Rethinking Location Sharing: Exploring the Implications of Social-Driven vs. Purpose-Driven Location Sharing

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ABSTRACT
The popularity of micro-blogging has made general-purpose information sharing a pervasive phenomenon. This trend is now impacting location sharing applications (LSAs) such that users are sharing their location data with a much wider and more diverse audience. In this paper, we describe this as social-driven sharing, distinguishing it from past examples of what we refer to as purpose-driven location sharing. We explore the differences between these two types of sharing by conducting a comparative two-week study with nine participants. We found significant differences in terms of users' decisions about what location information to share, their privacy concerns, and how privacy-preserving their disclosures were. Based on these results, we provide design implications for future LSAs.

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Location sharing, privacy, place naming.

ACM Classification Keywords
H.5.2 User Interfaces - user-centered design.

General Terms
Human Factors, Experimentation.

INTRODUCTION
With the ubiquity of GPS-enabled mobile devices, we are seeing an emerging class of location-sharing applications (LSAs) that allow users to continuously sense, collect, and share their current location. Without these devices, people previously relied on location awareness via communication channels like phone calls [32], SMS [15], or instant messaging [24]. With LSAs, we now see a shift in location sharing from previous approaches using one-to-one sharing to current approaches of sharing with many people at once.

The push for more information sharing is largely driven by popular micro-blogging and social media sites like Twitter and Facebook, whose users share 50-60 million status updates daily [25]. Past literature has shown that these micro-blogging sites are successful in part because they help users build up social capital within their network. We believe that this "social" factor has been under-utilized in past LSAs. Consider, for example, LSAs like Reno [18], WatchMe [23], and the Whereabouts Clock [10] – these LSAs are all motivated by scenarios that emphasize a more utilitarian perspective of location sharing and focuses on activities like coordination and planning. These purpose-driven LSAs are in distinct contrast from those that support location sharing within social networks like Foursquare [2], Loopt [4], BrightKite [1], and Locaccino [30]. These latter LSAs have motivating scenarios that emphasize the social aspects of location sharing, where users might announce their arrival at a location not because others *need* to know but because it is simply interesting or fun to do so. In this paper, we highlight this difference by reframing location sharing as being either *purpose-driven* or *social-driven.*

Past research has primarily focused on what we consider to be purpose-driven location sharing. In our work, we focus instead on social-driven location sharing and its differences from purpose-driven sharing. Generally speaking, sharing information within a large social network introduces several interesting properties that have not yet been thoroughly explored in previous work. In this paper, we are interested in understanding social location sharing in terms of how users choose what types of location information to share. We conducted a two-week study collecting actual location traces from nine participants. We focused on three particular aspects of social-driven location sharing. First, we looked at if users chose to share different types of location information, when given different motivations for sharing. Second, we interviewed participants to learn about their privacy concerns for social-driven location sharing and what strategies they used to cope with these concerns. Third, we looked at how privacy-preserving participants' location disclosures were by examining whether their chosen location disclosures could lead others to find them.

Results from our initial exploration into these issues revealed significant differences between social-driven and purpose-driven sharing. In particular, we found that social-driven location sharing favored semantic location names, blurring of location information, and using location information to attract attention and boost self-presentation. We also found a non-trivial amount of shared locations left

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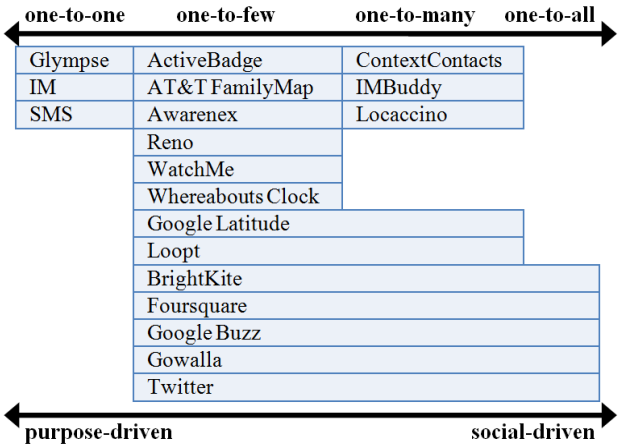

Figure 1. Two ways of describing location sharing apps (LSAs). One is organized by recipient group size. The other is organized by discloser's motivation being purpose- or social-driven.

participants susceptible to being physically located in social-driven location sharing scenarios. In summary, our work provides three contributions. First, we introduce a new way of framing LSAs that looks at people's motivation for sharing. Second, we provide results for a comparative study that examines location sharing from a new perspective (social-driven vs. purpose-driven). Third, from on our results, we describe design implications for LSAs.

RELATED WORK

This paper focuses on *location sharing applications* (LSAs), a particular class of location-based services that supports location sharing between users. We have organized LSAs into four categories (Figure 1): those that primarily support sharing location with one other person (one-to-one), with a small group (one-to-few), with a large group (one-to-many), or with everyone (one-to-all).

With one-to-one location sharing, a user's location is shared with one other person. For example, Glympse [3] lets users send a URL containing their current location to another person. After a specific time period, the map no longer updates. While nothing prevents a user from publicly posting this URL and making it accessible to the world, the original Glympse scenario was to share a time-limited lease of a user's location to one other person.

Other LSAs share users' locations with small (typically homogeneous) groups, like co-workers [27, 31], family members [10, 18], or close friends [7, 18, 23]. There are also LSAs that share location with larger, more diverse groups. These one-to-many LSAs are often integrated with services that provide a relatively extensive social network, like Facebook (Locaccino [30]), instant messaging (IMBuddy [17]), or one's address book (ContextContacts [26]). We also see some one-to-many LSAs opting to use their own application-specific social networks, like Loopt [4], Foursquare [2], and BrightKite [1].

There are also LSAs that publicly broadcast users' locations so that it is viewable by anyone. In fact, several one-to-many LSAs allow users to publicly share their locations, like Foursquare [2] and BrightKite [1]. Alternatively, these LSAs can also be scaled down to function as a one-to-few or even a one-to-one LSA, assuming users proactively adjust their privacy settings so that their location is only shared with specific individuals. It should also be noted that, in practice, users of one-to-many LSAs often have a relatively small social network (like Loopt [4]), making them more representative of one-to-few location sharing.

The range of one-to-one to one-to-all sharing is important to our framing of purpose-driven and social-driven location sharing. Often LSAs that support one-to-one and one-to-few sharing are purpose-driven sharing, while one-to-many and one-to-all sharing is more social-driven (Figure 1). Thus, to compare these two kinds of location sharing in our study, we use a one-to-one LSA to represent purpose-driven sharing and a one-to-many LSA for social-driven sharing.

Location Sharing User Studies

Past work has almost uniformly focused on purpose-driven sharing. Based on field deployments from past work [17, 18], three privacy features have been suggested: plausible deniability, real-time feedback, and audit logs. While these privacy features are important, they are not typically available in general-purpose information sharing sites like Facebook and Twitter. For these services, users have complete control over their status updates, so explicit mechanisms for plausible deniability are less of an issue. Both of these sites also have an open model where users do not receive real-time notifications about who reads their information and users are not able to see who has viewed their information. Yet, based on their usage statistics [25], the lack of these privacy features has clearly not impeded users from sharing their information. This observation suggests that, for social-driven location sharing, users may have different privacy expectations than they do for previous examples of (purpose-driven) LSAs.

As a foray into this idea, our work examines users' privacy concerns when considering social-driven LSAs, as opposed to purpose-driven LSAs. Our expectation is that privacy will still be an important issue for users, but how users deal with these privacy concerns will be different. By understanding these issues, future social-driven LSAs will be better equipped to address end-user privacy concerns.

Lederer et al [21] and Consolvo et al. [11] explored related issues in their work. Using ESM and hypothetical location requests, they found that the primary factor for location sharing was based on who sent the request. Why the request was sent also factored into users' decisions about what information to share, albeit to a lesser degree [11]. For our purposes, we consider Consolvo and Lederer's work as primarily focused on one-to-one (purpose-driven) sharing, where users share their location to only one other person.

We believe the type of sharing described by Consolvo and Lederer is markedly different from one-to-many (social-driven) sharing. Barkhuus et al.'s Connecto [7] comes a bit closer to this type of sharing, but still focuses on what we consider small-group (one-to-few) location sharing between close friends. In this paper, we explicitly target large-group (one-to-many), social-driven location sharing scenarios. This type of sharing introduces more privacy concerns than small-group sharing because there are inherently more relationship types to handle. In Facebook, prior work has shown that users' social networks mostly consist of "loose" social connections or acquaintances [13, 33]. We expect that location sharing within these groups will have vastly different privacy implications than when sharing locations with just close friends or with one other person.

In the next section, we describe in more detail how large-group sharing creates interesting tensions for social-driven location sharing. We then present our research questions.

IMPORTANT FEATURES OF ONE-TO-MANY SHARING

In one-to-one location sharing, the user's decision is simple: is the user comfortable telling this specific person her location. For one-to-many sharing, the decision is more complex: what may have been okay sharing with one person may not be okay sharing with many people. There are three reasons why large-group sharing might differ: (1) there is a larger variance in who receives the information, (2) there is a different motivation for sharing, and (3) there is a different expectation of plausible deniability.

Who is the Location Information Being Shared With

Large-group sharing involves disclosing location information to a diverse social network. Currently, large-group LSAs are integrated with an online social network like Facebook. The size of these social networks is often several orders of magnitude larger than offline networks [16]. Online social networks often also include several weak social ties [13, 33] and weaker ties suggests that there will likely be a large variance in how much the user trusts their social network with the user's personal information.

These features have significant privacy implications for location sharing. The success of Facebook is indicative that users are relatively comfortable sharing the same status information with everyone in their online social network (i.e., people of varying tie strength), but it is unclear if the same holds true for location sharing. For example, users may be comfortable telling their close friends that they are "at the movie theater", but are they equally comfortable sharing that with everyone else in their network? What makes our study interesting is that, by comparing large-group and small-group location sharing, we can determine how integrating location disclosures within an online social network can impact users' location sharing decisions.

Motivations for Location Sharing

For most one-to-one LSAs, the disclosure process begins with the requester. For example, Bob wonders where Alice is, so he sends a request to Alice asking for her location. This request-response model allows users to decide what location information to share using information like: (1) who is receiving the information, (2) what is the most likely reason for why the request was sent, (3) what would be most useful, given this reason, and (4) is the user comfortable sharing that level of location information [11].

We argue that this type of location sharing is better framed as *purpose-driven location sharing* since the requester most likely has a specific need for the user's location. This kind of behavior is used in many scenarios motivating prior LSAs (e.g., Reno [18], the Whereabouts Clock [10]) and in past ESM studies [11]. In past diary studies, it was shown that 85% of location requests were for pragmatic reasons, including coordinating meetings, arranging transportation, sending reminders, providing roadside assistance, checking for availability, and asking for estimated time of arrival (ETA) [28]. Consequently, in purpose-driven location sharing, the disclosure decision is often a pragmatic one: does the reason warrant a disclosure and what would be the most useful location information for this purpose?

On the other hand, large-group location sharing is better framed as *social-driven location sharing*. Current disclosure behaviors on social networks sites like Facebook reveal that users generously share their information [16]. Prior work has shown that this information exchange helps build up social capital [14]. Similarly, we believe that large-group location sharing can enhance peripheral awareness, which has shown to help promote and sustain social capital within one's network [29]. In other words, we expect that, just as general-purpose information sharing is driven by social capital, large-group location sharing will also be driven by similar motivations like social capital.

Generally speaking, our observations of past LSAs reveal that purpose-driven location sharing is often aligned with one-to-one and one-to-few location sharing. Social-driven location sharing, on the other hand, is closely aligned with one-to-many location sharing. It is important to note that the distinctions between purpose-driven and social-driven location sharing can be somewhat fluid. For example, consider a mother who is wondering if her son has arrived at his spring break destination. Her request (and her son's subsequent location disclosure) would fall under purpose-driven location sharing. However, it is possible that there is some hint of social capital involved since the mother may now feel more in-tuned with her son's activities (i.e., it contributes to her peripheral awareness). Despite this effect, we would argue that the son's primary motivation for sharing his location is most likely purpose-driven, as her son probably reasoned that his mother *needed* to know the information (e.g., for okayness checking [19]), as opposed to primarily asking just for the sake of curiosity.

Continuing this example, consider if the son had shared his location with his online social network. In this case, no

individual person is requesting his information, but he still chooses to share it. We would argue that, in this case, his decision to share his location is mostly to increase his social capital and, as a result, his social network is more aware of his activities as revealed through his location information.

Expectations of Plausible Deniability

Prior work has suggested that LSAs should support plausible deniability so that users can "stretch the truth" [18]. However, in field studies of LSAs that use one-to-one (purpose-driven) sharing, actual occurrences of outright deception are relatively uncommon, though use of location blurring does sometimes occur [11, 18].

For one-to-many (social-driven) location sharing, we expect that there may be more incentives to exercise deception. Evidence already exists in online social networks [9]. Social psychology literature also informs us that people often tell self-centered lies to make themselves look or feel better, or to protect themselves from embarrassment or disapproval [12]. This type of behavior is especially prevalent in casual relationships (e.g., acquaintances), as opposed to close relationships (e.g., family) [12]. Since one-to-many location sharing most likely involves more casual relationships, users may end up choosing to exercise plausible deniability when sharing their location.

Research Relevance for the Ubicomp Community

We argue that the framing of purpose-driven and social-driven location sharing is critical for the ubicomp community. Past literature has almost exclusively focused on purpose-driven sharing. However, with the popularity of micro-blogging, location sharing is shifting away from this model and will soon be integrated with the massive amounts of information sharing already occurring. If such data sharing is inevitable, the ubicomp community needs to better understand social-driven location sharing and, in particular, the privacy implications for this type of sharing.

In our work, we compare social-driven and purpose-driven location sharing. By breaking down the differences, we can learn about users' privacy concerns for social-driven sharing and inform future LSAs on how to better support social-driven sharing. In summary, our study will focus on:

Q1: Does social-driven location sharing result in different location sharing decisions?

Q2: What privacy strategies are used in social-driven (vs. purpose-driven) location sharing scenarios?

Q3: For social-driven location scenarios, are location disclosures actually privacy-preserving?

METHOD

To address these research questions, we conducted a two-week user study in November 2009 with ten participants, all of whom were recruited through a university-wide mailing list. One participant dropped out midway due to scheduling conflicts. Participants ranged from 18-46 years old (μ=27.1, σ=8.3); three were female. Two-thirds were either undergraduate or graduate students; the remaining participants were university staff members. Participants were evenly split between those affiliated with technical (e.g., natural sciences, engineering) and non-technical fields. Participants received a $30 gift card as compensation

Part 1: Entrance Survey

Participants completed a 10-min online survey to collect basic demographic and social network information. We intentionally did not ask include privacy to avoid biasing participants later. For their social networks, participants provided examples (names) for four relationships: family members, acquaintances, managers/bosses, and close friends. We told participants that their examples must live in the same city. This way we control for geographical distance and avoid having that influence participants' location sharing decisions. The names that were collected were used when creating scenarios for later on in the study.

Part 2: Location Data Collection

Participants were given mobile phones (Nokia N95s) to carry for two weeks and were required to use the N95s as their primary mobile phone. This helped to incentivize them to keep the phone sufficiently charged at all times.

The phones were equipped with location-logging software to collect participants' actual location traces (the same software used in [8]). The software ran continuously in the background (without user input), using both GPS and Wi-Fi positioning technology. To reduce power consumption, the application used the phone's accelerometer to selectively sample location information. When significant motion was detected, the GPS unit began recording every 15 seconds until the GPS signal disappears. The application recorded Wi-Fi MAC addresses every 3 minutes if the GPS signal was too weak. All location traces were stored locally on the device. We provided daily email reminders for participants to upload their location data each day of the study.

We acknowledge that there are some shortcomings to our automated data collection. But, by doing so, we had a continuous record of participants' location data, with little to no additional effort from participants. This is especially helpful for places where the participant stops by for only a short time. Manual data collection (e.g., like with ESM) would require interrupting the user and potentially risking large gaps in the location trace if users ignored the prompts.

Part 3: Location Sharing Interviews

Before each interview, we analyzed each participant's location trace. We used Skyhook's API [6] to translate Wi-Fi readings into GPS coordinates. We then computed the distance and speed between adjacent coordinates to determine if the participant was moving. Places that the participant stayed for more than five minutes were marked as "significant". During the hour-long interview, participants completed the following three steps for each location marked as a significant place (Figure 2):

- Describe the place, using up to eight labels

- Given a hypothetical purpose-driven location sharing scenario, choose what label to share and explain why
- Given a hypothetical social-driven location sharing scenario, choose what label to share and explain why

We chose to use hypothetical sharing scenarios instead of actual location disclosures to other people. This decision was primarily to protect participants from unintentionally sharing sensitive locations. To help ground the scenarios for our participants, each scenario referred to a specific person using names obtained at the start of the study. We also asked participants to think of up to eight labels upfront to help ensure that they carefully considered which location name to share. Interview responses also suggest that participants were thoughtful in their decisions.

For each significant place (as described by a timestamp & map, Figure 2a), participants responded to both purpose-driven and social-driven scenarios (randomly ordered). For each location sharing decision, participants were asked to explain to the interviewer their rationale.

To mimic purpose-driven location sharing, we had eight hypothetical scenarios in which the request for the participant's current location was motivated by a specific reason. For example, one scenario was: "While you're at this place, Maria (your roommate) contacts you. She has lost her keys and would like to meet you now to borrow your keys to the apartment now" (Figure 2b). Each scenario refers to a specific person (Maria) and relationship type (roommate), which reflects the one-to-one aspect of purpose-driven sharing. These scenarios are randomly generated by changing the location requester's identity. If a scenario does not make sense (e.g., a manager is looking for your apartment keys), then another scenario is randomly generated. For social-driven location sharing, we presented participants with a screenshot showing how their location might appear on a social network site (Figure 2c).

RESULTS

In total, we identified 98 unique significant places from 29,490 recorded location readings from the N95 phones. Each participant visited μ=10.9 unique places (σ=2.2).

Place Labels (Q1)

Using a bottom-up approach, we classified all the labels that participants chose to share under both the purpose-driven and social-driven sharing scenarios. Earlier work classified labels as relating to a place ("home") or an activity ("shopping") [18]. Others have looked at labels as a geographical hierarchy, ranging from street address ("123 Main St.") to neighborhood ("Brooklyn") to city & state [11]. Barkhuus's work used four categories: geographic, place-based, activity-based, or a mix of these three [7].

We felt that these categories were too broadly defined for our purpose. Using similar categories in [22], we settled on a

Figure 2: An example webpage used in our study. (top) Map reminds participant of a place they visited. They first write labels to describe the place. Next, we show two hypothetical sharing scenarios, randomly ordered. (middle) In purpose-driven scenarios, they read a randomly generated scenario, choose label(s) to share, & describe recipient's familiarity with the place. (bottom) In social-driven scenarios, they see how locations might appear in a social network site & pick label(s) to share.

more detailed taxonomy (Table 1). In particular, we used a more complete classification scheme for semantic place names that includes personal names ("my home"), functional names ("restaurant"), activities ("shopping"), and public businesses ("Starbucks"). Categories labeled as "specific" vs. "non-specific" refer to when a place name is more precise (e.g., there are several "restaurants", but fewer "Indian restaurants") or is unique (e.g., there is only one "my home", but there are more than one "friend's home"). We also extended the geographical category to include room, floor, and building. This change is mainly since our participants often visited a local university campus, which includes this level of granularity. Note that place labels can fall under multiple categories, so total percentages may exceed 100%. For example, "restaurant@5th & 2nd" counts as both "semantic, functional, non-specific" (restaurant) and as "geographic, street/intersection" (5th & 2nd).

Across 98 unique significant places, participants provided 505 place labels, (μ=5.15 labels/place, σ=1.57). 57.03% of the labels were geographic; 42.97% were semantic.

Overall, participants shared more semantic names than geographic names. For purpose-driven sharing, 69.39% of the labels were semantic names vs. 40.20% geographic names. For social-driven sharing, 77.55% were semantic names vs. 25.71% geographic names. Social-driven sharing used significantly more semantic names than in purpose-driven sharing (χ^2=27.74, p<0.001). Considering only semantic names, social-driven sharing also had a significantly different distribution (χ^2=23.68, p<0.005): social-driven sharing favored labels with activity and personal names over functional and public business names.

Location Sharing Decisions (Q1)

Prior work has found that users will choose to share their location at whatever level of detail is most useful, or to share nothing at all if the request is inappropriate [11]. Given that our scenarios are purpose-driven, we were interested in whether participants would unilaterally provide the most precise location label (typically a geographical name), or if they still opt to selectively share their location information.

To investigate this issue, for each purpose-driven sharing scenario, participants provided a familiarity score (5-point Likert scale; 1=completely unfamiliar) to describe how familiar the requester was with the participant's shared location. When recipients were unfamiliar with the location (scores<3), participants opted to share more hybrid labels (using both geographic and semantic labels). With higher familiarity scores (≥3), participants opted to share labels that contained only semantic place names. This difference was statistically significant (G^2=13.32, p<0.002) and indicated that our participants selectively decided what to share based on the recipient's familiarity with the place.

DISCUSSION

Our main research goal is to compare purpose-driven and social-driven location sharing. Information sharing has generally shifted from being one-to-one to now being one-to-many. In addition, information sharing is often tightly integrated with large social networks that span several relationship types. The diversity and size of these networks lead to several potential privacy concerns, particularly when it comes to sharing sensitive information like one's location

Type of Place Label	Examples	Purpose-Driven Location Sharing (%)	Social-driven Location Sharing (%)
Semantic	---	**69.39**	**77.55**
Personal	---	**12.24**	**17.35**
Non-specific	friend's house	2.04	4.08
Specific	my home, my office	10.20	13.27
Functional	---	**17.34**	**14.28**
Non-specific	restaurant, library	10.20	9.18
Specific	Indian restaurant	7.14	5.10
Activity	**---**	**16.32**	**31.35**
Activity only	in class, shopping	7.14	19.39
Activity@location	shopping @ Walmart	6.12	7.14
In transit	on my way home	3.06	4.82
Public business	**---**	**23.47**	**15.30**
Not unique within city	Starbucks, Barnes & Noble	10.20	5.10
Unique within city	Lewis Salon	13.27	10.20
Geographic	**---**	**40.20**	**35.71**
Room	<building name> <room number>	5.10	0.00
Floor	<floor number> <building name>	4.08	0.00
Building	<building name>	23.47	15.31
Address	500 Main St	6.12	0.00
Street/Intersection	Main St & 1st Ave	11.22	4.08
Neighborhood/Region	Downtown	6.12	5.10
City	San Jose, New York	4.08	11.22

Table 1. Taxonomy for place labels that includes both semantic and geographic place names. Breakdown of labels for each of the 98 unique places obtained from our participants over two-week period for both purpose-driven and social-driven location sharing. Note, total percentages exceed 100% since place labels can have multiple categories.

information. By comparing purpose-driven and social-driven location sharing, we hope to better understand users' privacy concerns and preferences through their decisions about what locations they share under each condition.

Differences in Location Sharing Decisions (Q1)

We found that participants share different place names for social-driven location sharing. When considering only three types of labels (geographic-only, semantic-only, and hybrid – a mix of geographic and semantic names), we found that social-driven sharing led to more semantic-only place names (39.80% vs. 64.29%, $p<0.01$) and fewer hybrid place names (29.59% vs. 13.27%, $p<0.005$). Generally speaking, hybrid names are more descriptive since they provide both geographic and semantic information. Sharing fewer hybrid names suggest participants prefer the ambiguity of semantic place names. There was no difference for geographic-only names (30.61%, purpose-driven vs. 22.45%, social-driven).

Our distribution of geographic, semantic, and hybrid names is similar to the distribution found in [7]. However, in our study, we can also examine labels that participants did not choose to share. In 64.29% of these cases, participants shared semantic place names (for social-driven sharing) and explicitly did not pick a geographic name that was listed in their list of possible place labels. This finding suggests that participants do make deliberate decisions when choosing to share a particular type of label over another.

When asked why they made their selections, participants cited two main factors: privacy concerns and attracting attention. For example, P5 reported choosing a label as a way to advertise to others that he might be nearby to them: "If any of my friends happen to be around me, then I will probably meet with them." This is similar to Weilenmann's observation that place is sometimes used to express availability [32]. In her study, she examined one-to-one (purpose-driven) location sharing. In our study, we confirmed a similar use of location information for one-to-many (social-driven) location sharing as well.

We also observed that social-driven location sharing decisions were influenced by impression management. For example, P3 reported that "being at Mad Mex [a local restaurant] is pretty cool and I want people to know that." This finding suggests that, for social-driven location sharing, participants use location information as an indirect way to enhance their self-presentation so that they appear more interesting to others in their social network.

Perceived Privacy Strategies (Q2)

Based on their Westin scores [20] obtained at the end of the study, most participants were privacy pragmatists (5/9), one was privacy unconcerned, and two were privacy fundamentalists. This classification suggests that most participants had balanced privacy attitudes and would be willing to forego some privacy if there is a clear benefit. Since our study used only hypothetical scenarios, one might expect our participants to exercise highly conservative location sharing behaviors. Instead, we observed only slight use of location blurring using three different strategies.

The most often used method was to leverage "insider knowledge" to obscure one's actual location. This strategy provides users with plausible deniability for providing less precise location information. For example, P6 shared that he was "at Giant Eagle" (a local grocery store chain) and said that he chose to share this because "for people who know where I live, they can figure out which Giant Eagle I am at, otherwise, they won't know". Similarly, P5 shared that he was "at INI" (a university building) because "if I say INI, classmates will know where I am, but, for other people, they will have no idea what INI is." This suggests that participants are actively deciding to blur their location.

It is important to note that the location blurring we observed is a relatively minor type of deception. When deciding what to share, participants were not precluded from lying and they could have opted to share fake labels. However, during our interviews, none of the participants chose to share outright false location information. Participants could have also hidden their true location by blurring at the city or state level. However, for social-driven sharing, we found no evidence of blurring at the state level and only 10.2% of all place labels used blurring at the city level (20% of these occurred when one participant was traveling out-of-state).

Our supposition is that participants' preferences for relatively minor location blurring are related to our previous observation that location sharing is often used for impression management. By opting to share a place name that is somewhat precise ("Giant Eagle"), as opposed to one that is fully precise ("Giant Eagle @ Center Ave"), participants can still appear as though there are actively involved in contributing to their social network's overall social capital. If they opt to share an overtly vague place label (e.g., "Pennsylvania"), then it may come across as though they are intentionally being socially reclusive.

A second privacy strategy that we observed was where participants hid their location information by opting to share their current activity instead of their current location. In fact, many participants cited that they were generally more comfortable sharing activity information: "I feel like sharing activity should not be a problem" (P4), "I'd rather say what I am doing than that I'm at a certain place" (P2), and "In general, I don't mind telling others what I'm doing" (P7). This is different from prior work which has stated that users opt to share activity in order to be *more* descriptive about their current state [18, 32]. Our findings suggest instead that participants are opting to share activity information for plausible deniability reasons. In other words, sharing one's activity is perceived as *less* descriptive than sharing one's location.

Of all the activity-related semantic names (31.35%), six common types of activities accounted for 78.26%: in class, working, with family, eating, in meeting, and shopping. Other activities were also shared (e.g., "getting a haircut, "dance practice"), but these were used by specific participants. Further work is needed to determine if these common categories can be generalized for other users.

The third privacy strategy that we observed was that participants all seemed to highly value their friends' location privacy. For example, while P5 was at her friend's apartment, she explained that "I'm uncomfortable sharing with people where I am at, since it's someone else's place." P8 had similar concerns: "Sharing a friend's name [in my location] is too much. People don't need to know her name." These responses suggest that participants are highly conscientious about sharing their friends' location. There are two possible motivations for this privacy behavior: (1) sharing a friend's name reveals the participant has a relationship with that person, or (2) sharing the friend's name reveals not only the participant's location information but their friend's as well. This finding is interesting given that prior work has found that social network users are often quite causal about sharing their friends list [13]. By attaching location to a friend's identity, our participants seem to have adopted a more conservative perspective.

These three privacy strategies, as observed through participants' interview feedback, were much more prevalent in social-driven location sharing scenarios. It should be noted though that purpose-driven sharing also practiced these blurring techniques to some degree. However, the critical difference is in the motivation behind using these strategies. In social-driven sharing, participant reported using privacy strategies in order to "hide" or blur their true location. In purpose-driven location sharing, participants blurred their true location primarily to convey their unavailability: "My manager doesn't need to know where exactly I am, so I will just tell him I'm at a restaurant [as opposed to the name of the restaurant]." (P6).

Actual Privacy of Location Sharing Decisions (Q3)

Given that participants factor in privacy concerns when sharing location, our last research question looks at how well participants' decisions *actually* preserve privacy. To do this, we looked at how easily locatable our participant's shared locations were for both purpose-driven and social-driven sharing scenarios. For each place label that participants shared, we considered how easily locatable they would be if a third party had access to certain resources. The most basic resource would be having a map of the area, or having the ability to conduct local map searches using a tool like Google Maps. The second resource we considered was if the third party had local knowledge of the area (e.g., from being a local resident) or if they had access to a search engine. The third type of resource we considered is if the third party had information about the participant and her routines. One can imagine that this information might be obtained from personally knowing the person or, if more malicious, from stalking the person. As a baseline, we assumed the third party knows at least the participant's current city. For physical stalkers or close friends, this information is obvious. For tech-savvy virtual stalkers, one could imagine that this information could be obtained through basic IP-based geo-location.

Available Resources	Purpose-Driven Location Sharing	Social-driven Location Sharing
Map	50.00%	10.20%
Map + Local/Web	62.26%	19.39%
Map + Local/Web + Routines	90.82%	51.02%

Table 2. Percentages of place labels that can lead to physically locating the participant. Organized by resources one might have access to (maps, local info, routines info)

We defined a place label as having "revealed" a participant's location if the label means the participant is locatable, i.e., a third party can physically find the person. To run this evaluation, we manually ran the participants' labels through Google's map search (for the map-only resource condition). For the web/local knowledge condition, we used our own knowledge of the local university community combined with a Google web search. We did not expose participants' labels to an actual third-party attacker to ensure participants' data confidentiality.

Each of the resource conditions require different types of labels in order to be found. To be found using only the map resource, the participant must have chosen to share an exact address, or have disclosed a place label in which the first result of a map-based search query (using only the place label) points to the participant's actual location. To be found using a map with local area knowledge, the participant must have shared a label that can only be resolved with some regional information (e.g., that another resident or community member would know) or be resolved by the first result returned in a search query (using only the place label). To be found using knowledge about routines, the participant must have shared a place label that is easily resolvable based on basic routine information that includes knowing the location of their work and home.

Using these definitions, Table 2 shows that, as expected, for purpose-driven location sharing, most of the location disclosures reveal participants' true location. This result is not really disconcerting since participants are aware of who they are sharing their location with. Note that for 9.18% of the place labels which could not be resolved using the three resources, participants were either in-transit or were out of town (and chose to reveal a vague place label).

For social-driven location sharing, participants' locations are revealed for at most 51.02% of the labels, when using all three resources. While this percentage is significantly less than purpose-driven sharing ($p<0.0001$), participants are still

locatable for over half of their disclosures. In social network sites, users often unintentionally leak information [16]. In future work, it would be worthwhile to examine if users are aware that the locations they choose to share reveal their true location. Findings from our interviews indicate that sometimes participants reveal their location for impression management or to attract attention. However, since there are also privacy issues to consider, it will be interesting to see whether privacy concerns about the aggregate revelation of location information will lead to changes in users' location sharing decisions over time.

It should be noted that we have adopted a fairly liberal metric for measuring privacy preservation. In particular, we consider someone as "locatable" if they can be found at the building level. However, finding someone at the university student center is not the same level of precision as finding him at a local coffee shop, even though both are considered building level granularity. Despite this difference, we believe our analysis provides initial evidence that privacy leaks in social-driven location sharing is an important factor to consider when designing LSAs and is worth further looking into. It is also worth mentioning that many social network sites allow sharing of photos and videos, which can also leak location information. For example, a photo can reveal a well-known landmark, revealing a user's recent whereabouts. This type of information could easily serve as an additional source for locating users. Our initial analysis here shows how different resources can combined to reveal location information leaks than users may not be aware of.

LSA Design Implications, Caveats, and Future Work

In future work, we intend to recruit a larger, more diverse sample size, including those with and without exposure to social network sites. To further validate this finding, we plan to explore location sharing behaviors from other social network sites, like Twitter. Using hypothetical scenarios is another caveat of our study and theoretically introduces one of two potential biases. One possibility is that users may show uncharacteristically low privacy concerns and opt to share all of their location information because there is no immediate privacy risk associated with sharing. Another possibility is that users may show highly conservative sharing behaviors and share little to no location information because there is no actual social benefit to sharing. Our results show a distribution of location sharing strategies, which suggests that neither of these situations occurred in our study. Interview feedback also suggests that participants carefully considered their location sharing decisions.

Our study is also only an initial exploration into the differences between purpose-driven and social-driven location sharing. We designed our study to compare two extremes of the spectrum: one-to-one purpose-driven location sharing and one-to-many social-drive location sharing. There are certainly other possible combinations worth exploring in future work. For example, crises like the U.S.'s Hurricane Katrina demonstrate the need to have one-to-many purpose-driven location sharing, where people can broadcast their location as an indication to their social network that they have reached a safe location.

Despite these limitations, our findings show that there are significant differences between purpose-driven and social-driven location sharing. These results have several design implications for future LSAs. First, LSAs should consider which type of location sharing they are primarily supporting. Purpose-driven sharing resulted in users sharing different types of location information, compared to social-driven sharing. These differences have clear implications in terms of what data types to support and what type of visualizations to have. For example, social-driven location sharing showed a preference for sharing activity, not just location information. Semantic names were also generally preferred for both purpose-driven and social-driven location sharing. Also, location information shared in social-driven scenarios were significantly less suited to map-based lookups than purpose-driven scenarios ($p<0.0001$). This result suggests that LSAs might consider other location displays instead of push pins on a map, like Locaccino [30].

Another important finding from our data is the factors involved in users' location sharing decisions. In social-driven location sharing, the identity of the requester is ambiguous, making a utility-based decision process (like that suggested in prior work) impractical. Instead, we found that, for social-driven sharing, users attempted to balance between maximizing their social capital while protecting their own privacy. In particular, users want to share information that is interesting, enhances their self-presentation (impression management), and/or leads to serendipitous interactions. Social-driven LSAs can leverage this information by playing to these factors in order to encourage users to share their location. This will, in turn, enhance peripheral awareness within users' networks and allow them to reap the social benefits of location sharing.

We also observed that, for social-driven scenarios where they were physically at home, all participants opted to describe their location as "at home", "my home", or "at my apartment." These descriptions were not used for any other locations. Because participants are somewhat predictable in terms of how and when they describe their home, it is important for future social-driven LSAs to have usable privacy controls to limit publicly sharing this data. Otherwise, sites like Please Rob Me [5] can misuse the data, leaving users open to attacks from malicious users.

CONCLUSION

This paper provides three contributions. First, we describe a new framing of location sharing applications (LSAs) where we distinguish purpose-driven from social-driven location sharing. Second, we provide results from an initial exploration into the differences between these two types of location sharing and find significant differences in terms of

users' location sharing decisions, their privacy strategies, and the amount of location information leaked in their location disclosures. In particular, we found that social-driven location sharing favors semantic place names, location blurring, and using location information to attract attention and boost self-presentation. We also found a non-trivial amount of location information is leaked in social-driven sharing. Based on these findings, we provide design implications for future LSAs that highlight how different types of location sharing can impact certain LSA features.

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