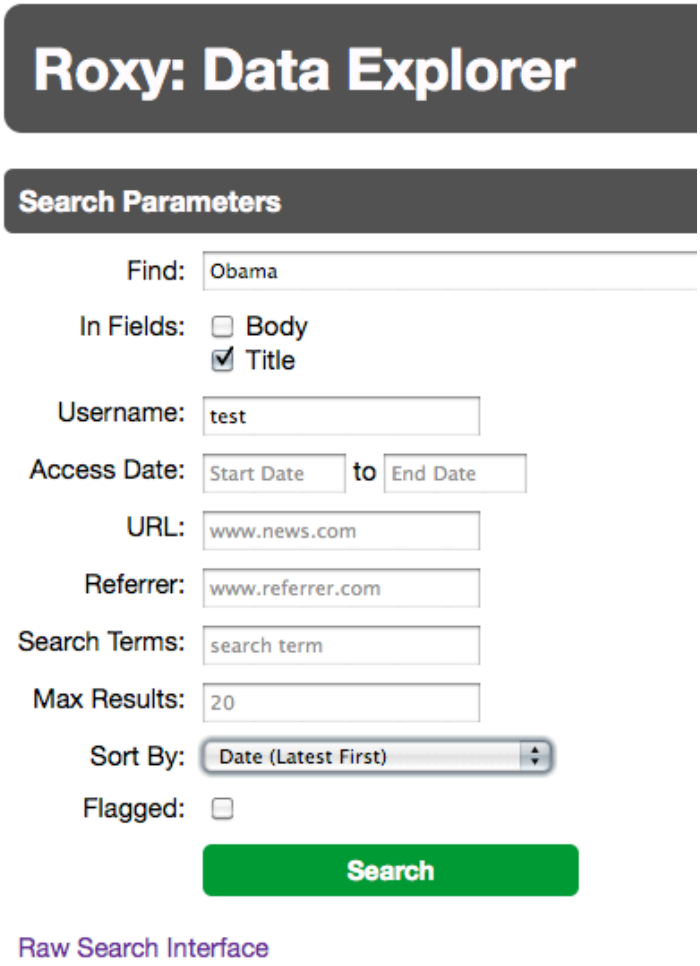
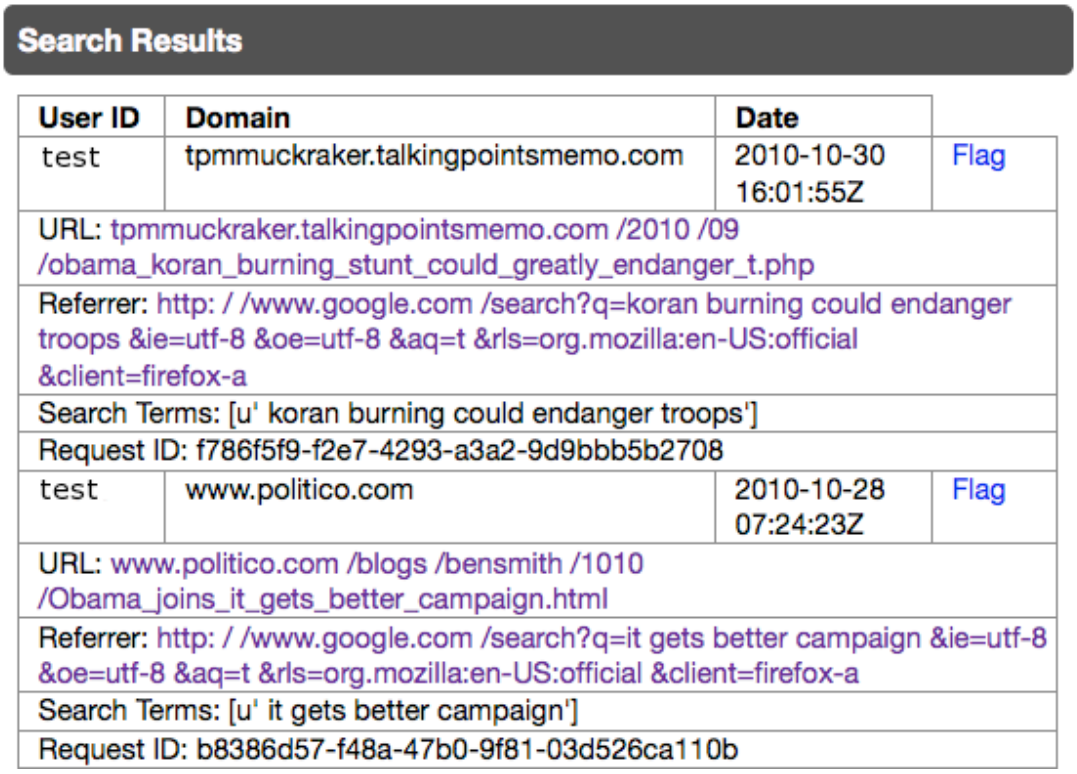

Roxy: Data Explorer
Search Parameters
Find:
Obama
In Fields:
Body
Title
Username:
test
Access Date:
Start Date
to
End Date
URL:
www.news.com
Referrer:
www.referrer.com
Search Terms:
search term
Max Results:
20
Sort By:
Date (Latest First)
Flagged:
Search
Raw Search Interface

Figure 5



Search Results

User ID	Domain	Date	
test	tpmmuckraker.talkingpointsmemo.com	2010-10-30 16:01:55Z	Flag
URL: tpmmuckraker.talkingpointsmemo.com /2010 /09 /obama_koran_burning_stunt_could_greatly_endanger_t.php			
Referrer: http: / /www.google.com /search?q=koran burning could endanger troops &ie=utf-8 &oe=utf-8 &aq=t &rls=org.mozilla:en-US:official &client=firefox-a			
Search Terms: [u' koran burning could endanger troops']			
Request ID: f786f5f9-f2e7-4293-a3a2-9d9bbb5b2708			
test	www.politico.com	2010-10-28 07:24:23Z	Flag
URL: www.politico.com /blogs /bensmith /1010 /Obama_joins_it_gets_better_campaign.html			
Referrer: http: / /www.google.com /search?q=it gets better campaign &ie=utf-8 &oe=utf-8 &aq=t &rls=org.mozilla:en-US:official &client=firefox-a			
Search Terms: [u' it gets better campaign']			
Request ID: b8386d57-f48a-47b0-9f81-03d526ca110b			

Figure 6

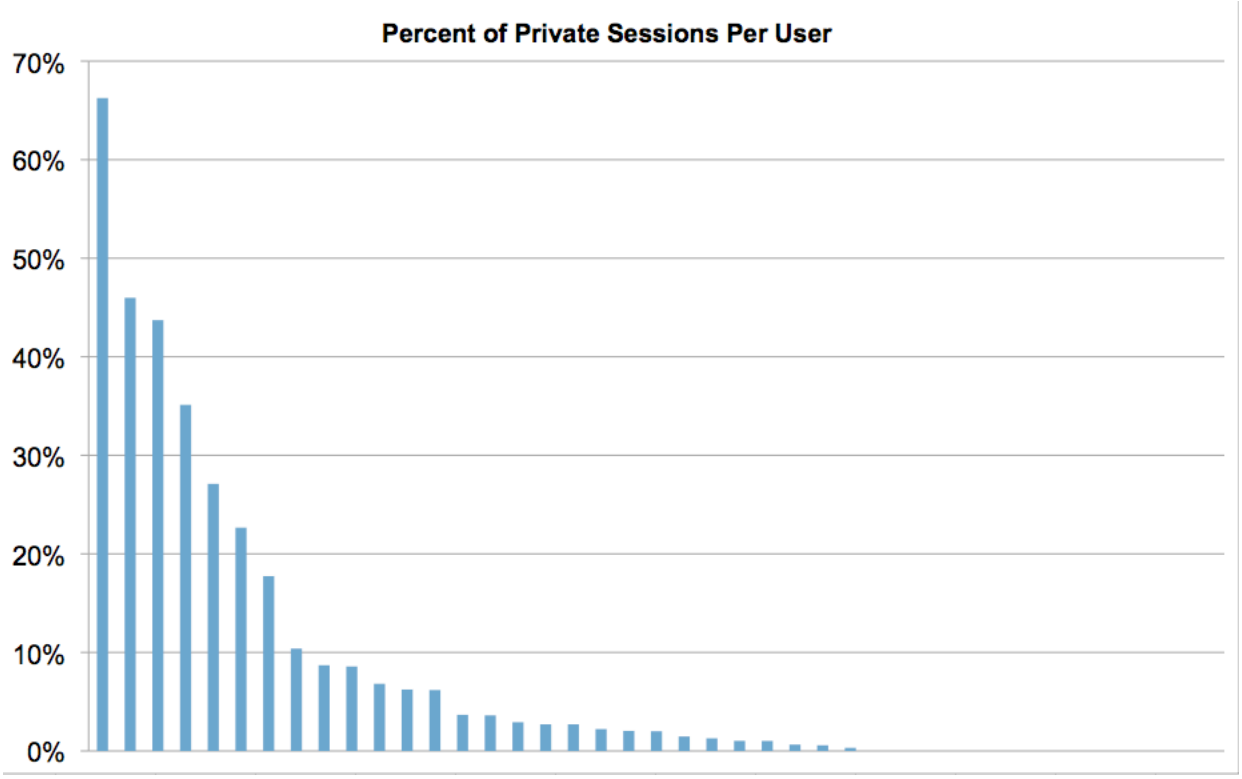


Table 1: Sample Roxy data

Request ID	Username	Time Stamp	URL	Search Terms	Referrer	Title	HTML Content
276767ad-fb27-4a14-b3e5-600e72a33dcb	User A	2010-10-08T14:26:35.573Z	www.chicagotribune.com/news/elections/ct-met-obama-visit-1007-20101007,0,5838339.story		http://www.chicagotribune.com/	Obama raises Senate money for Giannoulias - chicagotribune.com	<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN" "http://www.w3.org/TR/html4/loose.dtd"> <html> <head> <meta http-equiv="X-UA-
6612eaee-d2d5-4069-8d52-2b03afc34ac2	User B	2010-09-08 19:04:28Z	en.wikipedia.org /wiki /James_Meeks	james meeks	http: //www.google.com /search?q=james meeks &rls=com.microsoft:en-us:IE-SearchBox &ie=UTF-8 &oe=UTF-8 &sourceid =ie7 &rlz=1I7DKUS_en	James Meeks – Wikipedia, the free encyclopedia	<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd"> <html lang="en" dir="ltr" xmlns="http://www.w3.org/1999/xhtml"> <head>