

Research Article

Sharing the Cloudlet: Impression Management and Designing for Colocated Mobile Sharing

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Abstract

This article explores how designing for impression management affects the design of cloudlet and other mobile colocated sharing services. We demonstrate how colocated concepts and experimentation led to the conceptualization and design of a sharing interface that provides users with control over their shared content. We uncover usage behaviors and privacy concerns through the use of a technology probe and use those discoveries to develop a prototype designed with the principles of impression management to give sharers control over their content and identity. Our designs and results indicate users of cloudlets and other colocated sharing systems require visual control and privacy over shared content.

1. Introduction

Our mobile phones have become the most accessible means of sharing our (digital) lives. While they are designed to be always connected, capable of interacting with a wide array of communication services, and able to mobilize our communication to contexts that differ in both space and time, the ubiquity of connectivity that these devices promise and demand is something that many won't experience, especially in most developing world contexts (Gitau, Marsden, & Donner, 2010; Maunder, Marsden, & Harper, 2011; Ureta, 2008). For many in low-income communities, the mobile phone is the only device they have capable of sharing digital media (Gitau et al., 2010), but the expense involved to transmit and consume digital media makes this unaffordable (Bidwell et al., 2014; Walton, Marsden, Haßreiter, & Allen, 2012) and limits and/or excludes them from participating in the sharing afforded by these devices (Ureta, 2008). Similarly, many low-income and non-urban areas are subject to a sparseness of network availability, which means that users have limited or no access to network facilities or coverage (Fernando, Loke, & Rahayu, 2013). This becomes increasingly problematic as the majority of the applications and services designed for mobile phones rely heavily on high-speed mobile networking services and availability.

These issues of network expenses and availability experienced in developing world contexts are compounded by our mechanisms for sharing digital media on mobile phones, which rely heavily on third-party cloud-sharing services, such as email, instant messaging, and social media services. These services are predominantly designed for communication and sharing at distance, which is not problematic if suitable or equivalent colocated solutions exist, but the reality is that our mobile devices are inadequate to and complex at handling hyperlocal sharing. Even though dedicated mobile colocated technologies exist (such as Bluetooth, near field communication (NFC), and Wifi-Direct) most users don't use them or view them as clumsy and unreliable (Kirmani & Fleck, 2014; Reitmaier, Benz, & Marsden, 2013; Walton et al., 2012). These negative perceptions of colocated technologies pose further adoption difficulties and perpetuate our reliance on cloud-based services. This reliance is not only a wasteful and inefficient use of resources, from sending digital items around the world and back to powering the data centers that store and transfer these items, it also assumes the persistent

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availability of high-speed network connectivity. Colocated sharing is not only the most common and enjoyable means of sharing digital media (Frohlich et al., 2002; Van House, 2009; Harper et al., 2007), but for many it is the only way to share digital media (Bidwell et al., 2014; Gitau et al., 2010; Maunder et al., 2011). Denying or limiting those without the financial means or access to remote sharing services to share digital media not only prevents their participation in digital sharing but also inhibits their ability to create, sustain, and nurture their expression of identity and interpersonal relationships.

There have been several demonstrations of mobile colocated technologies that attempt to rectify and *re-imagine* the way we share digital media when colocated. These range from using mobile phones to interact with public displays (Lucero, Jones, Jokela, & Robinson, 2013; Maunder et al., 2011; Seifert et al., 2012; Skov & Kjeldskov, 2014) to cloudlets, hyperlocalized, ad hoc instantiations of the cloud (Fernando et al., 2013; Satyanarayanan, Bahl, Caceres, & Davies, 2009; Verbelen, Simoens, De Turck, & Dhoedt, 2012). Cloudlets are of special interest as they specifically aim to address the shortcomings of overrelying on the distant cloud by providing colocated sharing experiences typified by the cloud through nearby localized wireless connections but with the ability to fall back to the cloud when colocated connections are no longer possible (such as when the user is on the move; Fernando et al., 2013). This means that cloudlets enable nearby devices to establish a one-hop bandwidth wireless connection, enabling real-time connectivity without latency and the need for external servers. The benefits of cloudlets are not only applicable to developing world contexts, but the same features and benefits could even be applied to the most networked areas (Fernando et al., 2013).

While there has been much attention directed toward the technical aspects of the cloudlet infrastructure, little research shows how users conceptualize and navigate these systems or how applications that use cloudlet technology should operate. For example, if a user moves away from a cloudlet, how should changes in connectivity and proximity be displayed to the user and how should the user interact with those changes? Similarly, what happens to content created and shared in these cloudlet “sessions”? How do people interact with cloudlets when others aren’t present, and who owns the shared content when there is no centralized storage location? Privacy is also a central aspect of digital data management and has different requirements for colocated sharing than for distant cloud sharing (Fernando et al., 2013), but how do we design for them?

In developing world contexts, problems and their solutions often have similar, impactful applications as in the developed world (Jack & Suri, 2011). Because the benefits of cloudlets affect both the developed and the developing world, addressing and understanding *how* and *why* people use and conceptualize these systems is important. This study takes place within the geographical context of Cape Town, which is home to a mix of developed and developing world contexts in Africa, from technology use to economic status. It is within this context that we hope our study can present a mixture of mobile colocated sharing experiences and perspectives among the users participating in this study. While it is outside of the scope of this study to create a fully functional cloudlet implementation, our aim is to investigate the user and design requirements surrounding colocated concepts and cloudlet use. Basic cloudlet concepts and user behavior, such as users entering and leaving a colocated interaction, are implemented and investigated. For this reason, the study also employs user experiments in a laboratory setting.

In this article we describe the process of designing a sharing interaction for cloudlet-enabled mobile phones that extends concepts of identity and impression management to enable colocated mobile digital media sharing while addressing issues of privacy and content-sharing control. We begin by conceptualizing colocated interaction through the use of relevant concepts, theories, and related works, which we use to describe the design of a technology probe and prototype that provide users with privacy and control over shared content. The probe and prototype are evaluated in user tests and those results are reported and reflected on.

2. Related Work

The act of physically coming together is something people do all the time and everywhere. For many in developing world contexts, face-to-face interaction is the primary means of communicating and sharing with others. While the contexts and traditions in which face-to-face interaction occurs may vary from culture to culture, it is necessary for us to generalize the interaction space so that we can begin to understand the general contributing factors surrounding colocated interaction and to design for it. As such, designing for cloudlets

requires us to understand what happens before, after, in, and around the general act of people coming together before we add to it the technological act of sharing. Our intent is to derive our design guidelines from this understanding and to provide a rationale for the probes and prototypes built.

2.1 Physicality

All face-to-face interactions begin with the demarcation of physical space. This demarcation allows individuals to define and limit *who* and *what* are included and excluded from the interaction. This doesn't mean that interactions are predetermined by their physical location, but that there is a relationship between the physical space and the activities performed therein (Kendon, 2010). For example, what we share in an intimate setting will differ from what we would share in a public setting. Farman (2012) defines *space* as a construction of our sense of embodiment. Space is full of context, which emerges from the relations and actions inhabiting it (Dourish, 2004). Our bodies also take up space, and because they differ from person to person, so is sense of spatial embodiment. Our relationship with embodied space is also the way we "understand ourselves, our place in the larger context, and the cultural meanings infused into gestures, objects and sign systems" (Farman, 2012, p. 17). The *meaning* we bring into the space we inhabit during our colocated interactions will be cocreated by those present and will change depending on why, where, when, and whom we're with.

Researchers have shown that the way we arrange our body posture and orientation within a colocated setting greatly affects the interaction we have with others. Kendon (2010) demonstrates that different body postures, from the way feet, upper bodies, and heads are positioned and oriented, "serve in the process of making and maintaining the boundary between the inner world of current engagement, that is between them, and the outer, irrelevant distended world beyond" (Kendon, 2010, p. 4). Similarly, Hall (1992) demonstrates that people use their body's posture, distance, momentum, and orientation to interact with objects and others and that they use their perception of space as an indicator of (culturally dependent) social distance. This means that objects or people positioned or moving closer to one another are generally perceived as more intimate than people farther away.

2.2 Identity

From the bodies that occupy interactional space, it is important to know the "who" within those bodies and how they relate to others. Our identity is a unique, distinguishing feature and connects us with likeminded groups (Buckingham, 2008). We are who we are as we experience and perceive the world, and who we are varies according to whom we're with. Our identity is multifaceted (Farnham & Churchill, 2011), and whether those identities are constructed and performed due to the freedoms experienced (Giddens, 1999) or policed to conform with social norms (Foucault, 1995), they are bound by the social contexts they're in. Identity is not something people merely possess, but an outworking of the individual *and* the social (Jenkins, 2014) and a mixing of their standing, role, and relationship with others.

Within this larger interplay of context and identity, how we interact with the world around us is important. The social has a *reflective* and *reflexive* role in the construction and modification of the self-concept (Baumeister, 1982; Goffman, 1956; Schlenker, 1986). We see ourselves as we perceive others to see us (Sundstrom & Altman, 1976) and that perception has a strong impact on our self-concept (Kelly, 2000; Rhodewalt, 1998). As such, we perform different roles that carry behavioral expectations depending on whom we're with, such as friend, coworker, parent, or child (Sarbin & Allen, 1954). These roles are also expressed with physical behavior and are especially apparent when people are face-to-face (Bidwell et al., 2014; Sarbin & Allen, 1954) such as the roles governed by age and gender. For example, in certain developing world contexts and cultures, youths will avert their eyes from older people when communicating (Bidwell et al., 2014), and women are excluded from speaking in public community meetings (Kapuire, Winschiers-Theophilus, & Blake, 2015). As such, providing the flexibility that supports different social roles in the moment is important for colocated sharing systems.

2.3 Sharing and Technology

It would be impossible to separate the act of sharing from identity. Sharing personal photos is an important medium for the construction and maintenance of identity and relationships (Van House, 2009). This is even true for communities where oral traditions are prominent (Bidwell, Reitmaier, Marsden, & Hansen, 2010). With

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the advent of digital photography and online media sharing, sharing photos has become more available and convenient than before, and due to the advent of the Internet, our sharing potential and “reach” have extended to those not explicitly nearby.

In their analysis of online sharing, Farnham and Churchill (2011) observed that people use different sharing services to accomplish different communication goals. They found that email was used to direct content toward a known audience, as its design requires the recipients to be specified before the content can be sent, and social networks like Twitter and Facebook operated in a broadcasting manner where there was no specific audience in mind (Farnham & Churchill, 2011). In both sharing types, the audience is physically absent, which allows people to present multiple, simultaneous, and possibly conflicting identities to these social contexts (Farnham & Churchill, 2011). However, the sheer number of social contexts and contacts, each with their own cultures and norms, makes it harder for us to manage our identities and has led to sharing services overburdening their users with privacy controls in order to provide adequate awareness of what is being shared and viewed by whom (Bernstein, Bakshy, Burke, & Karrer, 2013; Farnham & Churchill, 2011). Similarly, because sharing takes place without the audience participating in the context being shared, this absence could also lead to the audience misunderstanding or being offended by the content shared (Sleeper et al., 2013). These factors have led to behaviors of self-censorship, regret (Wang et al., 2011), or ceasing to share altogether (Kairam, Brzozowski, Huffaker, & Chi, 2012).

In contrast to online sharing, colocated sharing is characterized by being in front of a *physical* audience that provides immediate context and feedback. Having an audience that is live and ephemeral allows individuals to pick up behavioral clues that help shape and direct their performance instead of constructing and imagining the audience's reactions and responses (Marwick & boyd, 2011). Similarly, colocated interactions occur in real time. The need for multiple, simultaneous identities is seldom required when colocated, allowing a singular focus on the performance at hand. However, colocated sharing is essentially dynamic: People enter and leave physical group settings. This means that while some sharing settings can be private and controllable, the setting can also be public and uncontrollable, such as at a public event or cafeteria. Because our everyday interactions range between the intimate and the public, it is important for colocated sharing to cater to both scenarios.

2.4 Colocated Mobile Technology

Bridging the gap between situated mobile colocated technologies—such as stationary hardware interventions (Lucero, Holopainen, & Jokela, 2012; Rädle, Jetter, Marquardt, Reiterer, & Rogers, 2014; Seifert et al., 2012) and cloudlets (Koukoumidis, Lymberopoulos, Strauss, Liu, & Burger, 2011; Satyanarayanan et al., 2009)—is colocated photo sharing. It is an active area of research, with Frohlich et al. (2002) and Kindberg, Spasojevic, Fleck, & Sellen (2005) suggesting it to be the most enjoyable method of photo sharing, as photos are mainly taken for the enjoyment of others rather than for the individual (Kindberg et al., 2005). The use of mobile colocated photo sharing is prevalent in developing world contexts (Walton et al., 2012) and has been shown to be a compelling interaction method of digital storytelling when coupled with voice recordings in oral tradition communities (Bidwell, 2014). While the methods and mechanisms of publicly interacting with photos is shown to be rewarding and compelling for those using these systems, most designs and implementations approach the mobile phone as a public device with minimal need for privacy or security as the interaction takes place in a colocated setting. However, we notice that users take great measures to hide and censor their behavior (Clawson, Voids, Patel, & Lyons, 2008; Lucero, Holopainen, & Jokela, 2011), even when they're interacting with public displays (Seifert, De Luca, Conradi, & Hussmann, 2010; Skov & Kjeldskov, 2014). Although some have put effort into designing colocated sharing systems with privacy in mind when interacting with public displays (Lucero et al., 2013; Seifert, Dobbstein, Schmidt, Holleis, & Rukzio, 2014), the requirement for a static, external display restricts the general application of these interventions.

Mobile colocated sharing is similar to its online counterpart and carries with it its own unique security risks (Palen & Dourish, 2003). While there are times when we can physically restrict who is nearby, such as in a private setting, there are times when it is out of our control, such as at a public event. It is this additional element which distinguishes mobile colocated sharing from its online counterpart and forces us to reflect on and

reimagine not only the design and features of colocated sharing technologies but also their privacy controls and mechanisms. Taking colocated sharing and the mobile phone seriously means we must consider that it is a deeply personal device and that privacy still must be explored in colocated systems (Jokela & Lucero, 2014; Lucero et al., 2011).

2.5 Guidelines for Design and Research

From the research above, we've seen that people move toward one another and use their bodies to create interactional spaces that serve as opportunities to share. We've also shown that colocated interactions are characteristically fluid and ephemeral as people move through their day and form new potential opportunities with others as the day progresses. The act of sharing is also deeply identity-forming, and the roles and presentations of self that are displayed throughout the day signify how a person sees his or her self in society. We also use technology to share that identity with those nearby, and colocated technology such as cloudlets and other ad hoc mobile technologies provides opportunities to explore ways to facilitate and augment those colocated interactions with mobile sharing technologies. In most cases, the designs of these systems have little to no privacy or security measures added to them; however, the need for privacy remains an area worth exploring.

The rest of this article describes how we used these theories and guidelines to design for a cloudlet-based interaction system. We begin by designing a technology probe to understand how users conceptualize colocated sharing so as to design a prototype to their requirements. The design process, experimental design, and procedures for both are described and discussed next.

3. Technology Probe

Using Hutchinson et al.'s (2003) definition of *technology probes* as simple and flexible design instruments purposed with investigating the unknown, we built our technology probe to investigate how people conceptualize mobile colocated sharing and its privacy implications. The probe enables multiple mobile phone users to connect to one another and share digital media among themselves. The probe was also designed with the assumption that participants were unfamiliar with *synchronous*, mobile colocated technology, which meant we had to design a probe that anchored them around a familiar activity and extend it to showcase mobile colocated sharing. Photo sharing was chosen as it has a solid foundation of past colocated sharing research (Van House, 2009) and it was the most common media sharing participants would have been exposed to. The functionality of the probe was also left incomplete, allowing participants to ask questions and to provide a more situated understanding of colocated sharing and further design directions (Gaver, 2012).

3.1 Design

The photo-sharing probe was developed for mobile phones running Android 2.2 and used Bluetooth to discover nearby devices and transfer photos. It allows users to send their photos to those connected and enables others to browse through the shared content. Transfer of photos happens automatically and immediately whenever a new device is connected. The probe notifies the user whenever there is a new device nearby and allows them to connect. Devices that leave, either by closing the application or physically leaving, visually disappear from the user's screen. A secondary screen with information about and access to nearby devices is accessible from the main screen, allowing the user to (dis)connect from/to the devices of their choice. An example of the probe's interface can be seen in Figure 1.

3.2 Experimental Procedure

Ten students from the University of Cape Town participated in the experiment, split into two groups of five. They ranged in age from 18–22, were 60% female, and consisted of three groups of friends and four strangers. Each experimental session lasted 60 minutes and started with the participants being queried on their current mobile colocated use. Next, each participant received a mobile phone and underwent a 5–10-minute demonstration of the probe. Participants were encouraged to ask questions and interact with the probes throughout the demonstration. A discussion of the technology followed: how they interacted and would like to interact with it as well as any feedback they had. To investigate their conceptualization of mobile colocated sharing, participants were asked to codesign two applications, a calendar and a music application. The aim of

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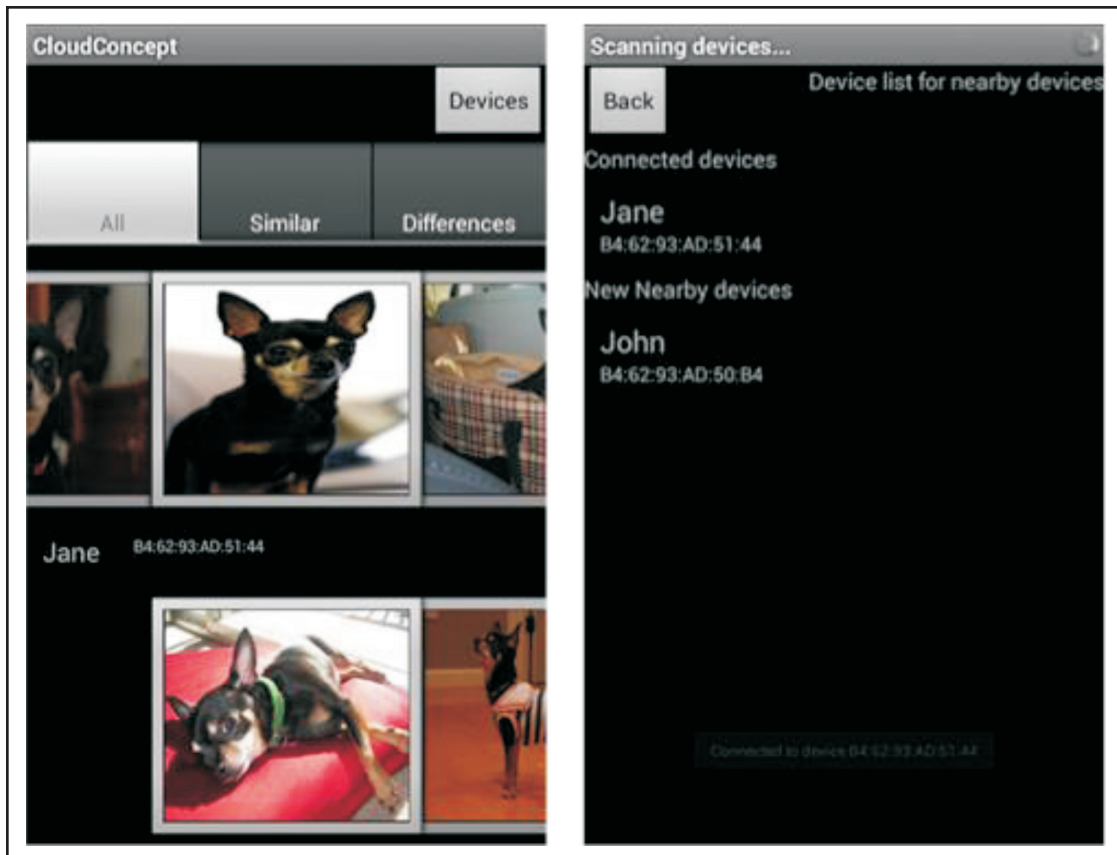


Figure 1. The probe's interface, displaying the sharing screen with photos shared by the user and connected devices (left) and the screen showing all nearby and connected devices (right).

adding the codesigns was to understand how participants conceptualized mobile colocated sharing beyond the use of photo sharing and to see how privacy could be generalized beyond the domain of photo sharing.

Participants identified direct messaging services such as email, BBM, Whatsapp, and Facebook as their primary means of sharing digital media when colocated. They knew about Bluetooth, but never used it, claiming it was complicated and slow. While some had NFC-enabled phones (phones able to share digital media with others by touching them together), they never used the sharing feature and found NFC-enabled phones to be obnoxious as they "showcased" to everyone that you had an expensive phone and were sharing with someone nearby. Other than sharing through cloud-based services, they would physically display shared content on their phones (screens) to others as an act of sharing. This "show-and-tell" gesture would accommodate sharing with friends and acquaintances. When sharing with acquaintances, shared items would be displayed in a controlling manner, where the phone stayed in the sharer's possession, but the shared content was viewable by others on the screen. For familiars, friends, or family, participants felt more comfortable "giving up" their phones; however, most participants felt uncomfortable parting with their phones and managed that anxiety by saying there was an "unspoken" law when it came to being in possession of some else's phone: "You look but don't touch the phone," meaning all you're allowed to do is view, not take control of it. Participants all had experiences of someone "swiping backwards" on a mobile phone to discover a photo they weren't supposed to see.

When interacting with the probes, participants were delighted with the ease with which photo sharing took place. They were surprised to learn that the probe used Bluetooth, a technology with heretofore negative

associations, to transmit photos and commented that the real-time manner with which sharing took place made the experience feel “fresh” and dynamic and was a big step away from the traditional single-file sharing they commonly associated with mobile colocated sharing (referring to Bluetooth). During the demonstration, participants would stare at their phones, waiting for incoming photos and commented on their arrival. When asked to codesign the calendar and music applications, participants came up with numerous interfaces and functionalities that they thought exemplified mobile colocated sharing and use. These included displaying and broadcasting free dates the devices had in common and the ability to identify similar music shared among devices.

One of the main concerns all participants had was the lack of privacy and control they had over shared content. “Who sees what?” “How do others gain access to content?” “How can content be limited and used?” Those questions were constantly asked and puzzled over. Participants revealed that they adjusted their sharing behaviors depending on whom they were sharing with. They also shared their annoyance with user interfaces that characterized personal relationships as a defined, static, one-dimensional list and that the list required too much maintenance, forcing them to either abandon the list and style their content for the general audience or not to share. They reflected that these sharing mechanisms and categorizations did not reflect the richness and complexities of their interrelationships.

3.3 Experimental Reflection

The experiment illuminated how the participants shared digital media when colocated with their mobile phones. Particular attention was drawn to their use of proxemic technologies such as Bluetooth and NFC, and they confirmed that those technologies were rarely used (Kirmani & Fleck, 2014; Walton et al., 2012). The “show-and-tell” gesture was common among all participants, which has also been demonstrated by other researchers (Kirmani & Fleck, 2014; Lucero et al., 2011); however, the hesitation and reluctance to hand over possession of their phones demonstrated how these devices have become private and personal (Ling, 2010). Throughout the experiment, the issue of privacy arose repeatedly. This not only confirmed our own development guidelines and the research of others that mobile colocated applications should accommodate user privacy, but it also made clear that participants want direct control over what and with whom they shared. They wanted to control the impression they were making on others and felt that the probe wasn’t able to do that.

This desire to control one’s information, with the aim of influencing the impression formed by others, is termed *impression management*. It goes hand-in-hand with *self-presentation*, a term defined as the act of controlling *oneself*, and any “self-relevant” images, to control the impression formed by others (Pontari & Schlenker, 2004). Goffman (1956) likened self-presentation to that of a theatrical performance, where the performer presents a controlled image to the audience, and the audience interprets and participates in the believability of the performance. Interpreting the reaction from the participants through the lens of Goffman’s metaphor, we understand that the performer and audience have a symbiotic relationship that establishes the believability of the performance. In the case of the experiment’s participants interacting with the probe, they weren’t sure who their audience was and wanted to obtain more control and privacy over the application and, in turn, over their impression and performance.

We recognize the limitations of the technology probes and how their design might have led the participants to search for ways to control the shared content. Because of the screen size limitations of mobile devices, users were unable to simultaneously see whom they were connected to while sharing, leading to the suspicion that the audience was unknown or hidden from them (even when they could see who was nearby). This raises the question: What is an appropriate design for mobile colocated sharing? When colocated, the advantage of the performer is she or he is within the immediate view of the audience. However, colocated interaction implies mobility, with people moving into and out of the interaction. For example, if I’m sitting in a coffee shop, I’ll experience many sharing opportunities with those entering and leaving, but do I constantly want to switch screens and manage whom I can connect to? Do I want to be bombarded with notifications as people walk by or enter a room? Sharing in a broadcasting manner is an adequate option for many online sharing services, but they require the managing overhead of groups and connections that might not be the best option for mobile colocated sharing. Similarly, online sharing services allow the sharer to engage with an audience

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that might not be immediately present, require less “on-demand” group or audience management, and allow the sharer to take their time to manage their self-presentation. From our participant feedback, the colocated nature might not allow for that mode of sharing.

But what is the alternative? Can we design a sharing system or interface that doesn’t force the sharer to broadcast or micromanage their audience? How do we give the user control over their impression? Over what they’re sending and to whom?

4. Prototype

Using the lessons learned from the probe experiment, we set out to design a prototype that addressed the privacy issues participants raised. The aim was to design a sharing mechanism that allowed for direct control over content being shared and directing it to the desired recipient.

4.1 Design

The first change we made was to switch from transferring data through Bluetooth to Wi-Fi. Developing the probes with Bluetooth was cumbersome, prone to dropping connections, and slow to transfer images in real time. Wifi-Direct was a suitable replacement, but was only available on one Android make and model at the time of development (Samsung Galaxy S2). Unfortunately, it wasn’t reliable and dropped connections. While NFC was an option for creating connections and had already been done by others (Bouzeffrane, Benkara Mostefa, Houacine, & Cagnon, 2014), our participants noted that they didn’t like initiating sharing by “touching” devices together. There were other user needs we had to design for such as private sharing that wouldn’t be possible with physical touching; for example, physically touching five phones to share one private picture. Similarly, there exist sophisticated mechanisms for proxemics that others have implemented, but they generally rely on custom hardware or specialist devices that neither we nor our participants had access to (Jokela & Lucero, 2014). As a result, we chose a more generalized solution by using a local wifi hotspot and connecting the phones to it.

The user interface was changed by making nearby devices visible and accessible from the main sharing screen. To do this, each device is represented by an interactive avatar displayed as a circular profile picture (see Figure 2). These avatars allow the sharer to perform basic sharing tasks: connect, share, disconnect. All available devices are displayed at the top of the screen when they are nearby, are horizontally scrollable, and disappear when a phone leaves the area. Each avatar is surrounded by a colored activity circle that displays its current activity status: red for available but not connected to share, yellow for initiating to share, orange for a pending sharing session, and green for connected and available to share. The orange and yellow colors represent two-way authorization functionality, which was added after a focus group tested the probe and provided feedback to the initiator and control to the responder of a sharing session. They are initialized when a red avatar is tapped, turning the initiator’s avatar yellow and the recipient’s orange. If the recipient accepts the intent to share, tapping the orange avatar turns both initiator’s and recipient’s avatars green. If not, the colors remain yellow or green until the initiator cancels the operation by tapping on the avatar to turn it red again.

We drew inspiration from concepts of direct manipulation (Rädle et al., 2014; Rekimoto, 1997) to address issues of privacy and directing photos to a desired audience. All available photos are displayed at the bottom of the screen, and the phone allows the user to horizontally scroll through them. When the user identifies a photo they want to share, they send it by dragging the photo up toward the chosen avatar and releasing it on top of the avatar (or releasing it away from the avatar to cancel the operation). When the photo is released on an avatar, the circle turns blue to indicate the photo is being sent and changes to green once the file has been sent. The interaction toward the avatar is designed to facilitate a move “away” from the content, with the dragging movement of the interaction capturing a semitransparent snapshot of the selected image, which acts as a visual reminder of the item being sent. The act of dragging the photo onto the avatar also facilitates identifying the photo recipient, mimicking the “show-and-tell” gesture while maintaining control and ownership of the device and screen. Each photo can only be sent to one avatar at a time, but an unlimited number of photos can be sent while the devices are connected. The prototype was also designed to evoke specific reactions from the participants. All the sent photos appear on the device, but would be replaced when a new

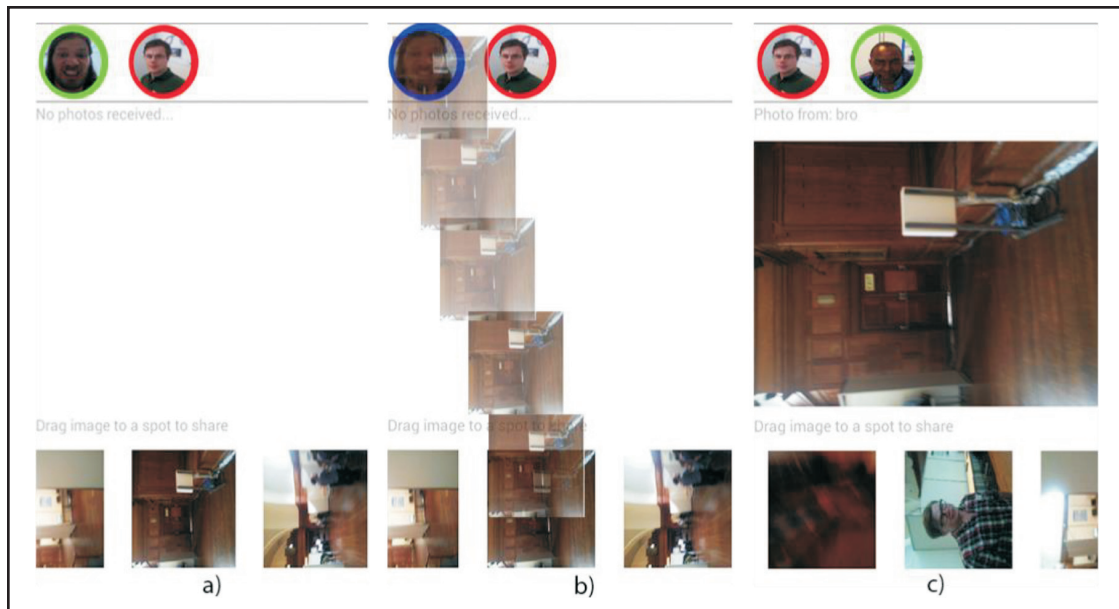


Figure 2. The prototype's interface and sharing interaction, showing the default screen with one connected and available device and the photos available to share (a), displaying the sharing interaction in motion (b), and the received photo on recipient's device (c).

photo is received. The photos are never stored on the recipient's device. This design decision was made to understand how participants felt about content ownership once shared. Grouping of avatars was also purposely missing from the prototype, forcing users to repeat the sharing interaction if they wanted to send the same photo to multiple devices. This was done to elicit discussions of grouped, colocated devices and their interactions.

4.2 Experiment

Twenty students from the University of Cape Town participated in the experiment and were organized in groups of four (sometimes consisting entirely of friends). Their ages ranged from 18–21 years, and 65% were female. Before the experiment started, each participant was handed a mobile device and instructed to spend time walking around taking pictures of things they found interesting. This was done so participants could share their own photos and feel a sense of ownership in the content they shared. Similar to the previous experiment, participants were initially asked about their *current* colocated mobile sharing practices. Next, the participants went through a step-by-step walkthrough of the prototype, after which the participants were given 5–10 minutes to use the prototype freely among themselves. This was followed by questions relating to their use of the prototype. They were encouraged to continue using the prototype during the discussion and to explain current or needed features whenever possible. Lastly, participants were asked for their views on content ownership, group management, and different types of mobile colocated sharing. Each session lasted 60 minutes.

Participants were eager and helpful when providing feedback for the prototype and interaction mechanics, while identifying social insights and practices. They responded with enthusiasm when provided with the opportunity to take their own photos, with each participant taking on average 15 pictures of nearby objects, locales, friends, or themselves. They also asked if they could keep the photos at the end of the experiment. Their current mobile colocated sharing practices were similar to those of the first experiment: primarily using cloud-based messaging services. Similar to the first probe experiment, users knew about Bluetooth and NFC, but had never used them. When asked to demonstrate how they would share, they said they would use either the "show-and-tell" gesture or open WhatsApp to share content. While they showed no preference for either method, they did indicate that the "show-and-tell" feature didn't provide adequate control in large

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Figure 3. An example of participants using the prototype in user tests. In this example, the four friends were accompanied by another friend who just sat with them for the duration of the experiment.

groups. They said, for example, “The minute I call someone to view the picture, everyone comes,” indicating participants felt they lacked control over the physical gesture afforded in larger groups. Participants also noted the feature discouraged them from sharing when in larger groups and they would instead send the photo later or at another opportunity. However, one benefit that the gesture had was that it allowed outsiders to feel included in the sharing. One participant reflected that she felt disconnected from her friends when they shared items through cloud-based services, as the sharing was never a one-off event and often caused her friends to spend long intervals “staring at their phones and ignoring” her.

As the participants grew more familiar with the prototype, they noted that dragging the same image to multiple avatars became tedious. In each experiment, this naturally segued into the discussion and conceptualization of grouped devices and how the participants would manage them. Their conceptual formalization of groups was heavily influenced by their use of WhatsApp. Most participated in multiple WhatsApp groups, ranging from 5–30 people. Even though these larger groups were more prone to share “spam” messages among group members, they preferred it to the alternatives. However, creating groups was rigid: Individuals could only join groups if its creator invited them and the act of leaving a group visually broadcast a notification to all group members. This would often result in “dangling groups,” groups that were no longer active but where no one wanted to seem rude by leaving. Groups also had their own language and sharing culture. For example, football groups would share football-related content and trivia. However, when friends participated in groups but with different members and contexts, conversations and content could occasionally spill over from one group into the other without realizing they’d communicated to the “wrong” group. This often resulted in inappropriate sharing, such as misplaced jokes that were followed by shaming or calling out by others in the group.

After experimenting with the prototype, the conversation turned to the topic of persistent and temporal content. For the users, there were appropriate times to retain content and times when the content was only meant for that moment, such as a joke. The acceptance of persistent content generally relied heavily on the relationship with the content itself or with the person sharing the content such as a photo of a loved one or a

place of significance. However, the users could reach no consensus between their preference of persistent or temporal content sharing. Some participants preferred the way the prototype replaced old shared content, noting that it was appropriate and complemented that moment in time. It also allowed participants to verbally refer to the image at a later stage, which was also something they did during the experiment. For the participants, this type of temporality was viewed as a “sampling” or “advertising” mode of sharing and allowed them to share the content and moment in later interactions. Other participants wanted a more structured approach, where each avatar and device had a history of shared items. This would allow users to relive and re-interact with the content and those participating, even when absent. When asked who owned the content, most participants felt that once the content appeared on their phone, it was theirs. However, they were just as quick to claim ownership when they had sent the photo.

4.3 Experimental Reflection

Similar to the first experiment, participants reacted to the prototype with excitement for and anticipation of the completed version. They often asked when it would be available for their phones or where they could download it. This not only convinced us that our prototype was successful, but that participants readily saw it as a viable addition to their current modes of sharing. One big change from the first experiment was that the participants never once reflected on or asked about sharing privacy or control. While this silence was disconcerting at first, especially considering the amount of time and thought that went into the prototype’s design, its invisibility to them may have meant the design provided them with the control and security needed to direct their sharing without encumbering them with privacy mechanics or permissions. Participants could identify which other devices they wanted to share with based on another user’s profile picture (avatar) and connection colors. Dragging photos onto the desired avatar also made it visually clear whom they were sharing with and facilitated cancelling their actions if they desired. It was also encouraging to see how the experiment’s setting was forgotten as participants grew accustomed to using the feature, and a playful group dynamic emerged. These playful dynamics were expressed as laughter, asking each other about a photo or resending it, often slipping into their native tongue and speaking to one another in a lower register. The ease with which photos were transferred triggered conversations and reminders of pre-experiment experiences. In these cases, the prototype and its control-sharing mechanism pushed the act of sharing to the foreground and the mode of sharing to the background. Because of the design decisions made in the prototype, the two experiments performed for this study were contrasting: the first one closed participants off and led them to worry about privacy, while the second one opened them up and allowed them to share with ease.

Participants used their experience with WhatsApp to provide guidance for future sharing applications that would facilitate group management and interaction. Participants’ main problems with the group messaging feature in WhatsApp were the lack of audience awareness, unwanted spam, and dangling groups. One way the participants proposed managing groups of cloudlet devices was by dragging avatars onto other avatars to create and manage groups, similar to Google+’s use of *circles* to manage contacts (Kairam et al., 2012). While this may help manage smaller groups, how this interaction scales up to multiple devices requires further investigation. Similarly, how does the act of physically moving in and out of groups change this type of interaction? Should groups be persistent or temporal? Similarly, what are the semantics and standard operations behind this interaction? What would happen and what would it mean if we dragged an avatar onto a photo? And what about persistent content? Should there be a history of past interactions? Should it only be available when the group is within proximity and connected? Who owns this information? Similar to the findings of others, content ownership and ephemerality remain a divided topic among participants who used the prototype (Lucero et al., 2011), but the participants’ perspectives provide a richness of opinion that provides us with a platform to further investigate the landscape that these mobile colocated sharing services allow us to partake in and share.

5. Conclusion

The ubiquity of connectivity that the mobile phone promises is not experienced by all, especially in developing world contexts where networking costs and access are unaffordable and sparse. Cloudlets is a rich area of

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technological inquiry that not only addresses the needs of those in developing world contexts, but also has benefits for highly networked and developed contexts. By designing and investigating how users interact and conceptualize cloudlets, we aim to move the discussion of cloudlets from being technologically focused toward how those applications and services should be designed and how they should function.

Designing for cloudlets and mobile colocated sharing provides us with a unique opportunity to reimagine the ways in which we interact and share digital media with those nearby, while simultaneously presenting their own unique design and implementation challenges. By surrounding ourselves with colocated concepts and through the use of a technology probe, we conceptualized and designed a prototype that takes seriously the concept of identity and the presentation of self in order to provide control over shared content. The design of this sharing system emphasizes that when we design with impression management in mind, we provide users with sharing mechanics that move issues of privacy and control from being of primary importance to being of least concern and that allow users to move from being closed and worried about privacy to being open and free to share. We hope that others gain inspiration from our findings and designs and use them to build rich and meaningful digital media-sharing services that take the presentation of self seriously. We also hope that our colocated concepts and guidelines will be used to design better ways of colocated sharing and, ultimately, facilitate the continued exploration of cloudlet-based technologies and applications. ■

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References

- Baumeister, R. F. (1982). A self-presentational view of social phenomena. *Psychological Bulletin*, 91(1), 3–26. doi:10.1037/0033-2909.91.1.3
- Bernstein, M. S., Bakshy, E., Burke, M., & Karrer, B. (2013). Quantifying the invisible audience in social networks. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 21–30). doi:10.1145/2470654.2470658
- Bidwell, N. J. (2014). Moving the centre to design social media in rural Africa. *AI & SOCIETY*, September, 1–27. doi:10.1007/s00146-014-0564-5
- Bidwell, N. J., Reitmaier, T., Marsden, G., & Hansen, S. (2010). Designing with mobile digital storytelling in rural Africa. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1593–1602). doi:10.1145/1753326.1753564
- Bidwell, N. J., Robinson, S., Vartiainen, E., Jones, M., Siya, M. J., Reitmaier, T., . . . Lalmas, M. (2014). Designing social media for community information sharing in rural South Africa. In *Proceedings of the Southern African Institute for Computer Scientist and Information Technologists Annual Conference on SAICSIT Empowered by Technology* (pp. 104–114). doi:10.1145/2664591.2664615
- Bouzefrane, S., Benkara Mostefa, A. F., Houacine, F., & Cagnon, H. (2014). Cloudlets authentication in NFC-based mobile computing. In *Mobile Cloud Computing, Services, and Engineering (mobileCloud), 2014*

- 2nd IEEE International Conference on Mobile Cloud Computing, Services, and Engineering* (pp. 267–272). doi:10.1109/MobileCloud.2014.46
- Buckingham, D. (2008). *Youth, identity, and digital media*. Cambridge, MA: MIT Press. doi:10.1162/dmal.9780262524834.vii
- Clawson, J., Volda, A., Patel, N., & Lyons, K. (2008). Mobiphos: A collocated-synchronous mobile photo sharing application. In *Proceedings of the 21st International Conference on World Wide Web* (pp. 187–195). doi:10.1145/1409240.1409261
- Dourish, P. (2004). What we talk about when we talk about context. *Personal and Ubiquitous Computing*, 8(1), 19–30. doi:10.1007/s00779-003-0253-8
- Farman, J. (2012). *The mobile interface of everyday life*. London, UK: Routledge.
- Farnham, S. D., & Churchill, E. F. (2011). Faceted identity, faceted lives: Social and technical issues with being yourself online. In *Proceedings of the ACM Conference on Computer Supported Cooperative Work* (pp. 359–368). doi:10.1145/1958824.1958880
- Fernando, N., Loke, S. W., & Rahayu, W. (2013). Mobile cloud computing: A survey. *Future Generation Computer Systems*, 29(1), 84–106. doi:10.1016/j.future.2012.05.023
- Foucault, M. (1995). *Discipline and punish: The birth of the prison* (A. Sheridan, Trans.). Vancouver, BC: Vintage Books.
- Frohlich, D., Name, Y. U., Kuchinsky, A., Pering, C., Don, A., & Ariss, S. (2002). Requirements for photoware. In *Proceedings of the ACM Conference on Computer Supported Cooperative Work* (pp. 166–175). doi:10.1145/587078.587102
- Gaver, W. (2012). What should we expect from research through design? In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 937–946). doi:10.1145/2207676.2208538
- Giddens, A. (1999). *Modernity and self-identity: Self and society in the late modern age*. Cambridge, UK: Polity.
- Gitau, S., Marsden, G., & Donner, J. (2010). After access: Challenges facing mobile-only Internet users in the developing world. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2603–2606). doi:10.1145/1753326.1753720
- Goffman, E. (1956). *The presentation of self in everyday life*. New York, NY: Anchor Books.
- Hall, E. T. (1992). *The hidden dimension*. New York, NY: Anchor Books.
- Harper, R., Regan, T., Izadi, S., Al Mosawi, K., Rouncefield, M., & Rubens, S. (2007). Trafficking: Design for the viral exchange of TV content on mobile phones. In *Proceedings of the 21st International Conference on World Wide Web* (pp. 249–256). doi:10.1145/1377999.1378015
- Hutchinson, H., Mackay, W., Westerlund, B., Bederson, B. B., Druin, A., Plaisant, C., . . . Eiderbäck, B. (2003). Technology probes: Inspiring design for and with families. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 17–24). doi:10.1145/642611.642616
- Jack, W., & Suri, T. (2011, January). *Mobile money: The economics of M-PESA* (Working Paper No. 16721). Cambridge, MA: National Bureau of Economic Research.
- Jenkins, R. (2014). *Social identity*. London, UK: Routledge.
- Jokela, T., & Lucero, A. (2014). FlexiGroups: Binding mobile devices for collaborative interactions in medium-sized groups with device touch. In *Proceedings of the 16th International Conference on Human-Computer Interaction with Mobile Devices Services* (pp. 369–378). doi:10.1145/2628363.2628376

SHARING THE CLOUDLET

- Kairam, S., Brzozowski, M., Huffaker, D., & Chi, E. (2012). Talking in circles: Selective sharing in Google+. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1065–1074). doi:10.1145/2207676.2208552
- Kapuire, G. K., Winschiers-Theophilus, H., & Blake, E. (2015). An insider perspective on community gains: A subjective account of a Namibian rural communities' perception of a long-term participatory design project. *International Journal of Human-Computer Studies*, 74, 124–143. doi:10.1016/j.ijhcs.2014.10.004
- Kelly, A. E. (2000). Helping construct desirable identities: A self-presentational view of psychotherapy. *Psychological Bulletin*, 126(4), 475–494. doi:10.1037/0033-2909.126.4.475
- Kendon, A. (2010). Spacing and orientation in co-present interaction. In A. Esposito, N. Campbell, C. Vogel, A. Hussain, & A. Nijholt (Eds.), *Development of Multimodal Interfaces: Active Listening and Synchrony: Second COST 2102 International Training School* (pp. 1–15). Berlin, Germany: Springer Berlin Heidelberg. doi:10.1007/978-3-642-12397-9_1
- Kindberg, T., Spasojevic, M., Fleck, R., & Sellen, A. (2005). I saw this and thought of you: Some social uses of camera phones. In *CHI '10 Extended Abstracts on Human Factors in Computing Systems* (pp. 1545–1548). doi:10.1145/1056808.1056962
- Kirmani, A., & Fleck, R. (2014). "People don't bump": Sharing around mobile phones in close proximity. *Proceedings of the 16th International Conference on Human-Computer Interaction with Mobile Devices Services* (pp. 549–554). doi:10.1145/2628363.2634231
- Koukoumidis, E., Lymberopoulos, D., Strauss, K., Liu, J., & Burger, D. (2011). Pocket cloudlets. *SIGARCH Computer Architecture News*, 39(1), 171–184. doi:10.1145/1961295.1950387
- Ling, R. (2010). *New tech, new ties: How mobile communication is reshaping social cohesion*. Cambridge, MA: MIT Press.
- Lucero, A., Holopainen, J., & Jokela, T. (2011). Pass-them-around: Collaborative use of mobile phones for photo sharing. In *Proceedings of the 21st International Conference on World Wide Web* (pp. 1787–1796). doi:10.1145/1978942.1979201
- Lucero, A., Holopainen, J., & Jokela, T. (2012). MobiComics: Collaborative use of mobile phones and large displays for public expression. In *Proceedings of the 21st International Conference on World Wide Web* (pp. 383–392). doi:10.1145/2371574.2371634
- Lucero, A., Jones, M., Jokela, T., & Robinson, S. (2013). Mobile collocated interactions: Taking an offline break together. *Interactions*, 20(2), 26–32. doi:10.1145/2427076.2427083
- Marwick, A. E., & boyd, d. (2011). I tweet honestly, I tweet passionately: Twitter users, context collapse, and the imagined audience. *New Media & Society*, 13(1), 114–133. doi:10.1177/1461444810365313
- Maunder, A., Marsden, G., & Harper, R. (2011). Making the link: Providing mobile media for novice communities in the developing world. *Journal of Human Computer Studies*, 69(10), 647–657. doi:10.1016/j.ijhcs.2010.12.009
- Palen, L., & Dourish, P. (2003). Unpacking "privacy" for a networked world. In *Proceedings of the 21st International Conference on World Wide Web* (pp. 129–136). doi:10.1145/642611.642635
- Pontari, B. A., & Schlenker, B. R. (2004). Providing and withholding impression management support for romantic partners: Gender of the audience matters. *Journal of Experimental Social Psychology*, 40(1), 41–51. doi:10.1016/S0022-1031(03)00070-2

- Rädle, R., Jetter, H.-C., Marquardt, N., Reiterer, H., & Rogers, Y. (2014). HuddleLamp: Spatially-aware mobile displays for ad-hoc around-the-table collaboration. In *Proceedings of the 9th ACM International Conference on Interactive Tabletops and Surfaces* (pp. 45–54). doi:10.1145/2669485.2669500
- Reitmaier, T., Benz, P. H., & Marsden, G. (2013). Designing and theorizing co-located interactions. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 381–390). doi:10.1145/2470654.2470709
- Rekimoto, J. (1997). Pick-and-drop: A direct manipulation technique for multiple computer environments. In *Proceedings of the 10th Annual ACM Symposium on User Interface Software and Technology* (pp. 31–39). doi:10.1145/263407.263505
- Rhodewalt, F. (1998). Self-presentation and the phenomenal self: The “carryover effect” revisited. In J. M. Darley & J. Cooper (Eds.), *Attribution and social interaction: The legacy of Edward E. Jones* (pp. 373–421). Washington, DC: American Psychological Association. doi:10.1037/10286-007.
- Sarbin, T. R., & Allen, V. L. (1954). Role theory. *Handbook of Social Psychology*, 1(2), 223–258.
- Satyanarayanan, M., Bahl, P., Caceres, R., & Davies, N. (2009). The case for vm-based cloudlets in mobile computing. *IEEE Pervasive Computing*, 8(4), 14–23. doi:10.1109/MPRV.2009.82
- Schlenker, B. R. (1986). Self-identification: Toward an integration of the private and public self. In R. F. Baumeister (Ed.), *Springer Series in Social Psychology* (pp. 21–62). New York, NY: Springer New York. doi:10.1007/978-1-4613-9564-5_2
- Seifert, J., De Luca, A., Conradi, B., & Hussmann, H. (2010). TreasurePhone: Context-sensitive user data protection on mobile phones. In *Proceedings of the 8th International Conference on Pervasive Computing* (pp. 130–137). doi:10.1007/978-3-642-12654-3_8
- Seifert, J., Dobbstein, D., Schmidt, D., Holleis, P., & Rukzio, E. (2014). From the private into the public: Privacy-respecting mobile interaction techniques for sharing data on surfaces. *Personal and Ubiquitous Computing*, 18(4), 1013–1026. doi:10.1007/s00779-013-0667-x
- Seifert, J., Simeone, A., Schmidt, D., Holleis, P., Reinartz, C., Wagner, M., . . . Rukzio, E. (2012). MobiSurf: Improving co-located collaboration through integrating mobile devices and interactive surfaces. In *Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces* (pp. 51–60). doi:10.1145/2396636.2396644
- Skov, M. B., & Kjeldskov, J. (2014). JuxtaPinch: Exploring multi-device interaction in collocated photo sharing. In *Proceedings of the 16th International Conference on Human-Computer Interaction with Mobile Devices Services* (pp. 183–192). doi:10.1145/2628363.2628369
- Sleeper, M., Cranshaw, J., Kelley, P. G., Ur, B., Acquisti, A., Cranor, L. F., & Sadeh, N. (2013). “i read my Twitter the next morning and was astonished”: A conversational perspective on Twitter regrets. In *Proceedings of the 21st International Conference on World Wide Web* (pp. 3277–3286). doi:10.1145/2470654.2466448
- Sundstrom, E., & Altman, I. (1976). Interpersonal relationships and personal space: Research review and theoretical model. *Human Ecology*, 4(1), 47–67. doi:10.2307/4602344
- Ureta, S. (2008). Mobilising poverty?: Mobile phone use and everyday spatial mobility among low-income families in Santiago, Chile. *The Information Society*, 24(2), 83–92. doi:10.1080/01972240701883930
- Van House, N. A. (2009). Collocated photo sharing, story-telling, and the performance of self. *Journal of Human Computer Studies*, 67(12), 1073–1086. doi:10.1016/j.jhcs.2009.09.003

SHARING THE CLOUDLET

- Verbelen, T., Simoens, P., De Turck, F., & Dhoedt, B. (2012). Cloudlets: Bringing the cloud to the mobile user. In *Proceedings of the Third ACM Workshop on Mobile Cloud Computing and Services* (pp. 29–36). doi:10.1145/2307849.2307858
- Walton, M., Marsden, G., HaBreiter, S., & Allen, S. (2012). Degrees of sharing: Proximate media sharing and messaging by young people in Khayelitsha. In *Proceedings of the 21st International Conference on World Wide Web* (pp. 403–412). doi:10.1145/2371574.2371636
- Wang, Y., Norcie, G., Komanduri, S., Acquisti, A., Leon, P. G., & Cranor, L. F. (2011). “I regretted the minute I pressed share”: A qualitative study of regrets on Facebook. In *Proceedings of the Seventh Symposium on Usable Privacy and Security* (pp. 1–16). doi:10.1145/2078827.2078841