Stress OutSourced:
A Haptic Social Network via Crowdsourcing

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figure 1. A prototype massage module attached to an SOS member's jacket

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Abstract
Stress OutSourced (SOS) is a peer-to-peer network that allows anonymous users to send each other therapeutic massages to relieve stress. By applying the emerging concept of crowdsourcing to haptic therapy, SOS brings physical and affective dimensions to our already networked lifestyle while preserving the privacy of its members. This paper first describes the system, its three unique design choices regarding privacy model, combining mobility and scalability, and affective communication for an impersonal crowd, and contrasts them with other efforts in their respective areas. Finally, this paper describes future work and opportunities in the area of haptic social networks.

Keywords
Haptic social network, social network, tangible interface, ubiquitous computing, wearable computing, touch therapy, privacy model, affective communication, crowdsourcing

ACM Classification Keywords
H.5.2. User Interfaces

Introduction
Stress is a universal experience in all industrialized societies and is experienced by billions of people, regardless of their nationality, gender or socioeconomic class. A large number of people around the world pursue means to relieve stress. Popular ways of

relieving stress include drinking in a group, exercising, and getting a massage.

Studies have shown evidence of the physiological effects of massage, such as its ability to relax skeletal muscles, increase blood and lymph circulation, and reduce anxiety. Zeitlin et al. concluded massage may be a useful stress-reduction tool capable of immunological effects [1]. Touch is also a powerful way of enhancing psychological and physical comfort in palliative care [2]. It is, however, in our everyday context where most touch interaction occurs. Routine interaction between loved ones includes various types of touch such as hugging, nudging, and massaging. Absence of comforting touch can lead to the development of social and emotional problems, as discussed in the case of Romanian orphans raised in overcrowded facilities during the communist regime [3].

Our changing llfestyle

Traditionally, we relied on our long-term friends and neighbors or on immediate family members we lived with for routine touch interaction. However, US census data shows such traditional households are in fast decline [4]. It has become more common for us to live alone, with roommates, and geographically dispersed from our parents, best friends or even spouses. How do we receive or give therapeutic touch when the traditional household structure and lifestyle no longer holds true?

While we rely less on a close-knit circle of people in geographic proximity to acquire knowledge from and discuss topics of interest with, we have created a much larger pool of knowledge and voices to draw from on the Web. Instead of asking the upstairs neighbor where to find a good cobbler or the nearest post office, we search online. Blogging and social networking inform us of the minute details of our friends living far away.

Crowdsourcing massages

With this new lifestyle and connectedness, crowdsourcing has emerged as a problem solving technique. Crowdsourcing is the act of taking a job traditionally performed by a designated agent, usually an employee, and outsourcing it to an undefined, generally large group of people in the form of an open call [5]. Procter & Gamble and Colgate-Palmolive post research and development problems online to be solved by over 125,000 participants worldwide [6]; Threadless, an Internet-based clothing retailer, sells T-shirts designed and rated by members of the website with expected revenue of $20 million in 2006 [7][8]; reCAPTCHA provides text fragments that can't be deciphered properly by OCR software to be read by end users of a spam filter and has transcribed over 440 million words from the New York Times archive [9]. When properly implemented, crowdsourcing leads self-interested individuals to cooperate with strangers toward a collectively beneficial outcome [12].

Millions of us already rely on strangers online to relieve stress. We post about our day, feelings and aspirations and receive nice words from friends and strangers who visit the blog or forum or watch the video. A North Carolina hospital has used a blog for patient therapy, where patients post with first names only and exchange their feelings [10].

Can we cooperate with strangers online to exchange touch therapy, rather than to exchange textual or

audiovisual information? Stress OutSourced (SOS) is a peer-to-peer network that allows anonymous users to send each other therapeutic massages to relieve stress. The SOS system consists of members wearing customizable signal modules for sending and responding to an anonymous SOS call, and wearable massage actuation modules to receive the massage strokes sent by others. It is complemented by a companion website where members can see more information about their previous exchanges and communicate with each other anonymously. SOS enables physical and affective communication for a large crowd of users through its unique design choices, including abstracted disclosure of user location and flexible form factor and signals, and application of the emerging concept of crowdsourcing.

This paper describes the system, contrasts the design choices with other examples in their respective areas, and discusses design feedback from our prototype. Finally, we present a preliminary set of opportunity areas and future work in haptic social networks.

System Elements and Basic Scenario

Wearable modules

A member of the SOS network wears garments with an embedded or attachable signal module and a massage module of various form factors. For instance, member A may wear a sweater with a signal module embedded in his sleeves and an attachable massage module in his upper back; member B may wear an earpiece signal module and a slim patch of massage module attached inside the lower back area of her shirt; member C may be wearing a jacket with only a signal module embedded in his upper arm (figure 2).

figure 2. Various form factors of embedded or attachable modules (dotted line).

Outgoing SOS signal and global responses

During a particularly stressful day, member A in Cambridge, MA sends out an SOS signal to its members worldwide, requesting a massage. Members around the world receive it through their signal modules in the form of subtle vibration, tapping, heat, light or sound. When member B in Seattle and C in Milan receive the signal, they gently press on the signal area as a gesture to calm the stressed person. This motion of pressure in turn sends an anonymous response back to member A, translating each response into one stroke of a massage (figure 3).

figure 3. Anonymous members around the world respond using a variety of wearable means.

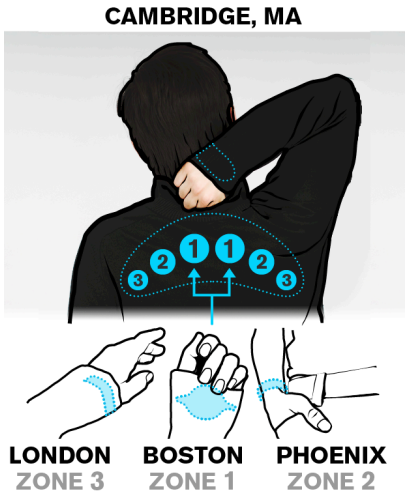

figure 4. Responses actuate different zones of the massage module based on their origins.

Geographically-zoned massage actuation

While there can be hundreds to millions of SOS members, only those who happen to be wearing their modules, notice the subtle incoming SOS signal, and be willing and able to respond in time will send responses. If 50 members send a response back, for instance, member A gets a massage consisting of 50 strokes distributed in sequence. In about a minute after sending the SOS signal, member A receives a massage that lasts several minutes through the massage unit attached to his garment or accessories. Each stroke is categorized by its geographical origin into three buckets: Responses originating from a 10-mile radius distance from A's location turn on the actuators located nearest to his spine, while those from the same country and overseas massage farther and farthest away from the spine, respectively (figure 4). Although A is unaware of the identities or the exact locations of the 50 respondents, he can physically tell that the responses are coming from all over the country and around the world.

Companion Website

Feeling comforted and refreshed by the generosity of anonymous SOS members, member A can go to the SOS website and check the list of responses he received. While the website does not disclose the identities of the respondents either, he can see which city in the world the signals originated from and choose to send anonymous thank you messages to the anonymous respondents through the website (figure 5).

figure 5. Each SOS signal and the responses are documented on the SOS website with their origin city, response time after the SOS call, local time of the respondent and an option to send a thank you message.

Design Choices

SOS combines haptic therapy with the mobility and situatedness of clothing and the reciprocity of social networks. As the concept draws from a multitude of fields including ubiquitous and wearable computing, haptic interfaces, social media and service design, interaction design choices play important role in determining its novelty and potential. In this section we will highlight the following high-level design choices, and contrast them with other efforts in their respective areas.

- Unique privacy model based on location-enabled anonymity
- Scalable in-situ haptic networking
- Impersonal yet affective communication through crowdsourcing

Facebook
Upon seeing a name or getting an invitation
IDENTITY Disclosed
LOCATION Optional, residence city

Gmail, Windows Live Messenger
Upon first obtaining an email address
IDENTITY Not fully disclosed
LOCATION Not disclosed

Wikipedia
Upon first obtaining a wiki signature
IDENTITY Not fully disclosed
LOCATION Not disclosed

SOS
Upon receiving a massage stroke
IDENTITY Not disclosed
LOCATION Abstracted, real-time location

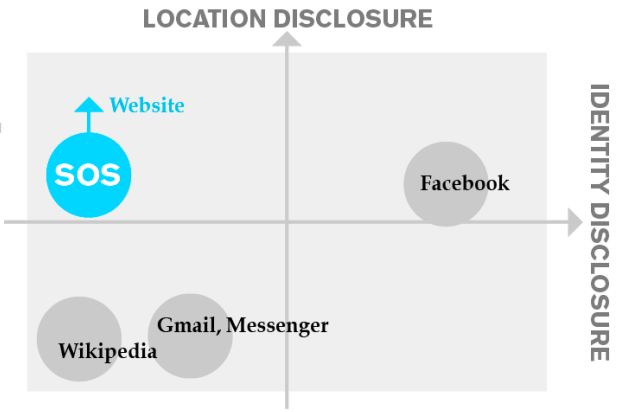

figure 6. Disclosure level upon the first encounter between two members

Unique privacy model based on location-enabled anonymity

LOCATION-ENABLED ANONYMITY: In 1993 Mark Weiser noted that a key problem with ubiquitous computing is preserving privacy of location, and that in addition to a purely technological solution, social issues must be considered in their own right [13]. SOS employs a unique privacy model where members' identities are not disclosed while their locations are disclosed—abstracted in the primary physical interface (massage actuation) and specified down to the city level on the secondary screen interface (companion website). As seen in figure 6, disclosing a member's abstracted location without her identity differentiates SOS from current interpersonal and social media online.

LAYERED DISCLOSURE OF MEMBER LOCATION: In addition, abstracting members' locations via geographical zoning enables simple haptic signals to convey multiple pieces of information including the sense of quantity, simplified geographical distribution, and approximate response time of the respondents. Disclosing the city-level origins of the responses on the website further informs the SOS sender with more precise diversity of the respondents. As noted by Chang et al., some interfaces may be improved or simplified by switching to haptic feedback modality [14]. This selective and layered disclosure of information allows SOS to take a simple haptic signal and create an active social network without requiring a screen full of audiovisual information presented in the wearable modules.

Also noteworthy is that, while SOS members remain anonymous throughout the user interaction flow, one-on-one conversations or personal encounters may still occur. Anonymous thank you messages between two

members on the Website can evolve into an ongoing conversation and lead to further association online and offline. Also, depending on the form factor of the signal module, the respondent to an SOS signal may be noticeable to others in the same room. On a rare occasion where the SOS sender notices a respondent shortly after sending out a call for massage, the sender may have accidentally discovered a respondent to her SOS call and faces the intriguing choice of whether to walk up to the person and talk to him.

Scalable in-situ haptic networking

As discussed by Kalanithi et al, screen-based social networking does not properly take advantage of foreground and background attention and tends to be task-oriented, and the vision of tangible and haptic social networks was demonstrated by inTouch as early as 1994 [11][15]. Compared to a number of research projects in the field, SOS offers a unique combination of mobility and scalability, while its discrete and subtle haptic signals blend into the physical environment and leverage the wearer's background attention.

MOBILITY AND CONTEXT-APPROPRIATENESS: inTouch by Brave at al., and Connectibles by Kalanithi are stationery objects bound to a location or a work surface, thus cannot adapt to user's changing location or context [16]. SOS's wearable and variable form factor allows users to take the interfaces with them, as an extension of their clothing and accessories. With attachable modules, users can create different signaling gestures that may be more suitable for their context and personality—pressing your upper arm with your arms crossed during a business meeting, pulling a necktie, or squeezing and fiddling with a waterproof wristband, for instance.

SCALABILITY: A number of tangible and haptic network concepts including Connectibles, BuddyBeads, and LumiTouch involve a one-to-one mapping between a tangible object and a person or a social group [17][18]. Through the networked object, a user interacts with the person or the group the object symbolizes. SOS users, on the other hand, wear modules that allow them to interact with a large number of members at once. The tangible and haptic interface in this case acts as a wearable communication device similar to the scarf prototype in Affective TouchCasting by Bonnani and Vaucelle [19]. However, instead of sending it to a specified friend or to patients, SOS aims to communicate with an unspecified and a much larger number of peers.

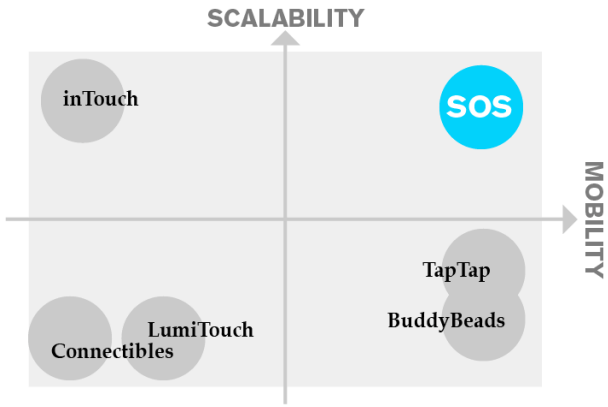

figure 7. Mobility vs. scalability of tangible and haptic networks

AMBIENT TOUCH: With scalability, the ability to ignore some incoming signals becomes crucial. An incoming SOS signal should be designed to be quite subtle, whether it is a vibration, tap, light, sound or

temperature change. Even when there are 10 signals coming in per hour, users should be able to continue their current activities without a noticeable disruption, except for when they opt to respond. With carefully designed signal stimulus, we propose, the inundating incoming signals may be experienced as ever-present and therapeutic ambient haptic stimuli, rather than a source of distraction. Rather than the touch stimuli in TapTap that are purposeful and directed to designated parties, SOS signals would be analogous to the breathing light of Apple laptops or the illumination in LumiTouch in terms of their ambient nature [18].

Impersonal yet affective communication through crowdsourcing

The third design choice that differentiates SOS is the ability to provide affective communication through the cooperation of the "faceless" crowd rather than through personal association and motivation.

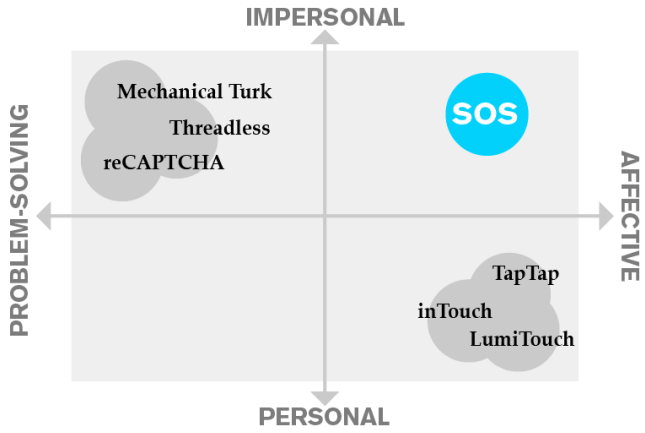

figure 8. Affective communication among impersonal crowd

HAPTIC COMMUNICATION FOR A CROWD: Previous attempts at tangible and haptic communication networks including inTouch, LumiTouch and TapTap aimed to convey affection and therapy between two personal contacts through the effect of co-presence [16] [21]. SOS, on the other hand, is a peer-to-peer network of a larger number self-interested individuals without personal association, under the assumption that the cooperation benefits everyone despite a small cost incurred to each individual. According to economists Samuel Bowles and Herbert Gintis and author James Surosiecki, such prosocial behavior of strong reciprocity between strangers may be attributed to the concept of trust that arose in European commerce in the 19th century—seeing individual transactions as a component of a long-term engagement—that was essentially impersonal [16].

CROWDSOURCING FOR AN AFFECTIVE END: Based on its impersonal nature of cooperation, crowdsourcing has been largely seen as a problem solving technique. Amazon.com's Mechanical Turk is a web-based marketplace where people perform "Human Intelligence Tasks"—small tasks computers are still not good at, such as identifying items in a photography or writing a product description [20]. SOS also requires very little work from each participating individual, but the end goal is to provide each other with comfort and relief rather than completing tasks.

Prototype

In order to illustrate the interaction flow and its physicality, we prototyped the massage module using spinning servo motors with different torques and varying sizes of attachments controlled by an Arduino board and a wrist-band signal module with vibration

motors and LEDs (figure 9). While these modules were not connected via a wireless network and we used common actuator parts due to time limitation, a broader selection is available for the longer term including slim electrodes to deliver massage strokes and thermo chromic materials or NiTinol shape memory alloy to note incoming signals.

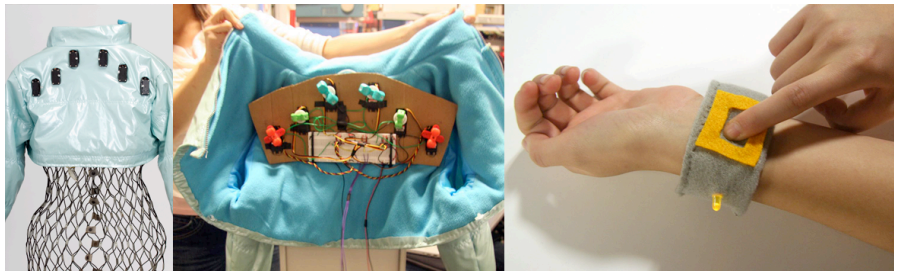

figure 9. Massage (left, center) and signal module (right)

Prototyping the modules and discussing usage contingencies led us to identify the following important considerations in designing the modules and the service interactions.

INVISIBLE AND BLENDED IN USE: Instead of requiring members to purchase specific garments, providing them with modules that can be added to their existing garments or accessories will improve user adoption. Variable form factors of wearable interfaces also allow users to choose or design signaling gestures that fit the wearer's context and personality. As the modules are hidden from outside or blended into the clothing, most wearable interfaces will not be noticeable to others. And the incoming subtle signal stimuli will be ambient in nature in the case of audiovisual feedback, or completely unnoticeable to others in the case of touch or temperature feedback. Being tacit, calm and not dramatic, we find this interface "unremarkable" and nearly invisible in use, following the ubiquitous computing vision [22].

MAINTAINING PEER-TO-PEER CONTRIBUTION: As a network built on the principle of strong reciprocity, it is crucial for SOS to incorporate mechanisms that encourage member contribution and discourage selfish behaviors. For example, to prevent members from sending meaningless and repetitive SOS calls and reward active contributors, each member may start with a relatively low number of calls they are allowed to make, and earn their right to send more through active participation over a period of time.

SERVICE MEDIATION: As we discussed the interaction flow, the need for the service to provide un-intrusive mediation of signal traffic has emerged. With one million active users a month and two SOS calls a week allowed for each user, if every member received every SOS call initiated, each would receive over ten thousand signals an hour. In such cases the service may mediate the traffic, for example, by dividing the user base into randomly-assigned subgroups and rotating the assignment. In the case of too few responses to an SOS call, on the other hand, the service may add extra massage strokes to help users perceive it as a useful relief or loan the caller some strokes that can be paid back through future contribution. Incoming massage strokes may be re-distributed over time with a small time delay, so that the SOS caller can receive a long enough massage with distinctive strokes.

A framework for developing haptic networks

As this paper has outlined, applying haptic and tangible interactions to a scalable social media and networking is a relatively young and unexplored space. Nonetheless, we find the ability to provide instant physical gratification to networked users of global scale to have strong academic and commercial potential.

Opportunity areas for haptic social networking

Screen-based social networking on PCs and mobile phones are bound to limitations of GUI. We have identified its biggest shortcomings to be: 1) task-centric approach and dependency on textual information; 2) lack of the ability to blend into a user's physical context and fit their personality; 3) poor leverage of background attention and 4) lack of synchronous interaction.

Based on this analysis, we have identified the following four opportunity areas for haptic social networking:

1. Affective communication through encoded and symbolic haptic signal rather than literal exchange: Exchange a nudge instead of typing and sending "how are you?"
2. Ability to fit and blend into user's clothing, accessories, environments, movements, and gestures: Aim for unremarkable and invisible computing as envisioned in ubiquitous computing research.
3. Ambient haptic: Leverage background attention; ever-present haptic signals as an ambient stream of information rather than discrete pieces of information. Investigate its informative and therapeutic quality.
4. Instant and physical gratification: Introducing tangible and haptic components offers the chance to have near-synchronous communication among networked users on a massive scale.

SOS: Stress OutSourced was our first foray into haptic social networks and focused on the first area—applying affective communication to a large-scale network.

Next Step: Tangible Poke

As our next step, we are directly addressing the fourth area by adding haptic modules to an existing social networking service platform. We are developing a set of wearable modules that deliver feedback when you receive a "Poke" from Facebook. Facebook Poke is a feature on the Facebook Website where you click a button to send a virtual "poke" to one of your friends, who receives it next time she logs in. While being quite simple in functionality, it is quite capable of carrying an extended exchange between individuals. Our first hardware sketch sends vibration to your wristband when your name is clicked (figure 10).

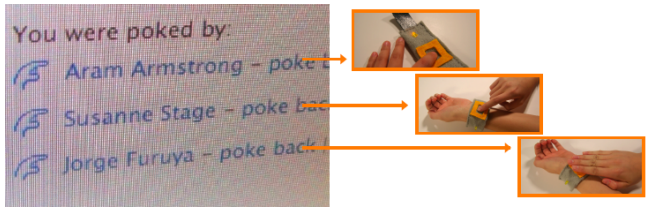

figure 10. Tangible Poke, a work in progress.

By creating wearable feedback modules that work with existing social networking platform like Facebook, we will test our assumptions about the ability to blend, and the effect of continuous and ambient haptic signals, through experiments in signal and form factor designs.

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