The Influences of the Just-in-time Social Cloud on Real World Decisions

by

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Abstract

People have intertemporal biases towards choices that result in immediate gratification versus delayed rewards. The social context can accentuate or downplay preferences towards virtues or vices when making choices in the moment. Especially in our modern world where social networks are virtually accessible at anytime, from anywhere, how our day-to-day decisions are affected by the "always-on" connection to our social networks via mobile devices is an open question. By understanding the dimensions of these social forces, we can utilize the just-in-time social cloud to nudge people towards decisions that have long term benefits for health and finances, while counterbalancing the forces of the marketers that trigger our impulses towards immediate temptations that we may regret later.

This work presents an empirical inquiry into the effect of just-in-time social influences in human decision-making. In order to understand these effects and discover their parameters, I design and deploy real-world experiments with the just-in-time social cloud using mobile phones as platforms for just-in-time social influence. The Open Transaction Network forms the basis of generating just-in-time social networks based on the transactions shared by people in the context of commerce. The Open Transaction Network is extended to several systems to conduct real-world experiments involving real choices.

By augmenting mobile commerce applications with just-in-time social networks, I design a mobile commerce environment that can socially influence our just-in-time choices. The Open Credit Card Application Framework augments existing methods of payment by using transactions as triggers to enable mobile applications that facilitate just-in-time decisions or reflections. Friends within communities show significant similarity in their hourly transaction behaviors. Varying manifestations of the just-in-time social cloud (individual friends, groups of friends and popularity information) can be used to nudge people's choices in the dimensions of taste, price and time as they decide.

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Chapter 1

Introduction

This thesis investigates the architecture of the just-in-time social cloud that enable the mobile phones to become platforms for just-in-time social influence. I denote the "social cloud" as the information architecture comprised of social relationships and common activities in the social network captured over time. The social cloud serves as a programmatic platform and makes the social activity information accessible from anywhere. Just-in-time social cloud brings filtered information from the social cloud to be used at the moment of decision making. Through an architecture that allows on-demand access to the "right" social cloud, mobile phones or any connected devices engaged in people's choices can help people make short term decisions that may benefit them in the long term (Figure 1-1).

The online universe has scaled up our inherent desires to be social by allowing people to share anything they want instantly with a large social network. Such openness have also allowed businesses to utilize this behavior and channel to promote their products. Social information is ubiquitously utilized these days in every conceivable service from collective buying, book recommendations, travel web sites, dining and fashion related applications to increase engagement. The number of people that have signed up for a service and what they have done, naturally affects our behaviors and decisions. As a result, the whole world is incorporating these elements into their services to increase user adoption. Businesses are actively utilizing social networks to influence users to sign up and market their products

Figure 1-1: Just-in-time social cloud with social network activities shared through mobile phones affecting choices in the real world. If your goal is to be frugal, then just-in-time social cloud would filter out the friend that purchased from Club Monaco.

and services. For example, social cloud is available when choosing a movie or buying a dress online. However, it is not yet clear what effects social information has on people's just-in-time decisions beyond increasing attention and encouraging user adoption. Understanding the impacts of the different forms of social cloud by connecting with the activities beyond online, we can utilize the social cloud to encourage more predictable behavioral changes.

Despite our rational and planning nature, people make automatic choices in their lives as they navigate through the physical world to reduce cognitive load. In the case of decisions made in the real world, people use different modes of economizing behavior to help more efficiently navigate by reducing energy, time, computational and cognitive resources in making decisions (Figure 1-2). Modes of economizing behaviors[104] outline 6 different modes: procedural optimizing, experimentation, imitation, following an authority, habit, and unmotivated search. Appropriate presentation of social cloud at the moment can facilitate "imitation" and "following an authority" by engaging particular social networks.

Especially, the present moment opens up to opportunities and options that increase uncertainty and affect how decisions are made due to hyperbolic discounting and pleasure principles[81]. People have intertemporal bias towards choices that result in immediate gratification versus delayed pleasure. When having to choose between a virtue with delayed utility with long term benefit, and a vice with immediate utility but long term cost, Read and Lowenstein discovered the "Immediacy Effect" where momentary value towards vices increases at decision making time, although people preferred virtues when making choices for the future[107]. Marketers utilize such human nature to influence people to increase purchases and engage in vices more easily. By creating a service for people to engage the just-in-time social cloud that can help with current decisions that will benefit them in the long term, just-in-time social cloud can give power to the individual to avert from the marketing forces that might not align with their long term goals.

In order to investigate the parameters of the just-in-time social cloud in the real world, I designed and deployed several social transaction systems. At the heart of it is the Open Transaction Network where people share their transactions with their social network and make them accessible on-demand. Through real world deployments I have learned that

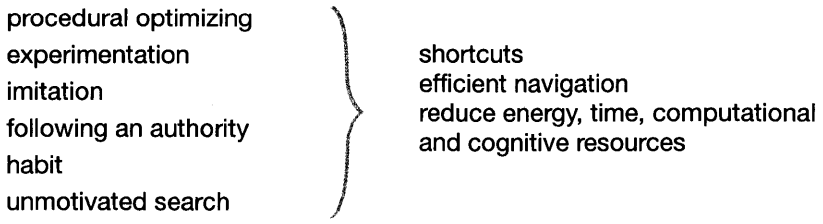

Figure 1-2: Economizing behavior leads to shortcuts and reduces cognitive load [104]

people have different tolerance in sharing their experiences. Such insights provide guidance on the limitation of the Open Transaction Network and the just-in-time social cloud that can be produced from it. Understanding the threshold in people's sharing behavior can help guide the design of the applications to increase the usability while allowing people to gain utility from such information.

The just-in-time social cloud and the Open Transaction Network architecture were validated through a series of real world deployments. These applications were evaluated through empirical experiments to understand how in-place and in-time social interventions can influence people's decisions. Real world studies helped identify the limitations of the just-in-time social cloud in real world applications. Different types of just-in-time social cloud (individual's, groups of people, and popularity) were found to affect people's behaviors differently when people make choices. These results guide the design and effective use of just-in-time social cloud based mobile applications. These applications can be used to further investigate the impacts of the just-in-time social cloud on mobile commerce and mobile health.

Mobile phones that are always on and always with us can become effective media to influence immediate decisions. In the current environment where people's choices are broadcast and changes in preferences are shared and consumed in real time, the social cloud is relaying social influences across time and space (Figure 1-3). Especially when there are uncertainty in just-in-time choices, marketers are actively trying to utilize the mobile phones to create multitudinous forces to affect decisions and behaviors. A well designed just-in-time social cloud can provide a service to the users to impede these forces and utilize the just-in-time social forces for their own benefit.

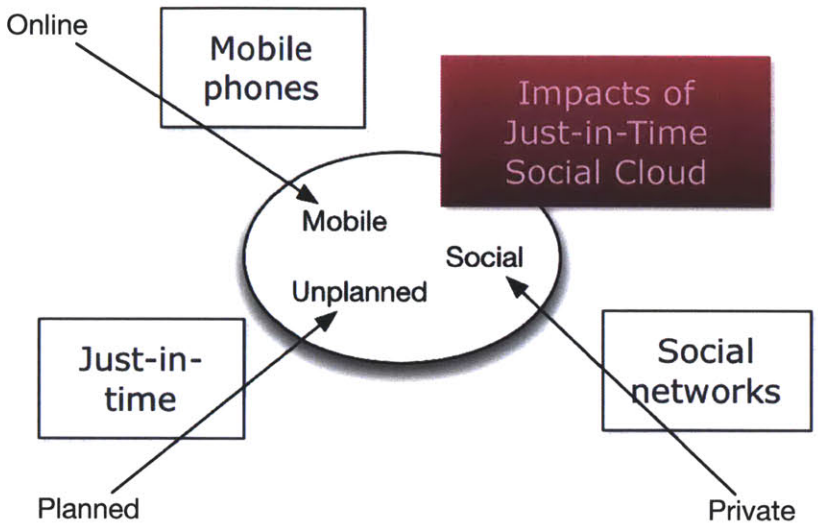

Figure 1-3: The evolution of communications that led to the increased importance of just-in-time social cloud in recent years.

This chapter outlines the theoretical frameworks and past research to help frame the thesis and the contributions. Social navigation focuses on how what others have done help people choose as they navigate through the complex world. Social influence theories form the basis of explaining how people are influenced in their real world and online choices through social comparisons with reference groups (normative influence) or informational influences of what other people have done. Widespread use of online social networks and electronic purchases in these social network sites give insights on the impacts of social networks on purchase decisions online. The thesis is motivated by these previous research to further investigate the effects of just-in-time social interventions using mobile devices. As a result, the thesis makes contributions to the persuasive interface research with particular emphasis on the use of social influence mediated through mobile phones. With the advent of the smart phones, recent focus on persuasive interface research is to build and design mobile persuasive interfaces to monitor people's behaviors and guide towards their goals at the right time. Just-in-time social cloud theory advances these past research by providing a clearer understanding of the effects of just-in-time social influences in the real world through the mobile phones.

1.1 Social Navigation

The theory of interaction history states that experiences captured through the objects and traces left by past users help guide people's interactions with the objects and navigate through the environment. The interaction history shared online could help other users and provide suggestions for future users to find great content or great online shopping deals. Early systems like Footprints[132] was designed to provide history rich navigation on the world wide web to increase the social experience in navigating the web. In recent years "the web has evolved to a social machine that allows interlinking and sharing"[58]. The proliferation of online social networks enable easy tagging and sharing of online content and digital information as they are consumed. The world's largest social network, Facebook, has over 700 million users making Facebook one of the largest social machines in the world. Due to the scale of the social network and the active participation by people in these networks, marketers are activity trying to utilize online social networks to create information cascades and viral adoption.

Goeck recently investigated social navigation to understand how community choices affect people's choices online and assess how informational and normative influences affect online giving behavior[47]. He analyzed user experiences when intervened with choices by community members. People had ego-centric discounting behaviors where they discounted other's choices in relation to their own choices. As a result, informational (objective) and community (subjective) influences affected people's decisions differently. The community data reinforced or promoted an individual's bias but was not strong enough to overcome an individual's bias. The social navigation information also created information cascades where people followed other people's choices without being informed about how knowledgeable previous people were in making their choices.

Social navigation literature also distinguishes between indirect versus direct social navigation. The use of the social cloud is an indirect social navigation. There are ongoing debates on where and when social navigation systems are useful. In my research, I dissect how different manifestations of online social networks affect people's choices and provide insights

on when the social cloud might potentially be useful in the real world settings.

1.2 Social Influences

Experiments from a hotel towel reuse program with different signages demonstrated that different appeals to participation affected people's towel reuse behavior. Among multiple signage using environmental, financial, and social appeals, the greatest influence occurred when people who occupied the same room were used as a reference group[50]. Studies on normative and informational influences have shown that these subliminal forces can change people's behaviors when utilized in the right context.

In contrast to the well-studied effects of peer pressure in our physical world, we have only a sparse understanding of the effects of virtually propagated peer influences that change and evolve in time[91]. Mobile devices present virtual peer and social influences that are different from physical social influences (Table 1.1). The effects of such social influence will become more important as many of our online activities migrate from online to the mobile. The combination of mobility and augmentation of contextual information through the mobile devices present choices in the physical world that are assisted by the online world.

Most past research on social influence have been carried out through artificially setup lab environments by using imagined situations and surveys. Mobile phones allow extending these studies a step further to carry out longitudinal studies[78] in the world and capture real world data. *The thesis addresses the limitations of past research by performing real world experiments with real people involving real choices.*

Advances in understanding the social influences online have been made through creative experiments and data collected through the web applications. Salganik et al.[115] investigated the role of social influence in online artificial cultural markets. They were able to create an artificial music download site to experiment music selection by real people. They separated the world into 9 different worlds with 1 world being in the independent condi-

Table 1.1: Difference between physical and virtual social influences

	Physical	**Virtual**
Strength	Strong	Weaker
Scale	Only through co-present people	Anyone over the Internet/Mobile
Scope	Limited by the physical space	Limited by the presentation medium
Time	Only influences at the moment	Transfers over time and space
Reciprocity	Two ways (simultaneously)	Delayed or one way

tion. The other 8 worlds were socially influenced worlds that were independent from each other. These socially influenced worlds showed the number of downloads by other users, next to the songs. The socially influenced worlds showed consistently higher *inequality*, popular songs were more popular and unpopular songs were less popular. In addition the social influence created higher *unpredictability* in quality music becoming successful. Inequality was measured by the average difference in market share between all pair of songs and unpredictability was measured by the Gini coefficient.

Research done online had shown that influences can transfer over time and space. *I extend the work done online to understand in a more granular scale how friends and groups of friends influence choices beyond just popularity.* In addition, online versus physical world represent different constraints which allow mobile platforms to be important in extending the previous work from the the online world. When people are in the physical world, the decision usually has to be made in-place or else there is an additional cost to coming back to the particular location to make the decision.

1.3 Purchase Decisions

Research on impulsive purchases show that the presence of peers increase the urge to purchase[90], while the presence of family members decrease the urge to purchase[87]. Two factors affect our purchasing behavior: *susceptibility to influence* and *group cohesiveness.*

Susceptibility to influence is a measure of an individual's willingness to accept information from other people about purchase decisions[9]. Group cohesiveness measures how strongly members of the group are attracted to the group[28]. These two factors can be observed through the mobile phone if we can capture people's choices from the phone.

Susceptibility to interpersonal influence is manifested through normative and informational influences. Normative influence occurs when a person makes a decision to conform to a peer group. People buy more drinks when in a bar with friends who may pressure one to drink more. Informational influence occurs when one can observe the behavior of other people or through indirect sharing of experiences[9]. When extended to online world, the informational influences lead to information cascades as adoption spreads quicker and further, while peer group influences tend to be more restricted due to the limited size of the peer groups[47].

Groups may create conformity, but also create diversity. When people were seated together at a table and were choosing their dishes sequentially, the order in which the dishes were selected created social influence that made people choose something different from preceding dish choices made by others on the table. Such ordering behavior created larger variety in dish choices[4]. In order to perform this research, the researchers manually collected all the order receipts and used them for data analysis. The Open Transaction Network approach allows such data to be collected and made available in real time using the mobile phone to understand people's ordering behaviors.

Yahoo researchers obtained data from a large retailer and matched e-mail and IM messaging activity to identify the social network that exists among the consumers. Using this data they were able to measure the impacts of social networks on purchase behaviors. The results showed that the purchase behavior of the social network was a stronger predictor of the amount of purchase people made than the demographics that they belonged to[48]. Their results show that people purchase more when they have friends that are shopaholics. My study extends this to make observations at the point of decision making. My results show that group of virtual friends can also make people spend less through social influence.

Analysis of 208 users of Cyworld, the most popular social networking site in Korea, showed

that there are three different groups of users with very different purchase behaviors[68]. Users were categorized into different statuses based on their degree of connectivity. The low status group of about 48% were not affected by the social influence because they were not well connected and showed limited interaction with others in the social network. The middle status group of about 40% were moderately connected and were influenced to generate 5% higher revenue. Finally the 12% of the high status group who were very active on the site were negatively impacted by their friends' purchases to maintain their unique status. Through the use of mobile phones, I extend these studies by engaging and measuring different types of social influences (peers, peers anonymous and popularity) in the real world at the point of decision making.

1.4 Mobile Phones as Persuasive Interfaces

Decades of research has been done to understand how people make decisions in varying social contexts. Lab experiments and field studies by social scientists have shown how social influence causes people to make irrational decisions and how such forces can be identified, managed and utilized for the benefit of achieving certain goals of persuasion[19]. However, with the wide adoption of smart phones, *social interactions we now engage in has become a mix of virtual and physical interactions.* Frequently we see people communicating with remote friends through the phone while meeting with a group of friends or coworkers at the moment. As people in the US are spending over 20 billion hours a year on Facebook both online and mobile, it is unprecedented how such networks might impact people's choices in the real world. We attempt to further understand the interaction of virtual social networks in the physical world by investigating the impacts of social information in particular decision making scenarios that are constrained by space and time. In such situations, people are prone to deal with uncertainty by following other people's choices. We are extending these bodies of research by investigating the effects of mobile mediated influences as mobile phones prevail in our lives.

Recent research with mobile phones have allowed us to capture in detail and understand our

communication patterns, mobility patterns and to deduce how people behave in aggregate in the real world. Researchers have been using mobile probes[65] to capture and understand people's shopping behaviors. Bluetooth scanning and location based information from mobile phones have been used to capture people's social relationships, patterns of activity and their habits in the real world[33]. AT&T study showed that people in New York City travel larger distances compared to people in LA[67]. In contrast, Barabasi's work showed how people in a city in Europe regularly do not leave the 3 mile radius during their daily lives. The communication patterns based on frequency of incoming and outgoing calls allow the tie strengths of customers to be identified[99]. Instead of focusing on mobility patterns and tie strengths, I capture the choices people make through the mobile phones and inject social information to understand how just-in-time choices are affected when certain social signals from the social network are available at the moment of decision making.

Fogg iterates how mobile phones can be used for opportune interventions to improve individual and social behaviors. People are so wedded to these devices that many people spend more time with their mobile devices than any other human being[40]. The nature of mobile phones being always available and responsive, allow mobile phones to be a continual channel of influence. Experiments performed with the mobile applications to encourage better eating habits, recycling behaviors and healthier life styles have shown positive outcomes in encouraging behavioral changes[125]. They also document that connecting with people who are enacting on similar behavioral changes strengthen the effectiveness of the application due to power of social comparison. I extend the investigation of these mobile social influences and utilize the discovered parameters and properties of just-in-time social cloud to design decision aids that guide our short term choices with the purpose of benefiting us in the long term.

1.5 Thesis Statement

Mobile devices have become platforms for social influence. By utilizing the context and goals of individuals, just-in-time social cloud can help users make better choices when faced

with the immediacy effect bias. Understanding the design dimensions and the proper use of just-in-time social cloud are critical to aid in long term behavior modification. I achieve this by designing and realizing an architecture to collect the transactions of people over time and use the collected data to provide a programmatic platform to push and pull appropriate social networks on demand. Transactions serve as proxy to people's decisions and can entail any exchanges or activities beyond just financial transactions. Through an open platform like the Open Transaction Network, consumers can identify better choices for them and merchants can better find appropriate customers. Such collective contribution to the Open Transaction Network can not only be used to help thwart the influences of the marketers but also help businesses collaborate on providing goods and services to benefit long term goals of the customers.

The goals of the people need to be specified to produce the necessary just-in-time social cloud. Attributes of the shared transactions can be filtered by the rules generated from the user's goals to create appropriate just-in-time social clouds for specific purposes. The following examples illustrate how goals can be specified. If a person is trying to save money, the just-in-time social cloud would filter people who have certain spending cap or those who have frugal spending behavior based on their transaction history and goals that they have specified in the past. If a person's goal is to eat healthier, the just-in-time social cloud would filter those people who buy healthier food and those people who have been successfully following healthier eating habits.

People's habitual and impulsive behaviors can be taken into account when determining best *time* and *decision points* to intervene. People have habitual behaviors toward the stores that they visit regularly. The interval between visits to common locations on MIT campus resulted in exponential distribution with 80% of inter-visit intervals within a week. A diversity index can be calculated based on the locations visited to characterize the strength of one's habitual behaviors. This diversity index can also be used as a measure of susceptibility to influence when applying interventions at decision points. People with higher diversity would be more willing to accept recommendations. Time series transaction data from a community can provide distribution of a community's habitual and impulsive behaviors.

Different forms of the just-in-time social cloud (individual, group and popularity modes) need to be used depending on the type of the decision and the purpose of the intervention. The normative group information has the strongest influence when price is concerned. The individual friends encourage reflection and increase time to decision. Popularity information serve as short cuts and reduce the time to making choices. The second degree social network serve as potentially stronger recommendation pool for new experiences due to their experiences being more diverse than the current circle of friends.

1.6 Contributions

How people are impacted by mobile phones have been explored through various research methods. Previously there has been research done on how people coordinate and communicate, how people use different applications on the phone and how applications could be used to capture people's mobility and social behaviors. As people are using the mobile phones to help make day to day decisions, the phone is becoming a decision aid platform. This thesis particularly makes contributions by presenting the architecture and the usage of just-in-time social cloud and empirically investigating how just-in-time social cloud influences people's decisions in the real world.

The field continually is in need of field experiments due to the disparity between people's behaviors in the lab or online versus their behaviors in the physical world. When real cost or risk is imposed, people behave differently. I have designed several mobile applications that could be deployed in the real world to capture real choices people make.

The sharing behavior of purchases have been less well understood due to most people being reserved about digitally sharing purchases. People have been sharing photos, their personal stories and communicating in real-time through interactive social applications. Purchase data are not only important because of its commercial value, but also because they embed explicit choices and implicit values of those choices that people have made. I investigate the design elements that allow people to share their transactions and make them beneficial to their decisions. By making the transactions more social and more open, social augmentation

can make the transaction experience more informative and beneficial towards our long term goals.

By developing and deploying social transactions, the design of Open Credit Card Application Framework was developed to create applications that can augment the current transaction experience with mobile phones. The end result is the creation of an open framework that integrates the transactions with the social system for empowering the users with decision aids that benefit their long term goals, rather than just designing mobile commerce systems that primarily focus on security and speed of processing transactions.

The thesis explores the micro-level effects of the social cloud and how different forms of social cloud affect people's decisions. The micro-level effects suggest guidelines on when to utilize certain types of social cloud. When trying to increase engagement, social cloud with individual information is more effective. When trying to affect choices regarding price, social cloud showing decisions by groups of peers is most effective. When trying to reduce the time for decisions and create shortcuts, the social cloud with popularity information is the most effective.

People's susceptibility to influence is usually dependent on the relationship with others. However, with respect to recommendations, the diversity index could be used to assess a person's susceptibility to new suggestions. Their transaction data can serve as a means to provide diversity index and provide a means to assess how much people are willing to try something new or different.

By understanding the impacts of the just-in-time social cloud, the thesis presents an architecture for on demand social cloud that can be utilized for helping people with their goals or decisions. Different scale of just-in-time social cloud can be used for amplifying or attenuating social influences during various decision making scenarios in the real world.

1.7 Thesis Organization

The following chapters are organized as follows. Chapter 2 reviews previous research and develops the problem and the challenges in understanding just-in-time social influences. Recent use of mobile platforms to understand people's mobile social behaviors are reviewed. Such use of mobile phones allow us to extend existing social influence and the social network research in offline and online choices. Just-in-time social networks and architecture of the social cloud is detailed in Chapter 3 and how it can be applied to various decision scenarios. Chapter 4 investigates how just-in-time social cloud can be deployed in a real world system in the domain of mobile commerce. Chapter 5 discusses how the social cloud based on people's transactions can be generalized to interest based networks that can be implemented in infrastructure and infrastructure-free manner. Chapter 6 details the social transactions environment that describes the approach, the experimental methods, the system architecture, and the applications I use to understand people's choices in the real world. An instance of just-in-time social cloud, the SocialMenu, helps us understand the impacts of just-in-time social cloud on in-time and in-place choices. Chapter 7 details the findings and analysis of the collected data. I also summarize the insights I gain in people's user experience with social transaction systems. I conclude in Chapter 8 summarizing and reflecting on the thesis and outlining the future research directions inspired by just-in-time social cloud.

Chapter 2

Born Connected: Mobile Phones and Social Networks

> "Let us say that in the ultimate, whenever a baby is born anywhere in the world, he is given at birth a *number* which will be his telephone *number* for life. As soon as he can talk, he is given a watchlike device with 10 little buttons on one side and a screen on the other. Thus equipped, at any time when he wishes to talk with anyone in the world, he will pull out the device and punch on the keys the *number* of his *friend*. Then turning the device over, he will hear the voice of his *friend* and see his face on the screen, in color and in three dimensions. If he does not see and hear him he will know that the *friend* is dead." [1954, Harold Osborne, Chief of Engineering AT&T]

The communication network and the social network have been intertwined from the early days as people started communicating over distances. Social norms evolved with the wide spread use of telephony. Before the telephony, people had to send invitation cards for special dinners or events. The society went through a transition where these formal invitation cards could be replaced with telephone calls. Phone calls were much less of an intrusion than the unannounced visits that it replaced, it was indulged in much frequently and undertaken more lightly[26]. The dating scene also changed with the introduction of telephones as

distant couples could communicate more lively and frequently. On the negative side, the long distance calls resulted in economic troubles for the guy who usually had to pay the phone bills[37].

In the last decade, there has been an unprecedented growth of mobile phone adoption in the world that surpassed the global adoption of the Internet. The growth has been especially more explosive in the developing countries. Similarly mobile phones have dramatically changed how people arrange meetings with other people and adjust plans on the go. People are able to make plan changes on demand as they can communicate with each other at any time. The mobile Internet enables people to search for location based information as they approach their destination. Navigation through the world is more fluidly guided by the mobile phones and less by preset schedules. Phones also empower adolescents to be connected 24 hours with their friends through text messaging and social networking applications. Such behavioral changes introduce opportunities for people to be influenced, helped and guided just-in-time.

This chapter outlines previous research on mobile phones as platforms and modern research in social networks and social influences. My contribution is in creating an architecture for the just-in-time social cloud to support real world decisions and extending past work to understand the influences of just-in-time social networks through mobile phones.

2.1 Mobile Phones as Platforms

This chapter illustrates the different mobile platforms and how the evolution affected people's behaviors. Mobile phones have evolved from communication platform to computational platform and most recently to sensing platform as insurmountable data can be collected and retrieved in real time through them. The next evolution is naturally a decision influence platform as people access information at the time and the location of decision making. My thesis makes contributions in the decision influence platform and particularly investigates the mobile phone as a *social influence platform.*

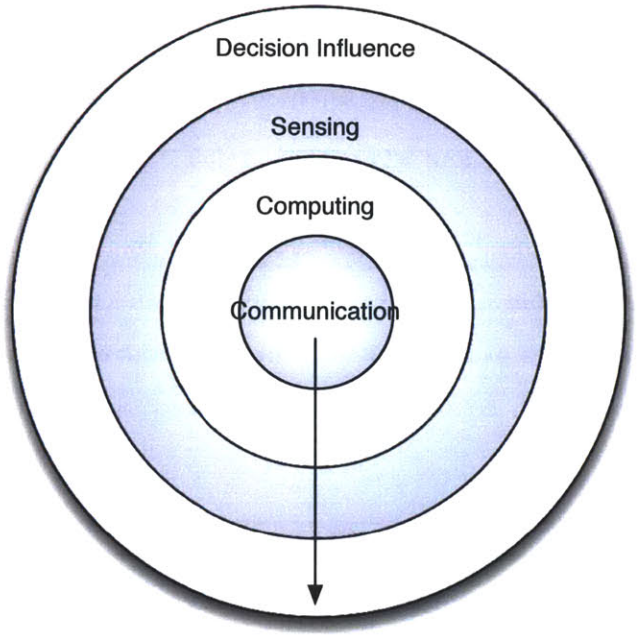

Figure 2-1: The evolution of mobile phone as platform.

2.1.1 Communication Platform

The phones have served as a communication platform since the creation of the telephone network. The focus was on transporting data in real-time and asynchronously (messages). The advent of mobile phones have allowed on the go communication and hyper-coordination through both voice and text messages. The phone being with you everywhere has allowed people to keep track of their contacts and communicate their availability status for more effective coordination, collaboration and opportunistic communications. Most recently existing online communication such as chatting and e-mail are migrating to phones, creating more opportunities to reach people at anytime and from anywhere, but also creating more opportunities for interruption.

Behavioral changes to mitigate interruptions were not for any particular goal but it was a side effect of being always reachable. Extensive research has been done on managing interruptions from instant messaging and e-mail[23]. Traditionally, when work was focused

on the stationary desktop, connectivity meant interruption and required technical ways to manage these interruptions[5]. As people go mobile, these interruptions cannot easily be managed due to the lack of situated context[101]. Always-on reachability also lead people to lie about their current status and where they are[55].

The greatest change in communication behaviors enabled by mobile phones is the increased opportunistic communications. The effects of opportunistic communication has been documented in different aspects of previous work in collaborative environments[30][130][110], mobile worker scenarios[103], communicating in leisure [21], mobile coordination[84] and opportunistic mobile commerce[71].

The opportunistic communications in collaborative environments emphasize the need for shared awareness of participants. In the mobile worker scenarios, four key design factors are highlighted: role of planning, working in "dead time", accessing remote technological and informational resources, and monitoring the activities of remote colleagues. The leisure environment studies focused on mobile interactions of groups using devices to chat, coordinate communications and plan activities. Hyper-coordination and communication patterns show results from ethnographic studies on how people can coordinate meeting times and utilize public transportation in dynamic ways in urban environment using mobile phones[84]. Opportunistic commerce[71] presents mechanisms, architecture and applications that match buyers and sellers that take into account of the personal inconvenience costs to mobile buyers by incorporating divergence from primary path to destination.

2.1.2 Computing Platform

ABI Research reported on April 2011 that 44 billion applications will be downloaded by 2016. As GHz processors and 3G/WiFi modules are embedded in the mobile phones, existing desktop services are migrating to the mobile phone and evolving the mobile phone into a computing platform. This led to the phones becoming personal assistants that can help people not only communicate but also manage their daily lives. Easy development and distribution environment for applications fueled the growth of applications on the smart

phone. Games on the phones became extremely popular globally as they allow people to do something during their dead times while waiting for an event or transitioning between places. As the mobile phones are becoming computationally more capable, applications and app stores are fueling the migration of existing web services.

The applications and the Internet have allowed people to tailor their phones and engage in multitudes of activities beyond just communication. As applications became more sophisticated with the computational capabilities of the smart phones, it also naturally made the phone a prime platform to consume media and to a smaller degree to capture media. Most recently, with the real time connectivity and the computational capabilities provided by the phone and the wide adoption of social network services, the phone has become the most active social media platform. Pictures and experiences are shared through the social network services in real time.

People on Android phone spend 42 minutes a day on average on third party applications. Recent research on people's application usage on smart phones have shown few applications taking most of user attention while providing understanding of people's diurnal patterns in smart phone usage behavior[35]. The application usage behavior can be described as exponential distribution for different applications for each user. Each user has a different distribution parameter and adapting to their usage can enhance battery consumption on the phones. There has also been increased understanding of the network usage by different applications[62]. The different applications people access is correlated with their mobility behaviors. E-mails are accessed when people are more mobile and music accessed when they are more stationary[126].

Location based and contextual information access have become the greatest convenience for people as the phones became location aware and Internet enabled, allowing people to quickly access what is important or needed in-place at that moment. Locations are tagged from the phone and shared with people to provide awareness on where people are visiting. [15] describes how text, audio, picture, video (different types of media) messages can be stored in a location and delivered to other mobile devices that pass by. It also supports location dependent queries (LDQ) by associating content with a bounding box. The resident

domain calculation on the mobile and the bounding box of pages allow updating and the delivery of geographical data to preserve energy consumption of the mobile device.

The different applications on your finger tips allow users to access information and entertainment on demand. The different applications provide the user with the information that is needed to make just-in-time decisions. However, how these decisions are affected by the just-in-time information from the applications are less well explored and my research makes contribution in understanding how social information affects these decisions.

2.1.3 Sensor Network Platform

Sensors on the device and the ubiquitous communication network makes the mobile phones a global sensor network platform that help researchers understand people's behaviors in scales that have not been possible before the availability of smart phones. Smart phones give researchers the ability to collect data on networks of people and provide new insights to people's mobility behaviors, social ties and application usage behaviors. Availability of such rich data has also raised a lot of privacy concerns due to the phone having many detailed records about one's life.

Availability of data from mobile phones allow researchers to understand our communication patterns, mobility patterns and aggregate behaviors of people in the real world. Bluetooth scanning and location based information from mobile phones have been used to capture people's social relationships in the real world, patterns of activity and their habits[33]. AT&T study has investigated how much people travel/commute over time in NYC and LA areas by using consumer's mobile phone data (excluding business phones). They showed that people in New York City vicinity travel larger distances compared to people in LA although on the average LA people travel farther during commute days[67]. In contrast, Barabasi's work showed how people in a city in Europe regularly do not leave the 3 mile radius during their daily lives. Their communication patterns based on frequency of incoming and outgoing calls also allow the tie strengths of the customers to be identified[99]. They also discovered that strong and weak ties are not effective in diffusing information and medium ties are

needed for widespread diffusion of information.

[43] presents aggregation and dispersion based analysis of crowds by clustering tweets of people using k-mean clustering based on the location. By analyzing their locations in time, they show people's movements in and out of those clusters. By using longitudinal data one can see how much population moves from one cluster to another each time step. By comparing past and present cluster sizes, dispersion and aggregation of population can be measured.

Recent literature on participatory sensing[46] and in-situ sensing through the mobile devices[42] demonstrate how users can contribute content and data from mobile devices to allow other users and services to understand the environment and user's behavioral patterns. [46] describes how people's mobile phones can be used to track tourist traffic and their activities in different areas in Rome. Such data allow the city to know which areas are popular on what days of the week and what months of the year. Also phone data from travelers can show where people from different nationalities visit so that local merchants can plan and manage their inventory and their offerings to tailor to certain nationalities.

Understanding people's intention to purchase is a very active area of research. Mobile probes to capture and understand people's shopping behaviors[65]. Systems that can measure excitation levels during shopping using EKG can further advance research in actual product purchase transactions and detecting arousal levels at the moment of consumption[69]. They allow marketers to also get real-time feedback on whether users like certain product or not. In my work, I capture the choices people make through the mobile phones and inject social information to understand how just-in-time choices are affected when certain social signals are published from the social cloud.

2.1.4 Decision Influence Platform

Most recently mobile phones are evolving to become persuasive platforms. Mobile technology can layer information into our moment by moment lives in a way that can affect and change our behaviors[40]. Mobile phones allow one to manually log data, automatically

gather information, provide feedback, and access information on demand to consciously and unconsciously make choices in the real world.

Commercial companies are trying to capture people's attention from mobile phones and influence people in real time to increase awareness, communicate with customers and lead them to making purchases. Though people may not want this, it is becoming more and more possible to do so. Therefore, being able to filter such information based on people's needs become very important. Additionally, these advertisements will be presented with social information and understanding how such social mediation would affect their choices at that moment in time will become an important area of research.

In this thesis, my focus is particularly on understanding, capturing, and measuring the effects of the social cloud that is mediated through the mobile phones. The just-in-time social cloud allows people to get real time feedback based on other people's past experiences and the decisions they are making. These virtual social influences have different properties in dimensions of time, scale and presentation that require extending existing social influence theories.

2.1.5 Social Influence Platform

As people are more connected, real-time information is constantly generated by the social connections we have. Until the advent of the Internet, explicit connections such as calling over the phone or physical visits in close physical proximity were required for people to influence each other. However, the recent proliferation of social networking and mobile communications (Twitter on the mobile, status changes on Facebook) show that people are willing to publish openly and consume continuously in real time. With the mobile Internet, this is only amplified due to its hyper-connected nature. This "always on" behavior allows people to ask questions and get answers from others in brief time intervals, to coordinate on the fly and to influence each other in collective decision making.

There is little doubt that peers influence our decisions and actions in the real world[51]. More importantly, they can be powerful tools for decision making and behavioral change. It

is a truism that friend influences a child's language patterns more than the style of speech at home[120]. Similarly, there's a strong evidence that people smoke when they see someone else doing it, they often take it up when their friends do[128][112] and give up as they age and become aware of friends whose health is affected[11]. We also have some evidence that the best way to lose weight or exercise is to build a group of like-minded friends and do it with them. The mobile phone allows them to easily log their activities and share them at any time with these friends[125][96]. The influence can be subtle, indirect, and occasionally deliberate.

Traditionally, mobile phones have been mostly used to communicate. Accessing social networks was to be aware and converse with people at any time. However, mobile phones have also created constant interruptions in our attention span. We get constant interruptions from our social network and interruptions from instant messaging during our work environments. Interruptions are usually not a desired feature, but they can become beneficial interventions. People with certain problems can utilize their friends, family and trusted people to interrupt them if they engage in particular activities. People with particular goals can inform and communicate with their friends to control their behaviors and update on their successes.

The thesis argues that mobile phones are becoming platforms of social influence enabled by the following elements:

1. Sharing transactions provide a means to easily access experiences of others
2. Real time availability of social transactions creates just-in-time social influences
3. Mobile decision points enable scalability of social influences across time and space

This leads to a framework to rethink the design of communication systems from transmitting bits to transmitting relational forces. This framework fosters design of mobile communication systems that can serve as social influence platforms. Every entity participating would contribute their choices so that this information can be aggregated at different levels: first

degree, second degree, anonymous group of friends, and anonymous popularity. The transactions or interests would serve as a means of filtering the appropriate social network. The availability of different social networks and the way we connect to them at different scales at anytime, from anywhere create opportunities to trigger social influences. The goal is to utilize them to help with individual's choices and provide social support to confront persuasions by marketers that can derail from one's long term goals.

The architecture requires a social cloud that can be morphed to different forms and accessible on demand. The different forms are generated by organizing the social network by activity, by friendship, and by different degrees of relationships. The social cloud will use the goals of the user to create rules to filter the social network by relevant events and activities. The thesis addresses the methods of generating the social cloud, the system architecture for supporting the social cloud, the API's, the applications and the influences of just-in-time social cloud on people's choices.

As applications are built with social features to increase adoption, designers will think of designing mobile applications with the potential to influence people towards certain goals or aid in behavior modifications. By making the application a decision point and embedding social information in a just-in-time manner, the thesis argues that just-in-time social cloud can impact people's decisions in a beneficial way.

2.2 Social Behaviors

Human beings are born with connections (family) and new connections are made and dissolved every day as we live in this world (school, neighbors, work, hobbies, strangers). However, as communication networks and the interfaces (computers and mobile phones) have evolved, the way we establish and maintain these relationships are changing. The time and the scale of our engagement with these connections are also dramatically changing. People are able to update what their friends are doing without explicitly asking or connecting with them at any time they want.

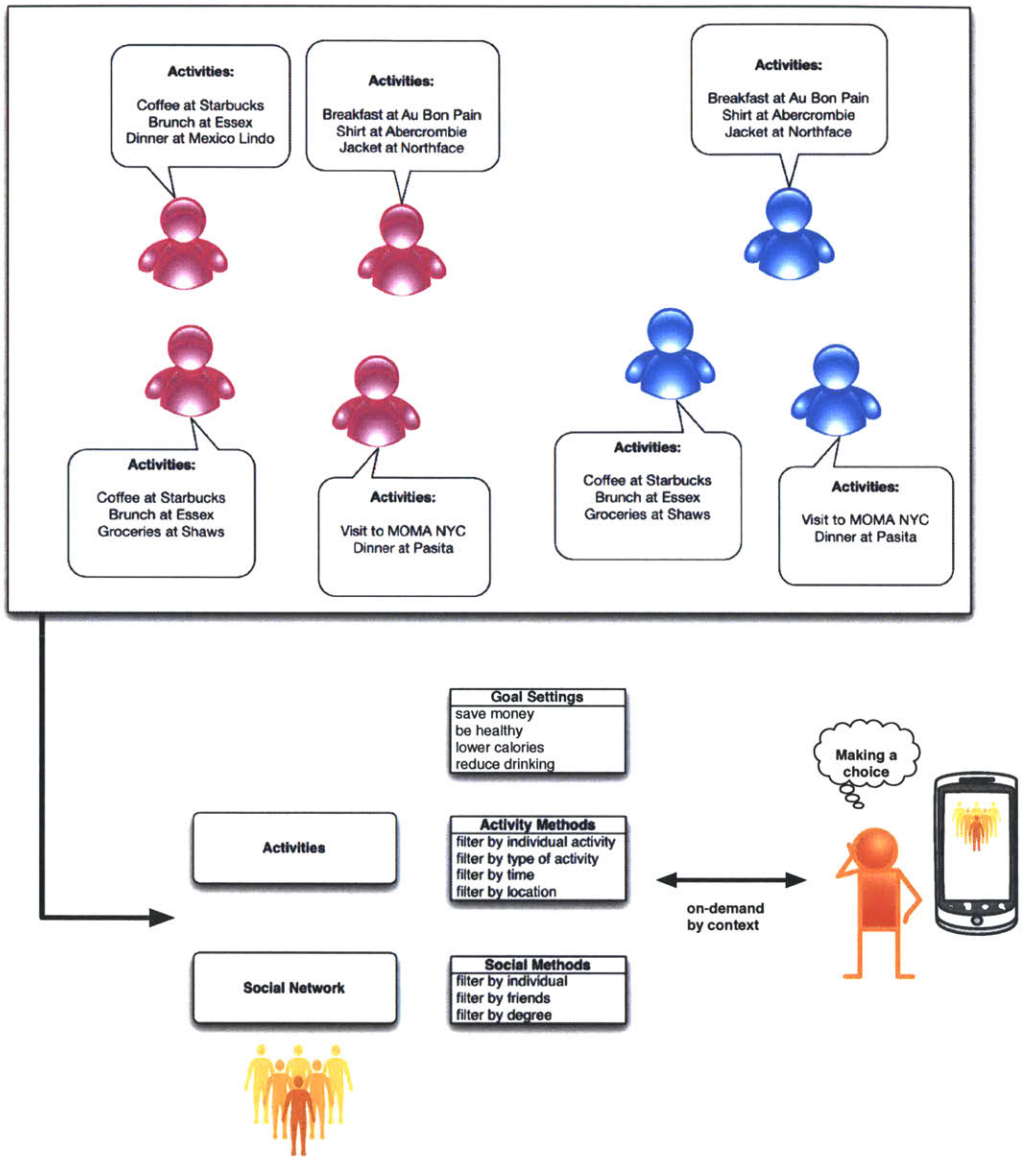

Figure 2-2: The social cloud: Captured activities (transactions) and social network information provides on-demand social cloud for people at their point of decision.

The social connection theory says that people have inherent desires to seek out and make connections through common attributes, similar knowledge and experiences. Brain researchers have theorized and shown that our brain maintains those social connections at different scales based on the intimacy levels[32]. Although these social networks have scaled through the Internet, our brains have not scaled to make use of the larger scale social networks. In the following sections I summarize past work on social influence and how the Internet has changed the scale of social influences.

2.2.1 Social Influences

The question of social influence has been explored for many years in the field of psychology, social psychology, communication theories, mass media and consumer behavior. Influenced by society, media, groups, friends, and experiences, our decisions are affected in irrational manners. For example, widely informing the public with news on suicidal events leads others to attempt suicide[19]. Trying to reduce garbage on the streets by informing people that a lot of people are littering and making the streets unpleasant can increase littering on the streets by justifying that it is a common activity[19].

Recent advances in behavioral economics show that we are very prone to irrational decisions. Although people attempt to behave rationally, many times people are poor at recognizing why they behave as they do[3]. Peer influence is many times gone unnoticed and underutilized. Especially when there is uncertainty, the peer influence can be more powerful[51]. Social norms subliminally influence the behavior of human beings in social contexts. It is especially intriguing how social influence affects our decision making without people really realizing it.

Researchers have theorized that Facebook friends do not matter because they are not "real" friends in the physical world and have little influence on our decisions. However, this is also due to people not having the tools to to understand and utilize them in their decisions. The online social networks have been able to capture a tremendous amount of user attention. People spend 20 billion hours a year on sites like Facebook. The influence of social networks

have been interesting due to its impacts on health (diseases) and marketing of products (product adoption)[17]. For example, when information about what friends have purchased is made available to you, you are influenced to take another look into what your friends have ordered.

Current communication technologies have made these connections easier to establish and more scalable. The Internet enabled smart phones have made these connections available, at anytime and from anywhere, but also made them accessible just-in-time in the context of decision making. This thesis explores the impacts of this social cloud as the social cloud is accessed at the point of decision making through the mobile phones people carry. The mobile phone serves as a host that presents the social cloud to push us from and pull us towards particular choices. When these forces become too strong, it can either isolate oneself or pull to go after someone or follow incessantly. However if we can utilize the social cloud, we can use them for our benefit to confront forces that attempt to make us comply to the desires that do not benefit us in the long term.

Human beings develop shortcuts to navigate through the complex world[93]. With the technological advances in the last decade, human beings are generating over 200 exabytes of information in a year; an order of magnitude no single human being can ever process in their life time. Especially as information and knowledge is created on a greater scale than any human being can consume, we are unconsciously developing shortcuts in our decision making to identify "single, usually reliable feature of the situation" to make conclusions about the complex world. Such behavior introduces problems when exploited by "certain compliance practitioners, who seek to profit from the mindless and mechanical nature of shortcut responding" [20].

Knowing that certain actions have been taken by several thousands or millions will lead us to do the same thing when there is no time to analyze the details of the information. Especially when there is uncertainty, people seek such signs to guide their behavior. We are naturally influenced by what others tell us and by what other people do because social proof is a way to establish shortcut behaviors that save energy and time. We view a behavior as correct in a given situation to the degree that we see others who are similar performing

it[86]. These influences are especially more powerful because they go unnoticed. As choices and alternatives expand, it may increase more uncertainty and cause these influences to become more effective.

Several studies on elections have found that after controlling for relevant factors, a candidate is rated more favorably when respondents are aware of more favorable poll results[61]. Early reporting of election results is undesirable because later voters may be influenced, either in their choice of candidate or their decisions of whether to vote. Low precision decision makers usually imitate high precision decision makers and this leads to people following the crowd. Such behaviors used to be localized, but due to ubiquitous communications networks, local conformity is quickly breaking down.

2.2.2 Consumer Social Behavior

Economist Kenneth Galbraith argued in 1958, Affluent Society, that many consumer demands arise not from innate needs but from social pressures[17]. [76] states that purchasing decisions are often strongly influenced by people who the consumer knows and trusts. Online shoppers wait for opinions from early adopters to reduce risk of buying a new product. Browsing, searching and buying a product on e-commerce websites are often a time consuming and frustrating task for consumers. There is an increase in traffic from social network sites to online retailers showing that highly influential customers directly affect other consumers' decision making. The article concludes that we are transitioning from transaction based society to a relationship based society.

Research on impulsive purchases show that presence of peers increases the urge to purchase[90], while the presence of family members decreases the urge to purchase[87]. According to Stem, impulse buying is a novelty or escape purchase that breaks the normal buying pattern in contrast to planned purchasing. When impulse buying is done to excess amounts it is considered compulsive shopping[29]. Some categories are more impulsive buys due to "symbolic consumption" for constructing, maintaining, and expressing self identity. The self discrepancy theory explains impulsive purchases as behavior for self-completion strategy. They

hypothesize that an individual who experiences a discrepancy between his or her ideal and actual selves, and who is disposed to use symbolic consumption as a self-completion strategy, will be motivated to acquire goods which are expected to perform this self-completing role[29].

[60] shows how social relationships and word of mouth advocacy with influencers allowed new telecommunication service to be diffused. It also indicates that there are future research opportunities in data collection based on the social network and the geographical proximity. Most data available is through surveys or online retail information which does not embed the social network information nor the purchases made from the real world at physical merchant locations. They also introduce the concept of *network neighbors* that are customers that could have potentially communicated with current customers. Their result shows that these people have 3-5 times more likelihood of adopting the service.

2.2.3 Virtual Social Influences Online

As it was summarized in Chapter 1, regarding online music market and Korean social networking site, online social networks create influences that affect the outcomes of the success of the products. The unpredictability and inequality are more clearly illustrated in Figure 2-3. Businesses like Groupon and LivingSocial that create collective buying opportunities have exploited these effects to encourage people to participate. Advertisers will also attempt to take advantage of such social influences by letting people know how many people are like you, or how many people in your local area have bought a specific product. It can be informational to the consumers, but also can be powerful in pulling the consumer to make unwanted choices.

Bakshy, Karrer, Adamic investigated SecondLife asset sharing data to understand how the user created adoption quickens as the number of friends adopted increases. This effect varied with the connectivity of a particular user[6]. In SecondLife, assets can be copied, transferred and shared (passed onto others). Sharing among friends occurs more rapidly than sharing among strangers. Content that diffuses through social influence tends to have

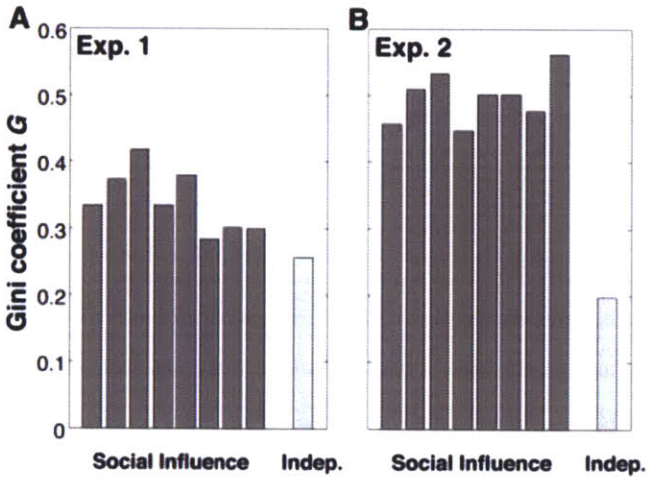

Figure 2-3: Effects of social influence on inequality of outcome [115]

limited audience. Some individuals play a more active role in diffusing content than others, but they are different from early adopters. Rate of adoption is related to the popularity of the asset in the population overall. However, once a friend has adopted, the adoption rate increases significantly. 48% of transfers occurred between friends. 38% of transfer that did not occur between friends occurred after at least one of their friends had also adopted.

Leskovec et al. have studied the effectiveness of person-to-person word-of-mouth advertising for thousands of products from a large retailer. They report that viral marketing is more effective for niche products as opposed to widely popular ones[83]. By effective they mean that the recommendation leads to higher likelihood of purchasing. They observe that the additional recommendations by friends increase the effectiveness of advertising until it reaches a saturation point. Similarly, more frequent recommendations between two pairs of individuals make future recommendations become less effective over time. Recommendations start to wear out between two people after 10 DVD recommendations and 20 book recommendations. Timing between purchase and recommendations show that 35$\sim$40% of people make purchases within a day of the first recommendation. Price also played a strong role on the effectiveness of recommendations. More expensive and more recommended products among densely connected communities had a higher success rate in leading to purchases by people receiving recommendations.

2.2.4 Social Charge

We know that people purchase based on other people's support. Community gravity shows that information about customer experiences flows through social relations[92]. Trust is established when users share their experiences with their friends and colleagues and when a person's rating matches with another user's rating. The rating of a user is then influenced by the trusted users. On @cosme web site, this behavior was investigated by allowing users to register/bookmark other users that can be trusted. When the users write product reviews, the site tracks the rating and trust relationships. Particular products that were dealt on this site are cosmetic goods where other users' opinions are particularly useful for decision making. They call this the community gravity effect. They have a constant for assessing trust μ and a constant λ to indicate how one's rating is affected by others. They assess the influence by calculating the community gravity measure. The brand value can be assessed through the community gravity. A high community gravity value implies the power of the brand to produce strong user communities.

In the simplest model, social influence could be envisioned as a gravitational force that pulls people towards others and makes the attractive forces change one's behavior. This suggested that the influence could act like gravity. However, recent studies have also shown that there are repulsive forces depending on one's state of susceptibility and the affinity relationship with others. Social relationships and networks are formed and dissolved due to attractive and repulsive forces that occur due to the individual affinities. This suggests that electro magnetic forces with positive and negative charges that can pull and push is a better model of social influence. The social cloud needs to contain these social charge parameters in order for it to filter certain social networks based on the desired goal of attracting or repelling a user from a particular behavior or decision.

In the case of shopping, people can be pulled to buy or can also be pushed to not buying if others have already bought it. This derives from the structural balance theory where they classify positive and negative links between two nodes in a network. These positive and negative links represent the existence of social charges. The existence of individual's susceptibility to influence is well known also. How these charges propagate and affect

people remotely are less well known. Susceptibility to influence is explained as a function of personality, the other parties and the situation that the person is in. It is a multidimensional problem to identify when and in what situations people are more susceptible to influence.

The social influence could be modeled as a function of four parameters: 1) time 2) location 3) number and strengths of influencers and 4) self-susceptibility. By understanding these parameters more clearly, we can utilize them to affect an individual in-time and in-place decisions. At a large scale, this insight also allows commercial marketing efforts or political campaigns to be engineered with different strategies for reaching out to every individual in the market.

Social network friendships can be modeled by the distance d and the exponent r. The probability that a person at a distance d could be friends can be denoted as the gravitational force d^{-r}. As the network grows, it also creates densification effects that reduce the average distance between the participating nodes. For example, the probability that you know someone is affected by whether you and they have similar occupations, cultural backgrounds, or roles within a large organization. Adamic and Adar studied how communication depends on the distance of people in an organizational hierarchy. They found out that the rate of email messaging between employees of a corporate research lab fell off as they looked at people who were farther and farther apart in the organizational hierarchy.

As Centola and Macy have recently argued, our long-range friendships may be much less useful for spreading information when it requires a two step process to influence a person to adopt or make changes. In situations such as these you can learn of something the first time from a far-flung friend, but to get a second confirmatory hearing you may need to wait for the information also to arrive through your more local contacts[77].

In some ways, this suggests that the social forces are more like electromagnetic forces rather than gravitational forces. The behavior changes with the influence of positive and negative social charges. By investigating just-in-time social cloud, we are advancing a step towards understanding the parameters where in-time social charges can be applied for effective behavioral changes.

2.2.5 Modern Social Network Theories

Most recent work on social networks have been focused on understanding the structure of social networks and the properties of the network that create the structures we observe in natural networks. Understanding the dynamics of social networks is a more important problem since the use of communication technology dramatically affects how people adopt or diffuse information. However, the dynamics create a much more complex and difficult system to understand. The study also requires timestamped data of nodes and links. Most recently large datasets have become available to help advance the understanding of these dynamics.

Diffusion of innovation has been an important area of research due to its wide applications in the adoption of products and services, spread of viral content, and behavioral dynamics of social networks. Also, the extent of how open the network is affects the transmission of behaviors along the links. By capturing the structure of the social networks and understanding the dynamics of how influences and information flow through these networks, we can design and develop systems that help the user control, react, and respond to these propagating influences. Social networks allow "funneling" of information toward far off destinations. Social network that has grown organically without central control may be able to accomplish the same task with reliability if regulatory mechanisms can be designed.

By applying the influence and the structure of the social networks, search engines can be designed more socially aware. Search engines trying to provide the right answer to a query might take into account what a user has previously searched for. If a user is looking for a restaurant or a movie recommendation, the search engine might look at the user's friends lists and see what those presumably trusted sources have experienced. Such information is superior to ratings and reviews generated by anonymous people and helps us make more reflective choices. Especially if the user is searching from a mobile device, they might be time constrained, and cognitively constrained making the just-in-time social cloud guidance more valuable[116].

2.3 Social Cloud: Fusion of Social and Mobile

After a decade of living with online social networking, people are more aware of ways to protect their privacy and worry less about sharing of information online. The information and conversations filtered through social networks have become one of the most popular means to consume media. As majority of such content is made available from mobile, people are actively utilizing their dead times making them twice as active when they access sites like Facebook from the mobile phone[34]. As such active engagement on the phone becomes a ritual in our daily lives, triggers through mobile channels will inevitably affect our timely choices in the real world.

Most of the high-profile Internet applications to emerge over the past half-decade are governed not just by the technological considerations but also by recurring and quantifiable principles of human social interaction; both technological and social forces, working together, shape the inherent operating constraints in such systems[77]. By understanding how the usage of these communication systems and the social interactions change people's behavior, we can create relationship based networks where influences are transmitted through the social cloud. These networks are not only useful to find information about what content or activity are popular, but they can be powerful when used in just-in-time manner for helping people with behavioral changes or making choices that lead to long term benefits.

Such forces from the just-in-time social network can be engineered to achieve our personal and social goals. People with goals for healthy eating habits no longer need to eat alone, but engage virtual friends who also eat healthy. At the moment one is making a choice, one can see what one had committed for the long term and be reinforced by others who are actively following through with their commitments.

People who want to be more financially prudent can be helped by engaging more financially prudent friends to help them shift their decisions from what they would have normally done. As we provide the tools to filter and select the people according to our goals, and as mobile devices seamlessly intervene in our decision making processes, we will be able to utilize the

social forces for our personal and social benefits.

In order to achieve this, data needs to be made available about people, activities and social networks[8]. There are many sources of data: 1) mobile phones, 2) social networks, 3) sensors and 4) other personal sources of information such as calendar, health records, and e-mail. A graph can be generated by relating every type of data as a column and creating a directed graph from one column to the next column. The number of nodes in each column is determined by the number of records that share information about the particular data.

[53] distinguish formal groups such as class of students or organizations in companies and informal groups which are more difficult to identify because of the lack of clear boundaries. Informal groups such as groups of students that have lunch together can be categorized into informal groups due to their semi permanent nature. They introduce group place identification(GPI) algorithm to detect informal social groups in specific areas based on location input from the devices. Their focus and usage for this algorithm would be to improve campus social life of students, faculty and staff.

The Viral Communications group has been engaged in understanding various components of enabling a social cloud. The social cloud is defined as a set of services that can be pulled and pushed on demand for the purposes of helping users access contextual information and making decisions. Some requirements of the social cloud are scalability, contextual access to social information and capturing of such information.

The social cloud can be divided into clouds of people, cloud of devices and cloud of services. Social information is overlaid on the current information of interest. Cloud of people consists of both real people and projections of real people mediated through a communication channel. If we divide the social cloud into components, we could divide them in the following ways:

- Social User Interface (Information, Timing, Intervention)
- Social APIs and Communication Channels
- Social Architecture (Platform and Data Management)

We have implemented several designs of social dashboard that allow one to view and interact with their social information. Fluid Voice, Comm.unity, and Social Saver applications used social dashboard in various forms. We have been exploring how social information mediated through the mobile phones affects our choices, decisions and behaviors. The underlying assumption is that the social information will be readily available when needed through the current social network platforms. Just-in-time social cloud architecture utilizes these social network platforms to filter and present relevant social information in the context of the decision. The architecture to support the social cloud will be elaborated in detail in the next chapter.

2.4 Summary

In contrast to the well-studied effects of peer pressure in our physical world, we have only a sparse understanding of the effects of virtually propagated peer influences. Although there are anecdotal evidences accumulated from mobile advertising, and SMS flash mobs, we lack a quantitative system understanding of these peer influences. In this work, I consider the extent to which social networks in the virtual world can change human behavior in the physical world by designing experiments enabled by new mobile applications.

Phones have evolved from communication platforms to computing and sensing platforms. People are now focused on location based services that can provide personal services through mobile phones tailored to the context they are in. With personalization and socialization of data, it is inevitable that the mobile phones will engage in influencing people's decisions. The question is to what extent can these decisions be influenced and how to utilize social information to nudge people's choices using the mobile phone. In my thesis I have deployed platforms to capture transactions and experiences shared among social networks to understand the impacts of mobile social influence platform. The goal is to understand the dimensions involved in designing the just-in-time social cloud, develop implementations of it to show the feasibility and evaluate the social phenomena in greater scales. The lessons learned can be used to design new computing applications that influence human behaviors.

The ability to reach populations at different scales and across time scales is an unprecedented phenomena. As a result, understanding these dimensions and theorizing the distinction between these communication patterns become an important research agenda for both communication networks and social networks. This inspired me to set out to explore the effects of social information on our decision making when mediated through the mobile devices. We can see that the fusion of social information and any service is here to stay. It has proliferated on the Internet, and this thesis work investigates how is it going to affect our choices when presented at the point of decision making through our personal mobile devices. In the next chapter, I walk through various scenarios where just-in-time social networks can be effective and define the constraints and parameters of the just-in-time social cloud.

Chapter 3

Just In Time Social Networks

Previous chapter has alluded to the influence and the power of just-in-time social networks on people's choices. In this chapter I bring together some of the concepts and specifically apply to particular decisions to demonstrate applications, design parameters and constraints of the just-in-time social cloud. We frame the thesis by addressing some of the issues identified in the behavioral economics research and how just-in-time social networks can be useful in extending some of the theories and helping people avoid some of the pitfalls in their moment to moment choices.

Hyperbolic discounting predicts that people have difficult time assessing the future consequences and as a result resort to short term gratification. Behavioral economists have investigated over decades how people have cognitive dissonance in what they have planned to do and what they actually do. This shortcoming presents opportunities to engage just-in-time influences to lead people to make better choices by informing people about their originally planned choices.

When it comes to virtues and vices, people are more likely to choose vices when they are making a choice at the present than if they were making a choice for the future. Read and Lowenstein found out that people will choose more virtues when people select multiple choices at the present moment (simultaneous choices) compared to when making individual

repeated choices separated across time (sequential choices)[108]. When people are asked to buy chocolate to consume next 7 days (simultaneous), they will buy less than when they are asked to buy a chocolate to consume each day (sequential). This leads to simultaneous choices reducing the number of vices and sequential choices increasing the number of vices people engage in. This result is explained by the immediacy effect bias where the utility of a virtue is higher than vice when people are planning for the long term, but the value of competing vice suddenly increases in value at the moment of decision making (Figure 3-1).

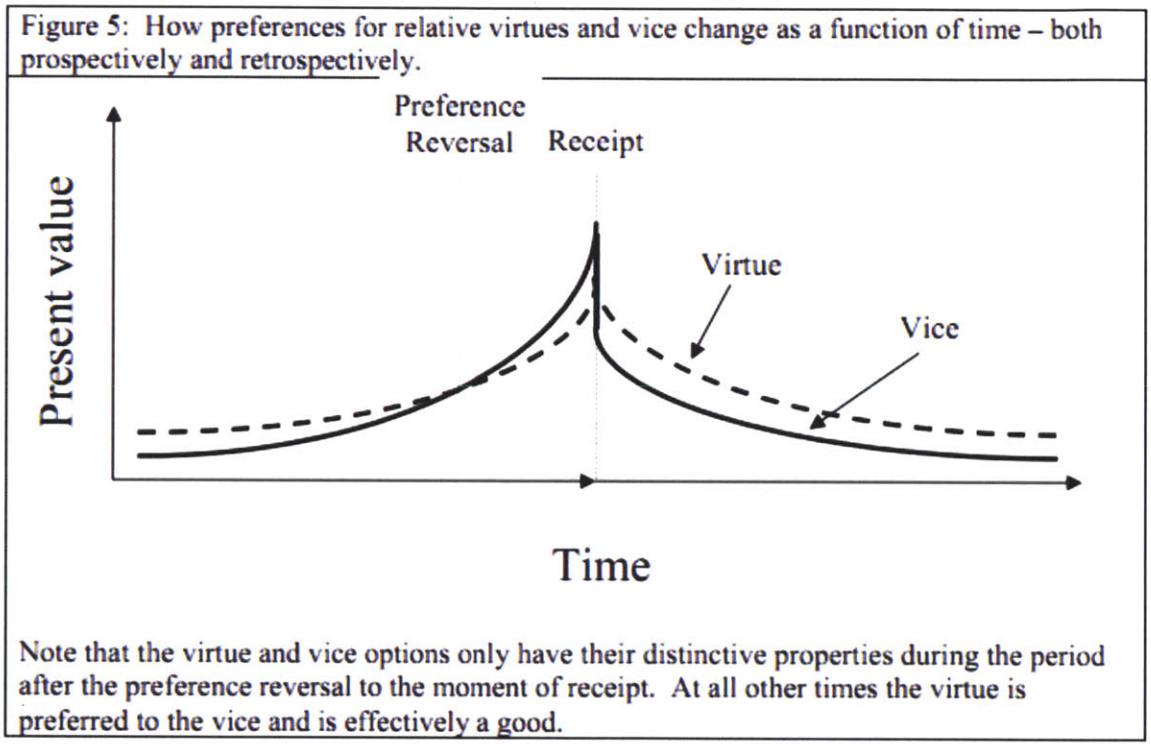

Figure 3-1: Utility of virtue and vice changing with respect to time of decision making[108].

The main design goal of the just-in-time social cloud is to embed the social network in the activity and make available at the decision point where and when the decision is being made. The difference between a just-in-time social network and the regular social network or social navigation is the dynamic selection and on-demand aspect of the just-in-time social networks. Depending on the user's particular goal, the social cloud is queried with the most influential set of social networks that can help guide one's choices towards one's long term

goal. This is beneficial because human beings have strong tendency to discount the future commitments when making the decision. As a result, we make promises about the future that is never followed through when the time arrives due to other competing choices that require immediate attention at the present moment. By introducing people with similar long term goals that have executed on choices, in a just-in-time manner, an individual could be guided towards their longer term goals more effectively.

One of the requirements in making effective use of the just-in-time social cloud is to introduce them at decision points in real life of an individual. Therefore, the designer of the application needs to identify the decisions points and create simple applications that the users can engage in at those decision points. The application may be on the mobile phone or designed as part of the environment so that the just-in-time social cloud can be effectively presented to the user. There are four main design environments I explore to illustrate how just-in-time social networks can be applied. These contexts will provide insights to some of the best ways to convey virtual social influences in situ.

1. Health
2. Financial Savings
3. Shopping
4. Saving Time

Persuasive interfaces research denotes these as major areas where well designed persuasive interfaces can help people reach a step closer towards their goals. Such study of persuasive computing technologies has been defined as captology. Captology defines three functional triad where computing technologies persuade people by serving as tools, medium or social actors[39]. In the case of just-in-time social networks, I am using the mobile phone as a medium of social influence to provide social support channel that is always available to the user. The architecture of the just-in-time social cloud assumes that there is a digital medium that can capture user attention at the point of deicision making (such as the mobile phone). In every one of the applications we need the following functional components (Figure 3-2):

1. Goal: The goal specification by the user

2. Selection: Identifies the social group that will influence the behavior

3. Presentation: Identifies the mode of presenting the past actions or real time actions of the social group

4. Timing: Identifies the best time that the just-in-time social cloud should be presented to the user depending on the activity and the goal.

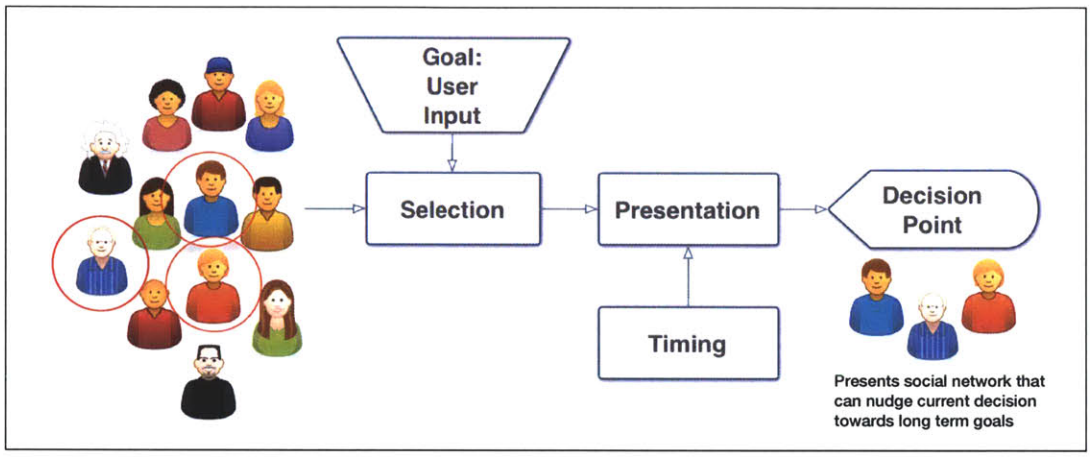

Figure 3-2: Components for enabling just-in-time social networks

The *goal* component is the short term or long term desirable goal of an individual that gets specified or automatically detected through an application. The goal that is specified needs to be translated into rules that help the just-in-time social cloud compute the right social network to help with user's goal. For example, if a user is attempting to eat healthier, the goal would be translated to filter locations that serve healthy food and provide a time constraint to filter the social network to those that eat at regular lunch and dinner times. This is utilized by the selection component to select those people that frequent these locations and those that eat at regular times so the user gets encouraged to eat at regular times and avoid eating really late at night.

Once the goal is specified, the social cloud identifies the people in the first degree, second degree social networks or a community of people that are pursuing the goal effectively and those that are not pursuing effectively. The *selection* component identifies the people that

may be the most influential in affecting one's decisions towards that goal. The selection process dynamically identifies the social network that meet the constraints specified by the goal. For example, in the case of the goal of pursuing healthier eating habit above, those friends that are successfully pursuing healthy eating habits will be selected.

The *presentation* layer decides on how to present the social information (i.e. as individuals, as aggregated popularity or as normative force by group of friends). In the future, this layer could be extended to support audio, video and pictures. Different manifestations of the social information affects people's decisions differently. For example, for helping people exercise, it is best to help them have less deliberation and make them decide quicker. Therefore, the presentation layer would use popularity view to encourage people to make choices with least cognitive load.

The *timing* component can be driven by the habits and impulses of the user. It will also depend heavily on the application. From the implementation point of view it would have the logic to identify the conditions which would dictate the intervention time. In the case of just-in-time social networks, I assume that the timing layer identifies the closest time to decision. This is done by embedding the just-in-time social cloud in the interface where actual choices are being made. For example in the digital menu experiment, I embedded the just-in-time social cloud by the menu choices which users used to browse and select the dishes to order. In the following sections, I illustrate in detail how each of these elements are integrated in different domains to assist in people's choices.

3.1 Healthy Behaviors

Obesity is a major public health challenge with over 65% of US adults either overweight or obese. Estimated annual costs of obesity are $78.5 billion[127]. PmEB (Patient-Centered Assessment and Counseling Mobile Energy Balance) mobile phone application was developed for users to monitor their caloric balance in real time throughout the day. The tool was designed to improve existing paper based diaries and logging habits. People entered their diet and physical activity on the mobile phone. People were intervened by receiving

a reminder SMS message to log their activities. The results of a 15 people deployment for a month showed that the users found the phone based application as usable or better than the paper based diaries.

In order to incorporate just-in-time social networks in this domain of managing obesity we need to first identify the decision points. There are two goals. One is to reduce food intake and the other is to increase physical activity. The decision points involve selecting the food you want to eat and getting yourself to exercise or make yourself to go to different places.

After identifying these decision points, we identify any applications or channels that we can present the social information. In the case of a logging application like the PmEB, one would show other users that are using the mobile application that are actively logging their activities. If the application designer wants to have the users make decisions quickly, the popularity information should be used. If the application designer wants the user to engage longer with the application, the actual individual friend's information should be shared through the application.

The *selection* of the social network requires identifying those set of people who have previously performed actions and made decisions that would provide the potential social influence to lead a person to make the same decision. There are various ways to select these people depending on the application. Polling them from self logging applications is the most obvious way. [125] showed that a group of young girls could be motivated to be more physically active and aware of their eating habits through a mobile prototype application that allowed them to compare their summary statistics. Showing when their non-obese friends eat and what they do would be another approach to select the just-in-time social cloud.

Presentation component will identify whether we want people to delay their decisions or to expedite their decisions based on the goal. If a person needs to consider what food to eat, it requires deliberate consideration to reduce their impulses. In this case we can present the particular friends that engage in similar diet program that have successfully restrained themselves from eating junk food or show those who have not been successful to exert influence through negative social influences. In the case of helping people make decisions

to exercise, it would be best to reduce their deliberation by showing that 35 people have exercised today or that 5 pm is a popular hour to exercise to encourage people to exercise after work.

Finally, the *timing* aspect of the input needs to be considered. PmEB study have shown that too many notifications can discourage people from engaging in logging of their activities. The best moment for influence for food intake is when people are searching for a place to eat, when they are actually at the moment of deciding to order and when they are deliberating on what to purchase in a grocery store. In terms of exercising, the best time to intervene would be when going to bed, when waking up, when leaving work or when going to a meal. Also if the system had access to the calendar, better times could be suggested based on their idle time blocks in their calendars or before their meals. Finally, in the gym people are using their phones to listen to music and in the future they will log their exercises. The time they are logging and reflecting on their exercises is a great time for influencing people to exercise more or try different exercises.

3.2 Financial Savings

Recent financial crisis has shown the importance of savings (Figure 3-3) in mitigating financial difficulties that individuals and organizations might face. However, saving money is motivated by long term virtue and people make similar short term compromise observed in health where people consume to fulfill immediate desires instead of saving for the future. In this section, I illustrate the design of the Social Saver application on the mobile to encourage savings behavior and specify how just-in-time social networks can be beneficial.

In Social Saver people can share ways to save through the mobile devices and be influenced in their savings behavior. They will all be subscribed to "savings" interest space. The savings tip available can be filtered by where they are, who they are with or the time of the day. The application allows people to be aware that neighbors and friends are saving. Exact dollar amount does not need to be specified, but the actions taken to save money will be shared. The shared information can range from a person identifying that a purchase

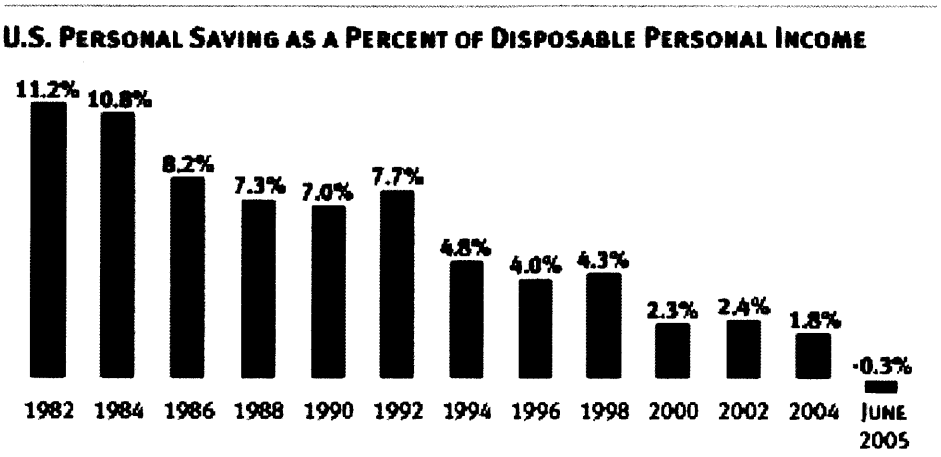

Figure 3-3: US personal savings crisis

was made when an item was on 30% saleto an act of depositing into a 401K or certificate of deposit account.

The goal can be specified as monetary savings behavior with possible dollar amount to reach. The goal can be further refined to saving in particular categories such as clothing. People can also specify their desired goals manually on the mobile phone or a web site. In order to monitor one's choices towards saving goal, just-in-time social cloud could also be connected with the bank account so that any choices made to save can be automatically tracked.

The *selection* can start with general population since that information would be easily aggregated through financial statistics. Studies on people's savings behavior show that the peer groups that one belongs to affect whether one engages in 401K like retirement plans[31]. We tend to follow other people's behavior in tipping, watching, procrastinating, smoking, and eating. More importantly, peer impacts and normative influences that are most situationally similar can affect the outcomes of people's decisions[50]. As a result, selecting a group of people who are either friends or are in similar situations would be the

best set of social network to select from the social cloud to encourage individuals in their day to day savings.

In the presentation layer, the above selected social network could be presented in different forms. Friends of similar demographics could be presented as individuals or as anonymous groups of people that could provide normative influences. If a general population is used, popularity information is the only means to preserve privacy. On the other hand, if one's friends decide to participate in sharing the information, then individual information could be used to allow people to think more about their actions.

Finally, the timing layer needs to specify the conditions that would trigger these just-in-time social influences. The particular times that the social influence is triggered could be when one is engaging in any activities regarding mobile banking, visiting ATM, or shopping at a shopping mall to remind the person that others are saving. These conditions are mostly triggered by the location and the particular application one is accessing from the mobile phone. The timing can also be tied to the biweekly paycheck period so that people can be reminded to save. Open Transaction Network pilot with people from Bank of America have shown that people tend to spend more on biweekly cycles due to their biweekly paychecks.

An attempt was made to prototype a concrete budgeting application that could be utilized when a person is trying to pay off their credit card or when a person is engaging in regular purchases such as coffee[80]. Concrete budgeting application would allow a visualization of a projection of future value of current payment, allowing one to either make an earlier payment or restrain on spending. However, utilizing the impact of social influence was left unexplored for future research.

An insight I gained from the data from Open Transaction Network and MealTime system was that people's spending behavior tend to have distinct behaviors between the weekdays and the weekend days (Figure 3-4). Mostly, over the weekend I observed larger spending behavior and during the week, most spending were on food. This leads to Friday afternoon as a good time of the day to alert and remind the user about savings and potentially weekend mornings to remind about how others are successfully contributing to their savings activities.

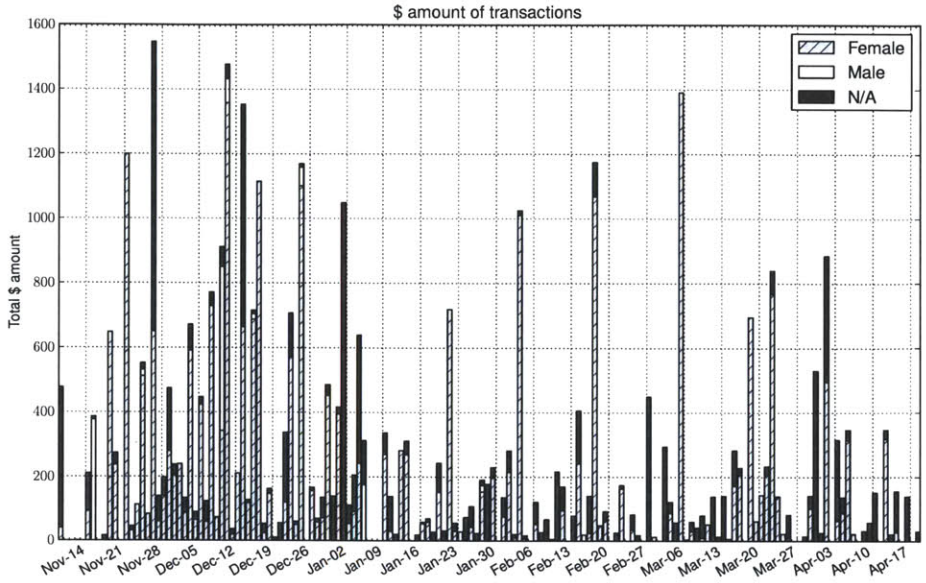

Figure 3-4: Transaction timeline of Open Transaction Network participants show bi-weekly spending spikes outside the holiday seasons.

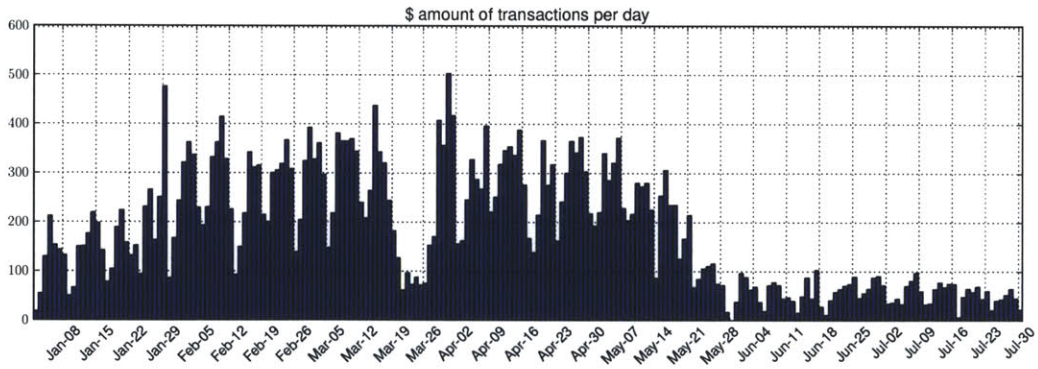

Figure 3-5: Transaction timeline of MealTime TechCASH users show higher spending during the week and lower spending during the weekends as people cook or go out to eat. The vacation terms are also very distinct with big decrease in transactions during the winter, spring and summer breaks.

3.3 Shopping

In this section, I illustrate a slightly advanced version of just-in-time social networks that is empowered by the current location, the activity context of shopping and the co-engagement of family members in the same activity. The concept of interest group is defined and used which I dive deeper in Chapter 5. The interest group is derived from interest based networking and proximity based services from my previous research that enable accessing the proximal social cloud.

Family members go on a weekend shopping trip. Father is interested in gadgets, mother is interested in jewelry, son is interested in latest video games, and teenage daughter is interested in designer clothes. The interest group changes from family at home to various interests in the shopping mall.

Mother is able to see from her phone, the average prices of the items she wants to buy. She users her phone to access her friend Mary's purchase experience in one of the stores. Mary is an expert and knows what the best deals are. She sees on her mobile phone that there are some saving tips that Mary had posted.

When son is interested in the Play Station 3 game, Call of Duty, he scans the QR code. He sees that one of his friend has recently bought it and he can borrow it from his friend instead of buying. Some of the latest fashionable items are pushed to the daughters phone with recent purchases and recommendations by her friends. One of her friend comments that the item will go on sale if she waits a week. She is also able to select an item and ask her friends on her social network to provide opinions about the particular dress she's interested in. Her friends can give her immediate feedback with thumbs up or down. However, just-in-time social network would filter the results from those friends that she would care about.

As father is looking at a few digital picture frames, the devices sense that father is interested in hiking and displays pictures related to hiking. When another person drops by to see the picture frames, they recognize that both of the customers like football and the frames display pictures from the last NFL game. The store also flashes that if they both purchase together, they can save 5%.

Movie showings that might be of interest to the family are pushed to the family members' mobile phones. The recommendation service knows that the family enjoys watching movie together after dinner. However, Social Saver shows that the family could rent a DVD at a much cheaper price instead of going to the theater.

As dinner approaches, restaurants broadcast to those communities of people interested in certain cuisine based on their past visits. The list of restaurants that are in proximity are presented to each family member to decide on. However, the family members would like to try something different. Based on the previous restaurants that they have been to as a family, other potential suggestions from friends and public are provided. In such shopping scenarios, decision points can be identified by the time of the day, the location and the proximity to certain stores. The just-in-time cloud changes for different family members depending on the decision they are making.

3.4 Saving Time

Finally, I discuss the domain of saving time since managing time is always difficult and people have inherent nature to procrastinate. It is many times a human nature to procrastinate[3]. Despite the importance of prioritizing and having deadlines, it is not easy for people to stop themselves from engaging in more relaxing and fun activities. Particularly in the case of procrastination, friends are known to make the problem worse by helping people engage in hedonistic pursuits or regular social activities that might require sacrificing activities geared towards long term goals.

However, if one has a goal of finishing up a task, one could obtain help from the just-in-time social cloud. In the case of finishing this thesis, I have polled the list of people who have defended recently and kept a list of them for me to continue making progress on my writing. Therefore, the selection process filters those people who have either finished defending their theses or those who are in the midst of writing them.

The presentation layer would present real names and show increasing number of people with

time to influence myself to write and join those people. The real names that are my close fellow graduate students allow me to think that I can do it because they also did it. The number of people gives me a quick decision to join the crowd.

Finally, the appropriate time to help one save time is by influencing the person to engage in the particular goal whenever one is found to be idle. Whenever, there is no activity on the computer, a pop up reminder could appear on the phone and show the set of social network that are engaged in thesis writing. Sometimes I find myself continually browsing through my mobile phone, without actually doing anything. This would be an opportune moment to present to me that a group of people are working on their thesis or have finished recently.

3.5 Habitual versus Impulsive

Before we conclude this chapter we identify how just-in-time social influence will differ based on modifying habitual behaviors versus unplanned behaviors. The two behaviors are thought to be very different although both are resulting from a cognitively limited behavior. The habitual behavior is created through repeated actions and decisions as people react mindlessly to familiar circumstances. In the MealTime experiment, I have shown how people continually visit the same places throughout the semester.

Impulsive decisions are usually unplanned and are made as we navigate the world and adapt to the unexpected desires that are triggered by the environment. Impulsive behaviors are much less well understood and the consumer behavior researchers commonly define it as an unplanned purchase behaviors. Many times purchases are driven by the impulses and there is no unifying framework that explains why impulsive purchases are made. Hyperbolic discounting theory explains why people focus on the present moment. Many people are not good at judging future consequences. Psychologists define impulsive decisions as the desire to obtain something at the moment and the onset of such desires driven not only by rationale but psychological and physiological changes[111].

The following real life anecdote regarding an iPhone purchase shows the power of planned

purchase and impulse. David had planned to get an iPhone as it was launched by Verizon, but his desire for immediate satisfaction led him to wait in the line at an early morning.

> "That craving to have the device in hand was what drove David Copado of Santa Maria, California, to arrive at 5:15 a.m. and stand in line. Copado, who was 10th in line, was the first to emerge from the store Thursday morning as a Verizon iPhone 4 owner.
>
> 'I could have ordered online last night, but then I'd have to wait for the mail to get here,' says Copado. 'I tried to pre-order last week, but I didn't expect them to sell out so fast.'
>
> Those who pre-ordered last week began receiving their phones in the mail ahead of Thursday's formal launch."

See full article from DailyFinance: http://srph.it/emr4XD

This opens up the question on which of the two behaviors, habitual versus impulsive, are more influenced by the just-in-time intervention of the social network during decision making. The habitual behaviors can be considered more difficult to modify due to the automatic reactions people have when a particular choices have to be made. Therefore, it would be easier for people to engage in an intervention. On the other hand, impulsive decisions are similarly difficult because there is a peaking psychological urge to engage in that decision at that particular moment that becomes hard to control.

From our results, we can intervene if any of these decisions involve the mobile phone. Both cases require adding some more time to the decision making process by creating deliberation time for reflection and providing information on other people's decisions that align with one's long term goals. This can be achieved by presenting what their friends have done regards to the particular decision they are making. However, the main challenge is that these decisions are usually made without any technological tools like the mobile phone. This makes it very difficult to intervene with these decisions. However, we can envision in the future where screens are everywhere and choices are made through these screens. As a result, we can expect that in the future, the environment could have displays that would detect one's presence and become the medium of social influence when needed.

3.6 Summary

We constantly face uncertainties in life where we have to make choices with real time and limited information. Especially in the cases of uncertainty, human beings are wired to base their decisions on what other people do, what Cialdini denotes as "social proof". Especially in the context of mobility, we constantly seek out information and short cuts to support our decisions with mobile devices that assist just-in-time information gathering. Aspects of economic activities will be impacted in such cognitively limited situations. The resulting transactions are a valid proxy to the economic decisions and I investigate how social influence affects these decisions. Impacts of social proof and mental short cuts due to mobile information are investigated through real world experiments with real people.

The chapter addressed the contexts where just-in-time social cloud can be applied to influence and aid decisions. With the pervasiveness of mobile devices in our just-in-time decisions and the way we are connected to our social network at various scales through such communication channels each of these scenarios show the importance of the just-in-time social cloud. An empirical inquiry on social influence and social networks in human decision making will help us foresee the impacts of mobile communications in our society. In the next chapter I dive into the implementation of social transactions that enables just-in-time social cloud architecture and the set of experiments I have deployed to understand the impacts of the social cloud on people's decisions.

Chapter 4

Future Consumption Network

In envisioning the future of transactions, I present a new paradigm of thinking about mobile commerce where mobile phones serve as augmentation to the traditional payment system to open the architecture, increase real time awareness of one's spending, and also to engage social networks by allowing people to be connected via transactions when beneficial. In this chapter we particularly focus on how such behavior will impact mobile commerce technologies and discuss the technical details of how social cloud and social transactions will augment existing transaction technologies. I describe the current mobile commerce process, its shortcomings, and related technologies. I then further develop implications and applications of social transactions from pre-sale, point of sale and post-sale perspective.

The social transaction theory leads to the framework of mobile phone as an augmentation to the payment system instead of trying to replace it as some of the existing mobile payment approaches are trying to do. Some of the benefits of using mobile phone as augmentation to existing payment process is described and how it is different from the approaches taken by the current industry due to the dichotomy of competitive approaches proposed by telecommunications and the banking industry. Finally, I discuss how mobile advertising will change with social transactions, just-in-time interventions and derive algorithms and user experiences that might be enabled by taking social transactions into account.

4.1 Connected Consumption

In the modern world, informed consumers are very frequent shoppers and utilize online resources heavily (i.e. Angie's List, Consumer Report or CNET Reviews) to inform them about the cheapest prices, best features, product comparisons and reviews of products. The time consuming process produces tacit knowledge on the product space and related items that can be used for recommendations. Traditionally, these recommendations from friends were difficult to capture because of the design of keeping the identity of the reviewers anonymous. As a result, very often people make their final decisions by asking their friends for references and prior experiences through their social ties[13].

By tying the purchase information with the social connections, I can build a social information cloud around the selection, purchase and the post sale experience which I denoted it as connected consumption environment. Such social cloud can be used to identify experts in particular categories by tracking their utilization of different merchants and accounting of actual purchase activity (which informs others of the true experience regarding the product and service). Automatically linking the post sale community for addressing problems and enabling reverse auctions by pushing items based on people's wish list are also possible benefits by keeping the transaction information more networked.

Ubiquitous availability of mobile devices that sense the user's context and interest is networking consumers in real time to help each other fulfill their short term and long term goals. Everybody carrying a mobile device and the device being able to detect what we purchase and consume, allows us to understand our time variant interests. These interests can be mapped across the social network in order to allow users to utilize the collective knowledge of people with complementary interests as a knowledge repository, but also to utilize them on demand. By mapping the interest network, identifying the influencers and the influenced and tracking the actual financial transactions occurring due to the recommendations allow us to quantify the economic activity surrounding a social network.

A realized phenomena due to connected consumption is the recent collaborative consumption movement[12]. Sharing has become a second nature to people with the culture shift

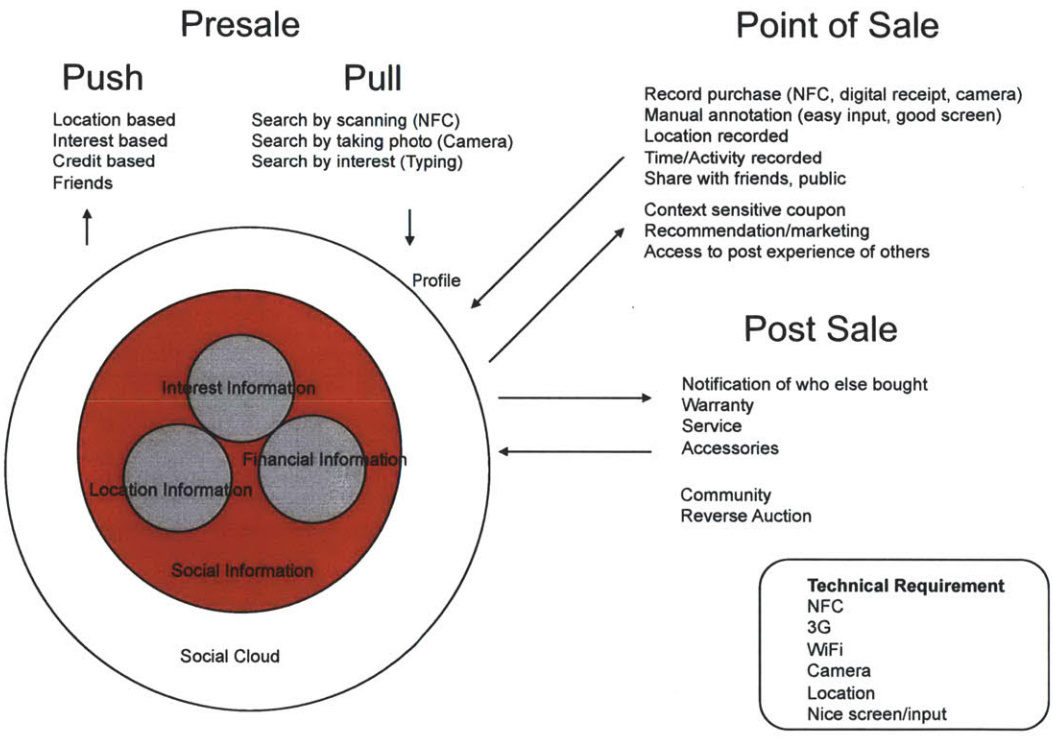

Figure 4-1: Connected Consumption

of me to we. Collaborative consumption is a rising phenomena by groups of people who are willing to share physical resources (borrowing cars, lending lawn mowers) with others. They claim "what's mine is yours." Any product or service with high idling capacity is good for sharing. This is becoming effective and growing in scale by the connectivity and trust provided by the social networks. It has become much easier to form groups that can collaborate. Easy matching of needs through the Internet, online reputation and people's openness is allowing people to engage in such collaborative consumption. The mobile communication platform can only enhance these activities by matching needs on-demand through just-in-time resource sharing at anytime, from anywhere.

Collaborative commerce was posed in 2001 as a means for web based services to provide open but secure interfaces to interoperate and collaborate to serve customer's needs in the most efficient and optimal way[79]. It would allow greater visibility of the status of an order to the customer. The applications that are involved in processing the order would communicate with both external and internal services providing all involved parties with the status of the fulfillment. External employees, customers and internal employees will have access to the status of the pipeline based on the permissions they have and be able to track the real time status at customer's request. The realization of it happened over the years as more and more web services developed and one click ordering from Amazon or "order now" features triggered suppliers and delivery agents to collaborate in fulfilling the order[16]. However, enabling it required tremendous collaboration and integration from the IT department to the executive decision makers (Figure 4-2).

Beyond connecting systems to make the fulfillment process more transparent, IBM MyGrocer views consumers as partners in making the supply chain more efficient, targeting on automatic home replenishment (Figure 4-3) as the goal of the efficient supply chain management[114]. Retailing is converting/transforming into an information processing node in a fully networked supply chain. In this context, attracting and maintaining consumers is an information mediation process, including keeping track of consumption patterns, preferences and catering for their needs as well as offering the best value for money proposition via increased competition enforced through reverse auctioning.

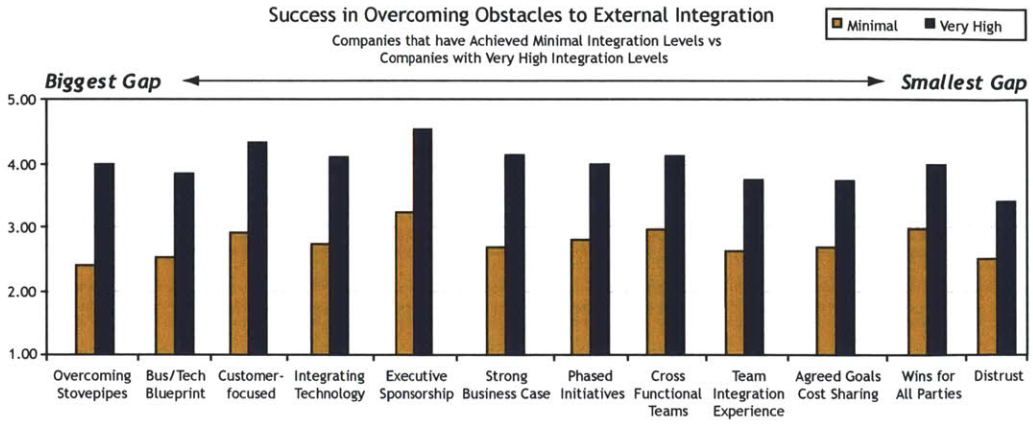

Figure 4-2: Integration between systems, people and businesses were required to achieve collaborative commerce[66]

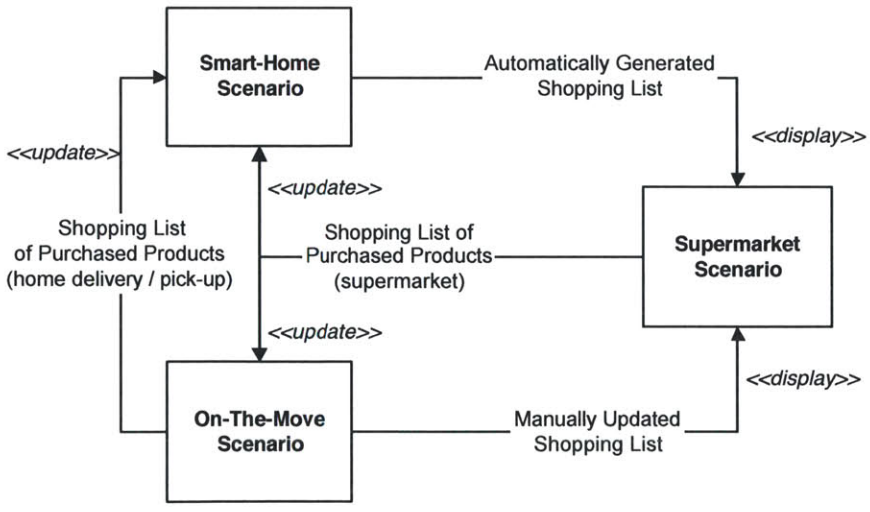

Figure 4-3: IBM MyGrocer collaboration among three scenarios at home, on the move, and in the supermarket[114]

Connected Consumption envisions an environment where social networks serve to benefit individual decisions through easy connectivity with others that have engaged in similar experiences. The approach to enabling it is less through high level of integration, but in a grass roots manner by encouraging individuals to easily share their transactions and be able to connect on demand via other people's transactions, both past, present and future. This allows decisions to be informed by past transactions and also provide guidance for future decisions. The goal of collaborative commerce is to provide a transparent interface to the customer on the status of their orders and provide an architecture for fulfilling the order efficiently, making it a system networking problem. The Connected Consumption is a social networking paradigm that connects people through the transactions to provide a social networking platform for market efficiency by helping people better find what they need and make better decisions on competing choices through the help of the social network of experienced.

4.2 Problem

Mobile payments have been promoted as a means for people to more easily pay for products and services both in the online and the offline world. It has been successful in certain Asian, African and European geographical areas particularly in places where card networks and communication infrastructure has been slow to develop. In the US, mobile payment and commerce is projected to grow significantly in the next 10 years, but currently the usage has not reached even close to the level of usage of payment cards. This is mainly due to the great popularity and convenience of debit and credit cards and difficulty for the industries to agree and collaborate.

The direction that the industry is taking with mobile phones is to replace existing methods of payment and serve as an alternate channel to existing payments. The goal is for the mobile phones to serve as a replacement for cash and card. There are competing payment technologies: NFC, QR code, paying with minutes, paying over the web or paying with SMS. Different countries have different methods that dominate the landscape. For example, in

Kenya the M-Pesa payment shifted cash payments to electronic payments through SMS and has been the only mobile payment solution which quickly penetrated 90% of mobile subscribers in 3 years (over 10 million users). In Asian countries such as Japan and Korea, payment for public transportation has been the main uses for mobile payments.

Mobile phones can be used beyond e-wallet that is used to just store and manage electronic cash. The phone has interactive user interface and computational capabilities along with continual use by the user throughout the day. Such distinct usage pattern allows it to be a platform that helps the user make better financial decisions. Currently, it is most widely used for purchasing virtual/digital products such as ring tones, music, videos and to buy items from online stores on demand. However, it is not well connected with the current physical context: location, activity and environment that the user is engaged in at the present moment.

The mobile shopping experience requires several different applications due to every store creating separate applications for their own branding and marketing purposes. Currently there are many different applications specific to the particular stores that allow one to gather information about a product including price, details, reviews. These applications implement the "order now" feature to lead these searches to purchases. However, there is a disconnect in having to use a search engine and having to use a separate application for the particular store that users are planning to buy the product or service. This suggests that collaborative commerce like effort is required for pre-sale and point of sale experience to be more seamless and integrated with the context from the user's point of view.

An experimental study, SmartRestaurant, also showed that making payments from the phone was acceptable use when special lunch menus at a local campus restaurant were served from the phone and people were allowed to pre-order what they wanted for pick up from the phone before heading to the restaurant[85].

An example of such contextual design is depicted in the design of mobile ticketing for public transportation service in Finland. The Helsinki Public Transport deployed an SMS based mobile ticketing system where one can immediately purchase a mobile ticket by sending

an SMS message. Over 3 year time frame over 1.9 million tickets were sold through the system. They argue that the design of the service have to be context based on the activity the user is engaging in and has to be compatible with the consumer behavior. When they surveyed over 300 users they found that consumers who perceive mobile payments as compatible with the way they use both the public transportation and the mobile phones are most likely to adopt the mobile ticketing service. The contextual factors, including lack of cash, unexpected need to use public transportation, expiration of a periodic travel card, and hurry, were also found significant in determining future use of mobile ticketing. Their data indicated that the users are likely to resort to mobile ticketing when no other means for paying are available[89] indicating that the other existing means whether due to habit or convenience had precedence over mobile ticketing.

4.3 The World of Mobile Commerce

Research report from Bank of America Merrill Lynch estimate that mobile commerce will reach $12 billion in the US by 2020. It will also disrupt the existing financial institutions' credit card businesses while creating opportunities for startup companies and consumer technology companies like Apple, Amazon and Google who are aggressively gaining hold of the smart phone market. What makes the industry exciting is the convergence of the smart phones have created a platform where innovation can happen more quickly while providing means to bypass existing major players. In this chapter I illustrate in detail the consumer behavior of mobile phone users and detail how some of the upcoming technologies will affect the pre-sale, point of sale and post-sale process. I particularly focus the discussion on how each stage of the process could better be integrated with the other stages and describe in detail how and when the just-in-time social cloud should be utilized in the process.

Over the last two decades, paper based (cash, check) transactions have been declining and electronic (debit, credit, electronic ACH) transactions have been steadily increasing (Figure 4-4). Current digital payments through cards have the following limitations which limit the potential applications that may be created from it. Transactions posts in 24 to 48 hours

due to the widespread batch processing system. This makes it difficult to identify the exact time and date of the transaction. Only approximate information is available which makes it difficult to identify what time of the day the transaction was made just from the transaction information. However, this is a limitation due to the system deployed in the US. In some Asian countries transactions details are available with the exact time stamp.

The card transactions are also deprived of the exact product (SKU level data) or service information or the exact address of the location of transaction. The limitation in location information is due to the merchant having multiple locations, having registered head quarters at different location. For example, if a BoltBus ticket was bought to travel between Boston and NYC only the transaction with Bolt Bus is available with no indication of travel destinations nor time. Only the receipts contain this information, but there are disparate formats and no coherent display standard for receipt information. The basic transaction information from the credit card companies are the most widely available transaction data that is available in common format.

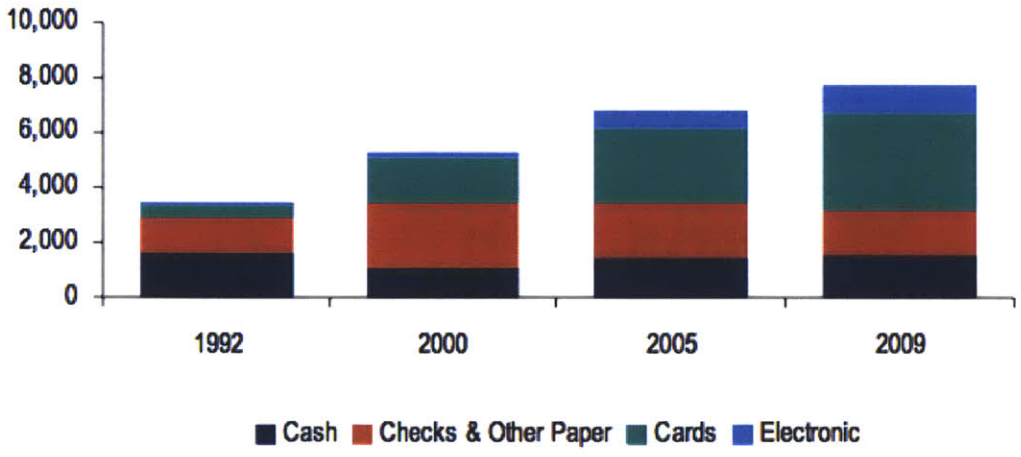

Figure 4-4: The number of paper based transactions have been steadily declining and the electronic payments dominated by debit and credit cards have become majority (58%) of transactions in 2009. [Source: Nielson Report]

The mobile commerce field has been a rich field of exploration due to its business potential and how it can change people's commerce activities particularly in the real world for on-demand consumption. Telecoms want to get a handle on the payment industry and thwart

the stronghold of the banks. Banks consider mobile phones as an alternative payment method that may increase the transaction volume that they process without harming their existing card transactions. As various entities such as banks and telecommunication service providers see a great opportunity in enabling commerce through people's personal phones, mobile payments have been driven by the industry to increase payment volume and profit. However, customers do not have an avid need for mobile payments. Credit card is serving as simple but sufficient means of paying for their purchases.

Academically the field is interesting because it opens up to novel ways of human computer interaction due to richer interaction provided by the phone during the shopping process. Seamless integration of reviewing and communicating with friends and public to make a purchase decision with payment enables a better informed purchase experience. People carry their phones around all the time so it can serve as a means for intervention and a way to measure the effects of such interventions. It can also provide real time feedback, on-demand access to product information when in front of a product and provide an interactive user interface that may change the decision process. Due to its intervention capability, it can also shift from spending to saving tool. Credit card has traditionally detached people from the actual money, making it an abstract interface towards one's assets. Results from MealTime study show that digital interactive interfaces of smart phones can make people be a little less detached with their spending[105].

Despite mobile phones providing an alternative means for payment, it has had trouble in achieving a wide scale adoption. People have a higher expectation regards to security when done on a phone versus a credit card[59] due to its interactivity and computational capability. A major challenge of new payment system is achieving a wide adoption by merchants and consumers. Customer want to use this payment in a universal way at any merchant. An approach taken is using the existing credit card network for processing payments by providing a wallet on the phone. Processing micro-payments on vending machines has been successful in places like Japan. Authenticating remote consumers who purchase products online through a verification code that is sent to mobile phone in real time at the time of transaction is a popular service that is being adopted in wide scale.

Various literature have indicated how mobile payment requires banks, merchants and telecommunication service providers to work in collaboration with competing interests to provide a widely available mobile payment service[27]. However, making these entities collaborate is not easy due to the complexity of their business dynamics. There has been many studies on understanding supplier, merchants and consumers [113]. Complexity of using it is a common barrier for mobile payments. Perceived ease of use and usefulness are the most important dimensions of mobile payment adoption, however such simplicity has not been achieved due to the complexity introduced by the capabilities of the technical system. Users have to browse the mobile phone menu, open the wallet and then select the payment choice.

[25] illustrate the importance of understanding the cultural context, the consumer characteristics and preferences from different cultures. There are only a limited set of research done on the adoption and applications of mobile commerce in the context of different cultures. Just like security online has been a hindrance to adoption and usage of electronic commerce services in the past, security in mobile commerce is hindering the adoption by the masses. However, with increasing convenience, usage, and protection provided by the credit cards, and growth of major online commerce brands such as Amazon and eBay, nowadays in the US, it is uncommon nowadays in the US to find people who are worried about the security aspects of conducting transactions online with a known brand site. The paper reports that Chinese consumers are influenced by cost and subjective norms to adoption, while US consumers are influenced by privacy, innovativeness, perceived usefulness, perceived enjoyment and compatibility for intentions to use.

An empirical study on trust factors[94] show that technology trust is less important than institutional trust which offers reliable transactions, guarantees, legal recourse and regulations that exist to assure the success of the transaction. Mobile payment research in China shows that the adoption of mobile payment depends on the culture and how widely other payment mechanisms are used[133]. In China, the existence of widespread municipal bus card makes the mobile payment less attractive by existing public transportation service providers. Merchants on-site regard the mobile payment as potentially useful only if the fees were lower. [24] describes the payment habits of Finnish population. It indicates that

the following 4 factors: social norm, compatibility based on skills, trustworthiness, compatibility (large applicability) and ease of use are major factors in people adopting certain payment systems. Facilitating factors are trust. Differentiating factors are ease of use.

4.3.1 Mobile Payment Technologies

In this section I review the different technological mechanisms for mobile payment and summarize their advantages and disadvantages. NFC allows touch or proximity based payments. Although NFC allows a smooth interaction for the consumer, the infrastructure behind the scene is complex and requires the cooperation of different entities in different industries (bank, merchants, card companies and mobile phone manufacturers) to ensure interoperability and a thriving contactless scheme to be widely used[88].

Industry experts globally have been eager to have NFC deployed in wide scale to facilitate payment and commerce in the physical world. Countries like Korea and Japan have been leaders in utilizing NFC like technologies to process payments for transportation and retail. Despite the enthusiasm, the customers have not adopted it as the main payment mechanism[98]. Analysts had predicted that by 2009 50% of payment terminals would be NFC enabled, but reality has not come close to the predictions. [129] argue that the current storage (available memory), security and speed (computation) are limitations. However, I believe we are trying to over-engineer the payment system. I believe mobile payments could thrive along side the cards by making it more accessible and easier to use.

QR codes provide a cheap alternative to NFC as phones come equipped with a high resolution camera. [44] presents a mobile payment scenario where a user can use 2D bar codes to get product information and make secure payments through the mobile phone. When the current interaction is focused on the phone due to the user browsing for an item or viewing product information, making payment through the phone facilitates the interaction.

SMS usage accelerated globally and integration to existing merchants' business model was relatively inexpensive[45]. Most mobile phone users use text messaging service and as a result SMS based payment mechanisms can be made universally compatible. Successful

adoption of SMS based mobile payments happened with Danal as they utilized mobile phones as a means to confirm and augment the existing card payment. Mobile ATM deployed in Sri Lanka provides an overview of how mobile phones can be used to provide cash access to people without the burden of deploying infrastructure as is done with existing ATM networks. Mobile ATM agents served as mobile ATM's where customers can easily access money wherever they are if they can find these mobile ATM agents. All transactions are handled through SMS messages. They have also started to deploy it in the rural areas of Sri Lanka[72].

Internet protocols also enabled novel protocols to handle peer to peer based payments. SipCents [38] analyzes how SIP protocol could be used to handle payments. SIMPA - sip based payment architecture tries to standardize payment infrastructure using Internet protocol for both peer to peer and regular merchant based payments[135]. However, such architectures still try to modify the existing payment systems instead of augmenting. [7] did research on how mobile peer to peer payment compared with paying by cash at the point of sale. What the phone should provide is greater security and faster payment processing when making payment. However, compared to a credit card or smart card, the interface is clunky, taking several steps to process payments and not common across the phone platforms. The work focuses on design and usability of a mobile P2P payment system which is not dealt with in the past. Past work have mostly been on investigating the security aspects and less about the usability.

These competing and complementing technologies and culture will continually trigger innovation and change how mobile payments get used as long as they do not hinder existing commerce activities. Most of these approaches focus on the phone as a mechanism to handle payments, and less as an interface to provide greater insight into one's spending pattern and decisions. In the following section, I will show how they can be better utilized to improve the commerce experience through a detailed discussion of pre-sale, point of sale and post-sale process particularly focusing on how social transactions may impact the processes.

4.3.2 Pre Sale

Pre-sale behavior has changed since the advent of the Internet where people use price comparison sites and reviews heavily before they decide to purchase. For many products that are not "experience" based products, purchasing them online has become cheaper and convenient. However, when it comes to style, experience and immediate gratification, people still prefer in-store purchases where they can feel the product. In general, e-commerce has grown tremendously, and companies like Amazon has had negative impacts on offline stores like Borders, but for clothing, cosmetics, food, electronics, cars and services that require in person attention, retail shopping is still thriving.

As people traverse through different locations throughout the day, it is many times convenient to make purchases on the way and in those cases, smart phones have enabled access to the Internet to make those pre-sale research and information gathering on the spot. This has led to a shorter time interval between pre-sale activity and point-of-sale, allowing people to make more informed decisions on the go. Services like massage and yoga lessons require the person to be physically at the location to experience the service.

Those purchases that are first time or require experience will benefit the most from the Social Transactions environment. During the pre-sale people will be able to view in detail how many people have previously purchased an item, whether a known friend or group of friends have purchased an item. The social information can help them decide quicker if people can see that others have performed the transactions by increasing the willingness to join the crowd. In the case of individual friend, it might make the customers switch to another item that is different from what was purchased by the friend. If a group of friends purchased it, customers will think it's a good deal in terms of price.

4.3.3 Point of Sale

Currently, point of sale is defined as the place and the moment when the payment is made for the product or services rendered. Merchants understand people's impulsive purchases

and taken advantage of the last minute decisions by placing many different small items near the register so that people may add it easily to their total purchase. The paying experience does not involve any reconsideration and make it easy to pay so that more purchases can be made.

From the merchant's point of view, it is best for people to not reconsider and move through the point of sale as soon as possible. Therefore, there is no incentive from the merchant's point of view to enhance this experience beyond making it more simple and quick with least mental effort.

However, from the customer's point of view, this is the moment they are making a decision and it would be best to be guided by information to help them avoid purchasing too much or unnecessary items. Especially often times, sales people may influence them to purchase at this moment to increase sales. The mobile phone can come in most handy for the consumers at this point by providing reminders from friends and family to avoid certain purchases. The mobile phone also allows consumers to be able to compare the products in real time and contact their social network for opinions on their choices prior to their purchase near the point of sale. It can also inform them that certain purchases are repeat purchases and might create waste. At this moment, the social transaction environment can provide the virtual presence of quotes from those close individuals warning about the potential purchases, helping the consumer save and avoid impulsive purchase. Therefore, actual transaction will be impacted by the social information that is available at that moment of decision.

Cash registers may become obsolete as consumers pay immediately with their phones by-passing long lines at the register. This is beneficial to the merchants that are willing to reduce time to process transactions. However, safe mechanisms would be needed to reduce fraud or theft. A way to do so would be by allowing transactions to be verified by passing the items purchased through an automatic scanner to verify what was paid through the phone is equivalent to those items that have been scanned. In order to achieve this scenario though, it requires easy tagging of items and detailed item level information which does not usually exist in the current transaction environment. The data can be used to index people's experiences with certain products and services and provide an empowerment for

consumers, allowing them to easily share and access other's experiences.

Social transactions can also enable the application scenario where other people in need of similar or same items can ask the friend who's already in the store to pick up the items for them. An escrow method needs to be setup where it will transfer the payment when the item is received. Depending on the price and the convenience factors (i.e. how close they live from each other), this will be something people could benefit by sharing their shopping lists. TaskRabbit is a startup company that is enabling these through crowd sourcing.

One of the demos that was conceived with Open Transactions was allowing the merchant to provide a real time offer at the point of sale such as buy two get one free offer if one has a friend that wishes to buy the same item and this can be automatically communicated by the phone and merchant's point of sale system (Figure 4-5).

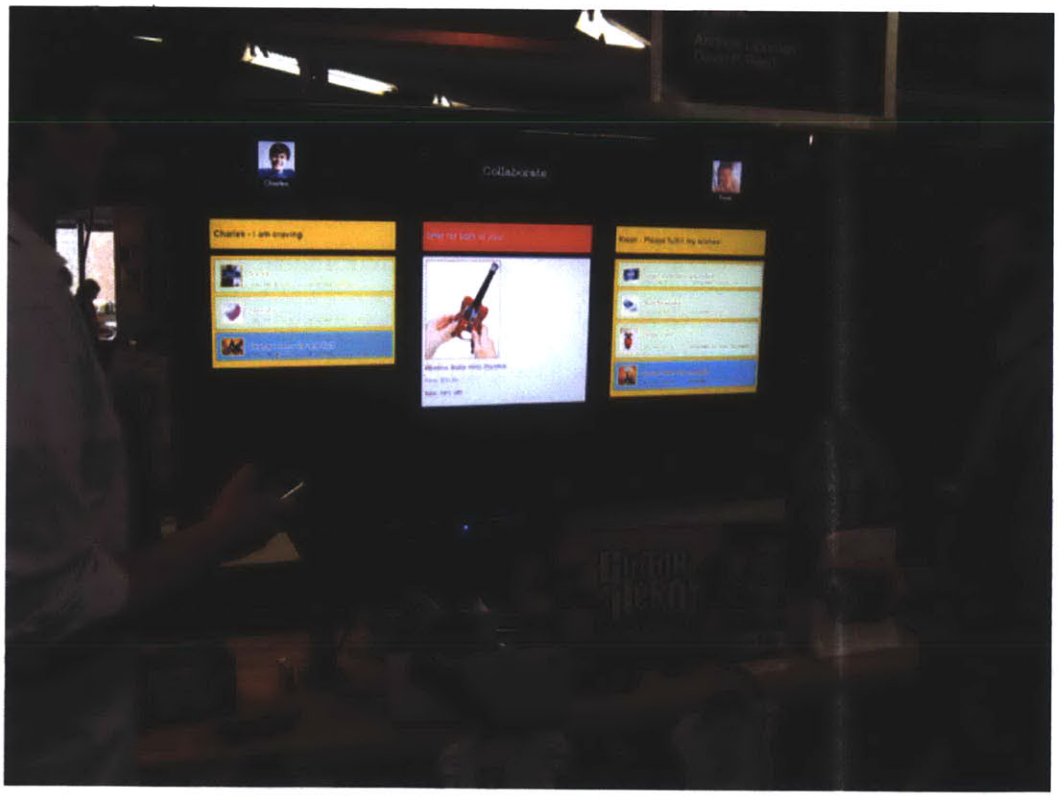

Figure 4-5: Two friends approach the point of sale (screen) and see that they want to both buy Guitar Hero. The store offers an immediate discount if both will purchase them at that moment.

4.3.4 Post Sale

I have deployed a digital receipt system (MealTime) in the real world and connected it to a real payment system (MIT TechCASH) at MIT to understand its impacts with real people. The initial hypothesis to test the impacts of social information and popularity did not result in statistically significant results in changing people's consumption behaviors. However, one of the best reviewed feature was the ability to receive immediate confirmation of the transaction on the phone and the ability to see the history of transactions on demand. This provided the students with an awareness of their spending which was not possible before. The real time confirmation service over text message has existed in Asian and European countries. Being able to access the history on demand allows people to reflect on their transaction behavior. I will be discussing more about the Reflective Commerce in section 4.5.1.

In the MealTime study, the deployment did not involve transactions of any physical products. Most of the transactions were food related (perishable products). The expanded usage of a social transaction system to tangible, durable products such as electronics and intangible products such as insurance or cell phone services would provide the participants to be able to communicate with each other on demand when they require troubleshooting or customer support. Intuit has shown how customer forums help reduce the number of customer service calls regarding their Turbo Tax product.

After a purchase (post sale), people will be able to connect with communities of people who can be real-time resources to provide quality assessments to those considering a similar purchase; to seek out guidance and aid in troubleshooting; and to ask warranty related questions. Therefore, social transactions can empower customers when they need the most help. One of the downsides of social transaction system is that people's willingness to share the transactions. However, if deployed in the real world, people could pay a premium for the service when they access it to help find others to help with troubleshooting or need empowerment to file complaints. The premium could also be paid to those who shared their transactions and increase incentives to share.

4.3.5 Current State

Mobile commerce users are more than technology users. They play dual role of technology user and service consumer. Traditionally technology adoption lies mainly in the interaction of the user with the technology. m-commerce users are customers of a business and have to pay a fee in order to receive services for as long as they remain customers of a business. Currently, m-commerce adoption ignores the effects and the power of social networks in impacting one's beliefs, attitudes and perceptions. Sociability of consumers, value added services, personalized services are not taken into account by the technology adoption model[36].

The current state of mobile commerce is governed by the bank and telecommunications companies. Large consumer Internet, electronics companies are transforming it slowly through introduction of their devices and open platforms. Industry analysts foresee that there will be waves of change happening in the next few years as the NFC based payment system gets adopted and the eco-system becomes more open with the venture backed startups attempting new approaches to disrupt the incumbents.

Looking at the adoption of mobile commerce from the perspective of technology has been a major focus, but the personal/social factors and the role of consumers is also very important due to its greater impacts in adoption as more information and more usage spreads to create social influences in adoption. Amazon had personalized recommendations through collaborative filtering and increased sales on their site by showing people that consume similarly and making additional suggestions. Social network allows a social payment system that may be utilized in different ways by allowing people to participate easily in group purchases, coordinate in accepting deals, and make it easy to track IOU's. In addition, social networks will have impact on where people go and when they buy products or services because what others do and when they do, influences people's choices. For example, the following are some impacts the social transactions may have in just-in-time behavior.

1. People will mirror their friends purchases.

2. Making transactions of authority or expert more available makes people purchase more.

3. Minor's consumption behavior can be restrained by their parents imposing virtual influence through mobile.

4. One may see how other people are spending their money (or filter by people who save more money) and utilize them as reference group to their consumption behavior.

The act of sharing transactions is still not seen as a needed aspect of the mobile commerce and services like Blippy and Swipely have shown that not a large number of people are willing to share their transactions. These conclusions are however based on several short comings. The data currently available through transactions have not shown any real benefits of socializing it. There is not an easy way to socialize only certain aspects of your transactions, while keeping some of them for premium or private use. Usually credit card transactions are downloaded in full by linking the whole credit card. People would usually not go through each transaction and decide to share or not share. This leads to the hypothesis that if people are allowed to share individual transactions at the point of sale or post sale from their mobile phones, it would allow people to engage in selective sharing behavior. In Chapter 6, introduce the Open Credit Card Framework that enables this.

4.4 Advertising

Social transactions present an environment with new dimensions to advertising. The goal of advertising is to let a user become aware of a product and service so that they may be encouraged to buy the product when the need arises or when the impulse arises. Traditionally, this is done by advertisers attempting to find services that allow targeting of advertisement by finding potential consumers and segmenting them into different demographics or preferences and finding the best means to advertise for each of those groups. Traditional metrics of advertisement has been on measuring exposure. In the Open Transaction environment, I envision that certain products and services of interest by users could be broadcast at the

right time to help the consumer get best deals for the purchases they desire to make that may be habitual or impulsive purchase. It changes the model of pushing advertisements to seeking deals just like Google did it online.

Internet advertising by Google led to a more dynamic model of advertising where what people are currently searching served as a context to refining what kind of advertisement gets shown to the users. Internet advertisers have enabled advertisers to track how many people actually view and react to their advertisements, creating greater efficiency in advertising. Mobile advertisers are trying to use similar mechanisms where they present different advertisements embedded on the web page or on the mobile application and presenting it to the user based on the current context: the application they are using and the current location.

With social transactions, it is possible to take into account of the social relationships and people's similar transaction behaviors to fine tune the recommendations or advertisements. This presents novel ways to advertise where advertisements actually happens implicitly through the friends of different degrees propagating their purchase activities through the social network. The advantage that it has is that the advertising cost becomes lower and also it engages the social network to influence and inform others. Recent survey on advertisements have shown that people trust more what their friends say about a product than advertisements from merchants and manufacturers.

4.4.1 Marketing and Social Relationships

As social networking became the most popular activity online, people started to revisit the influence of social networks in purchasing behavior. Traditional studies on consumer behavior have been done through imagined situations, trained confederates, observing people in the real world and surveys to understand how different people (friends, family, significant others) affect people's purchase decisions. With the proliferation of online social networks, various studies were performed to understand how online social information affects people's choices.

Browsing, searching and buying a product online is often a time consuming and frustrating task for consumers. [76] states how purchasing decisions are often strongly influenced by people who the consumer knows and trusts. Online shoppers wait for opinions from early adopters to reduce risk when buying a new product. There has also been an increase in traffic from social network sites to online retailers demonstrating that highly influential customers directly affect other consumers' decisions. The article concludes that we are transitioning from a transaction based society to a relationship based society.

[60] investigates how social relationships and word of mouth advocacy by influencers affect diffusion of a new telecommunication service. The research introduces the concept of *network neighbors* that are potential customers that could have communicated with current subscriber. Targeting the network neighbors resulted in 3.4 times greater adoption of the products they were marketing. However, most data is made available through surveys from online retailers which neither takes the social network into consideration nor the physical stores where the purchases were made. As a result, it points to future research opportunities in data collection based on the social network and geographical proximity.

In OTN network neighbors can be defined by people's friendships and the similar categories of purchases. The open purchases that are made public allow for mobile propagated recommendations beyond the walls of friendship. OTN allows the implicit advocacy of products and services as users publish their purchases at the time of purchase through their personal mobile phones.

4.4.2 Influential Friends

One of the goals in social advertising is to find those individuals that are most influential and those that are most susceptible to influence. Finding those influencers in the social network is an NP-hard problem[73]. Various methods are used to assess one's influence. Simple structural ways of assessing the influentials are finding high degree centrality or high betweenness centrality measures. Other methods involve their relative centrality compared to those nodes around them. Even if a node has a high degree centrality, if other nodes

around them are similar, then any advertising influence will be contained in that cluster of people.

Categorizing people by similarity is an easier problem and this can be done based on the transactions or wish lists that can be collected. When people have similar transactions or wish lists, they can be considered similar. Similar friends have shown to portray similar behaviors and similar buying patterns. This can be further refined if wish lists are collected and used to identify those wishing the same products.

An important consideration is that there is a time dimension to the network evolution. As a result, people's relationship changes and also people's preferences changes over time depending on the season, depending on the geography and life stages they are in. Such changes can be detected from the transaction behaviors. The influence detection mechanisms should always take these evolving changes into account. Those who have more recent experience should be more influential.

It is difficult to calculate and collect information about who could be influential in all the different contexts. People who are influential in one context might have totally different social network structure and behavior in another context. Individuals have different influence in different categories of products and services. People have different expertise level in different domains. Having a mapping of people by those categories and domains would be most ideal to filter and select from the social cloud. The question is how would one collect such information without creating a lot of extra work for users. One system that was conceived was Barter or Quora that allows questions and answers by people. This allows finding of people with knowledge in certain areas and it has a social network backend that provides the social relationship between people. In the case of products and services different people have different experiences and expert knowledge. However, availability of detailed transaction knowledge can serve as a proxy to filtering people with experience in certain categories.

4.4.3 Mobile Advertising

There is no metric in current advertisement models that incorporate how much users are willing to accept advertisements. Depending on their frequency of transactions in different categories, it should limit the advertisements that user gets in each category. However, advertisers that do not get as many exposure or business are the ones that are willing to reach out to people more. Therefore, providing advertising privilege by the amount of transaction one processes would be an unfair mechanism in the real world. However, it would create efficiency where marketers can know the demand size for their services more easily.

Mobile advertisements can be effective when openly shared through social network. [121] evaluates a technical system for anonymous ways of sharing advertisements and receiving incentives. eNcentive framework also looks at a peer forwarding advertisement model where peer devices propagate local promotions[106]. By having the devices relay these recommendations, it reduces the involvement of the user. The simulated reward system demonstrated hypothetically that people will get better rewards as their friends refer each other to visit the stores. It remains to be seen if such systems can be commercially viable.

Due to the mobile phones being carried with people all the time, there is less tolerance for spam and it requires more control when advertisements are presented to the user. Also, the phone has the ability to alert the user when an event occurs making the advertisements both push (like e-mail) and pull (like ads on web). Therefore, there needs to exist a mechanism to clearly control how much one is willing to receive. Another beneficial feature is to allow filters both automatic and social that helps narrow down the advertisements that one might receive. Finally, the advertisements should be sorted and matched according to a likelihood criteria that would determine a particular individual's propensity to receive.

From the consumer perspective, it would be beneficial to indicate to the advertisers to filter the ads they receive based on their transaction behavior. This leads to another aspect of OTN where it provides an API for third party advertisers to find the right target. The system would allow a certain percentage of advertisements to reach people even though

they might not transact in those locations based on similarity of products to past purchases or if anybody in the social network has transacted in these new locations.

In mobile advertisement, due to mobility, the context of relevance changes continuously. All these reviews and advertising has less value if the moment of contact is what really matters and if at the moment of contact people's choices can be shifted due to the change in context, activity and social environment. Therefore, there are several dimensions that needs to be looked at when disseminating mobile advertisements. Each activity of the user can be differently categorized by these dimensions. Daily meals, gifts and pet care activities would have very different values for these dimensions.

1. Frequency of advertisement (hourly, daily, weekly, monthly)
2. Time of the day
3. Geography scope
4. Habitual, one time or impulsive
5. Affinity to particular product or merchant
6. Social relationships and similarities in product use

In the case of lunch, usually people do not travel farther than a certain geographical area and advertisements should be geographically restricted based on whether people walk or drive to lunch. Transactions from the past can show the range of distance that one travels to eat lunch.

In general, food related items have strongest ad conversions (i.e. pizza TV ad at dinner or couch time). Focus on mobile advertising research has been on coupons and incentives but they do not directly look at behavioral changes of people. Systems that have been evaluated for performance, but less attention has been given to how users would react to such technical systems. [56] indicates that college students are quite open to accepting mobile

advertisements if there are appropriate incentives. In their study, the level of responding to an ad has been steady, as long as there are incentives and rewards.

Here are two typical examples of current demographic based mobile advertising that takes mobile real estate while providing no value to the user.

1. Weather application: Allergy relief is not needed if my transactions do not indicate medical symptoms in the past.

2. Bloomberg application: Car advertisement and financial services advertisement. My bank balance would indicate that I have no ability to purchase a car or in need of particular financial services.

These advertisements could have been either filtered by the OTN like platform if the advertisers could target based on my financial behavior. Ideally, the ads should be targeted by individual's goals and intentions. Users may have willingness to spend or willingness to save and advertisement should be targeted based on such behavior. It can also be tuned to habitual behaviors since people engage in repeat transactions that show that up to 80% of purchases can be habitual.

4.4.4 Target Advertise

It is a holy grail to predict what a user would want to buy. This is possible for repeat purchases, but for impulsive on the go purchase, this would be difficult. However, predicting how much one would spend is an easier problem. Individuals income is greatest predictor of people's spending. For a department retail store consumption, past sales behavior is a stronger predictor of future purchase. Social network data have predictive power for products that have social use that may involve word of mouth information sharing post purchase. Social network data seem best suited for campaigns that have the objective of identifying small numbers of highly probable and presumably highly profitable adopters[49].

Therefore, in order to create greatest adoption of innovation or behavioral change, marketers try to figure out the best set of people to target market so that it would create viral adoption and cascade to help spread the information to the largest number of people. Finding the influencers becomes the key in influencing the network. Traditional social network research literature estimated the influence of a node by its degrees to other nodes (higher the degree, higher the influence) or distance centrality (closer in node distance to larger number of nodes). These are structural properties of the network.

However, various algorithms to target influential nodes and heuristics to generate cascades[74] have shown that taking into account of the dynamics of the social network allows finding of better target sets to maximize influence[73]. For example, a greedy algorithm based on different edge weights show that it is better at selecting target sets by 18%$\sim$40% than traditional models. The reason for the inefficiency of traditional influence models based on network structures is because there is a large clustering behavior between high degree nodes. Therefore, if a high degree node is targeted, it is already in close proximity to another high degree node, making the subsequent targeting less effective.

If we now consider, targeting for just-in-time influence through the social cloud, an additional parameter is needed to model whether the particular node is engaged or not in the decision activity. Only a subset of the social network is involved in a particular decision activity. In the context of utilizing just-in-time social networks, targeting is triggered by someone who either searches for a product or service, or tries to make a transaction. Simple models of influence maximization and cascade models assume that when a node is activated, it no longer has a chance to get reactivated but only can influence neighboring nodes to activate. They also assume that every node in the social network is being activated with common message.

Secondly, in the case of utilizing social cloud for influence, the system is automatically selecting the set of social networks that may influence a nodes behavior. Therefore, the structure of the social network matters less and the selection of a set of social network will determine the strength and the result of the influence. Therefore, in such scenarios creating cascading behavior is not the issue, but finding the right set of people that may influence a

particular action or behavior.

4.4.5 Measuring Success of Advertisements

Natural progression to advertising are ad networks that try to target mobile consumers with ads. However, they are using ad models currently that do not map to the context or the need of each user. Having a simple mechanism to log wish lists would allow companies like Amazon and BestBuy to target people with ads related to that. Key is with so little attention span on the mobile, it is not clear what the best strategy is to target ads for mobile population. If we depict few well working scenarios, Yelp is doing a great job of presenting offers based on the restaurants of interest, which is very powerful. However, because it does not close the loop with the transaction/payment system, one cannot know the effectiveness of such ads unless the act of viewing the offer can be linked to the transaction at the restaurant.

New measure of success of advertising should be used to enhance closing rates instead of per clicks and exposures. By closing, I mean the advertisements leading to actual transactions. In order to measure the potential impacts of the social cloud in closing rates I generate a new transaction timeline based on how people's transaction behavior would have changed if social influence were maximized and if social influence were minimal. By finding these bounds, I can understand the impacts of successful influences by the social cloud.

In order to measure the strength of just-in-time social networks on people's transaction behavior, I use the MealTime transaction data to calculate those that could have been potentially influenced by others by connecting each individual's transactions with common previous transactions of their friends (Figure 4-6).

4.5 Desired and Undesired Effects

The impacts of social influence has been measured in different ways. People and businesses know that it is critical for marketing, advertising and influencing the crowd in a viral way.

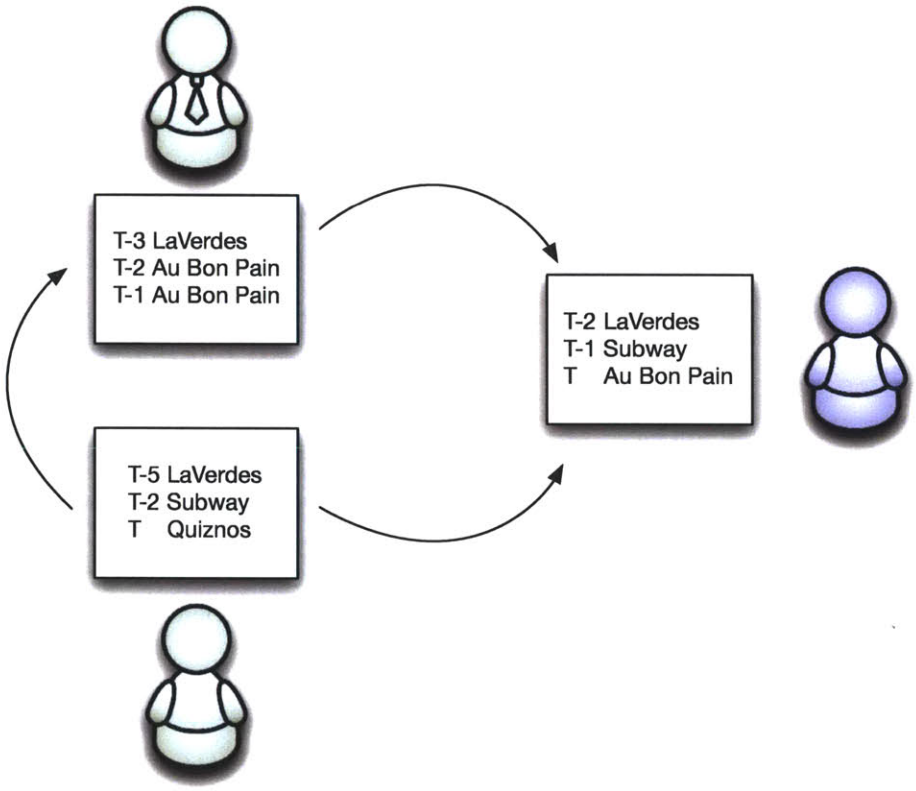

Figure 4-6: Transactions by friends from the same location on previous times can influence future purchases of friends.

However, micro-mechanisms to induce those effects, how to control the strength of its effects, and how to model the larger effects are still actively being researched.

The challenge with utilizing the social cloud is that it does not result in a deterministic outcome due to the nature of social influence. It also may be potentially abused by the businesses who are willing to utilize it for their benefit. However, there are mechanisms and architectures that can be deployed so that users have greater control on whom they are willing to be informed and influenced while preventing unwanted influence from those businesses that try to make people comply to their desires.

The benefits can be summarized from three levels. From the individual level it enables reflective commerce where the decision one makes can be aided by the social cloud and avoid any sales gimmicks or impulsive purchases. From the group level, it allows people to coordinate their shopping to engage in group purchases or to help people coordinate in meeting together or finding a desirable venue to spend time together. It can also enable merchants to be notified of such group and provide opportunities to capture their needs. Finally from the larger aggregate perspective, it allows people to be able to assess the quality of products and be able to access the most popular products, the most used product by your social network and real time access to users who have experienced the product. Post purchase, people are able to connect with other consumers to enable greater consumer power when there are problems with the product or increase reuse through collaborative consumption.

The undesired effects are companies utilizing the social forces to identify customers and utilize customer data for unnecessary sales. However, with real time feedback by consumers, services and companies that do not serve the needs of the people will easily be communicated so that consumers can avoid any scams. Sales people who are trying to abuse the system would risk sacrificing their reputation quickly due to the easy communication by the masses. However, it may also become easy for groups of people to coordinate and create group based scams that might harm individuals.

In this thesis I assumed that the social network selected were specifically focused on the goals of the user. However, it is possible that the selection layer could be compromised and

the social influence could lead to negative influences away from the goals. The user will most likely be aware of this over a period of time. It is a future work to understand the negative impacts and how strong those social networks will pull one away from one's goals and design of security architectures to support them.

4.5.1 Reflective Commerce

Less has been explored about the effects of giving people feedback about their spending and how it changes or affects their behaviors. There has been many innovations that relate to changing the color of the credit card, changing the stiffness of the wallet depending on the bank or balance on the wallet. De Tar explored ways to intervene people when they approach near the location of spending by utilizing the phone as a means for intervention. No extensive study has been done beyond exploring the design and usability with few people.

There are many tools that provide the users with the ability to think and reflect or get feedback on their personal finances. However, though people are good at reflecting on data and rationally deciding what they need to do, many times these decisions do not get carried through when the time of decision comes. What if the social network or group could actually help and impact these decisions in real time? By notifying others about the potential spending, suggestions and recommendations on whether to purchase or sign up. Such augmented application is what the mobile can provide to the existing payment systems beyond just processing payments.

Real time feedback is key to designing a more compelling mobile experience, and finding use for real time feedback - such as keeping the user conscious and aware of spending, finding products and integrating the search with payments. Our study have shown that there are ways to simulate future consequences and provide people feedback so that they may be able to reflect before they actually make the decisions. With regards to the social information, it will be most effective to show the individual friends that have made particular decisions in order to help individuals spend longer time to decide.

4.5.2 Discussion on Security, Privacy and Authenticity

Privacy issues can be dealt with by sacrificing the details available from the data. There are privacy issues related to the sharing of the transactions and making them available to a third party or to the businesses. The information contains the time and location of one's activity making it possible for people who are following one another to know where they have been in real time. Such issues have been raised during the Meal Time deployment where participants have indicated that delaying the availability of time of transaction or hiding it completely can be a possible design choice to make it more comfortable for people to participate.

Security can be enforced through a service that secures the data and provides an API that allows access to the features of the data without revealing the details of the data. Security becomes an important issue due to the valuable and detailed information that is available through the open transaction network.

A distributed mechanism to enforce security could provide an architectural way of providing security to the end users. Such mechanisms can be implemented with the necessary infrastructures in place to route and discover content. However, new protocols need to be developed when computation with the data are required, making the API potentially more complicated.

Finally, the social information can be fraudulently manipulated from the client side application. Either not showing the correct social information or selectively showing the social information. Such misuse leads to different outcomes for the customers and therefore a verification mechanism is needed to verify that the client application has truthfully displayed the information. It is difficult to enforce such usage, so it is important for the application to communicate with a secure element or secure service on the client that verifies that the social information is true. Another feature that would be needed is the ability to show or hide the social information so that the user can make a real time comparison of whether they find certain social information more useful for their decisions.

4.5.3 Potential Commercial Applications

The real world deployments have provided insights on integrating social information with applications and particularly with the payment systems and ordering systems to measure the effects of social information on actual transactions. There are many means for tracking effects of social information on online behaviors by tracking people's click through rates and using cookies to track people's actions. However, when it becomes to bridging the online and the offline world, currently it requires active action from the user such as keeping track of a code and reporting the code during the transaction or taking a picture of a QR code or scanning it at the point of sale.

The social information can guide people when people search for particular geographical area for places to avoid or places that must be visited. User interface design for such applications are implemented in Google Places application, however, it only provides user contributed ratings and comments which are not necessarily reliable and are only backed by those users that actively comment and rate. Linking it with the real transactions and the actual dollar amount spent can provide a more reliable measure that is more quantitative.

In the case of enabling flash sales, the merchants can trigger flash sales and the social cloud services could direct those flash sales to only those people who may most likely engage. Such service requires knowing the likelihood of a person buying from that store or engaging transaction in those categories. OTN can provide a measure for not only the individual but for a cluster of people and allow the flash sale to be targeted to that group. However, for those participants who want to feel more exclusive and different, such behavior can be assessed from the transactions and allow them to be excluded from the targeted flash sales.

One of the design elements that I described in the previous section is the ability for the user to toggle between showing and not showing particular social information so that they can experience in real time how those social information are affecting the choices. Such toggling capability can provide the user the power to assess the impact of the social information and reflect on it themselves.

4.6 Summary

Transactions in the real world are vulnerable to attacks by compliant officers and involve navigating the space unaided by the experienced. With the availability of the Internet enabled smart phones, this experience is changing as users continually seek out the necessary information and are able to reach out to any experts on their social network in real time by calling or messaging.

When I was shopping for a car 10 years ago, the only way I could make myself equipped to face the sales person is buying pre-sales research, reading through a lot of expert articles, and printing out consumer reports on the car model that I was planning to purchase. When I went there with my mother, we still were not capable enough to negotiate strongly on the price and features of the car. We were vulnerable to the looks of a displayed product and the big sales sign which led us to purchase the car right away. The second time I went to buy a car, I had few friends that had experience purchasing the car and they went with me to negotiate and helped me to restrain from purchasing right away. The third time I recently went to purchase a car for my niece, I was equipped with a mobile phone and as I was dealing with the sales manager, I was continually reaching out to those friends that have purchased the same car, while doing research on the mobile web on the true price of the car without having to do any prior research before heading to the car dealer. I was able to come out of the dealer shop with $2000 less in price from what they originally quoted, but still confident that I can get the price further down in future negotiation.

Mobile advertising was discussed to describe the constraints that mobile phones provide when traditional advertising models are used. Instead of spamming people with unnecessary advertisements, Open Transactions framework can enable "need based" advertisements that provide those businesses greater opportunities when they can meet the needs of the customers just-in-time. This leads to more sophisticated loyalty programs where businesses are not only trying to increase sales by providing individuals with exclusive offers, but allowing the businesses to continually communicate and react to people's financial behaviors. Those that can use the data to provide more customized services for the individual's life

style will thrive in the open transaction network environment. Those that try to abuse the network will quickly be condemned by the network of consumers.

I have also argued for the mobile phone as an augmentation for existing payment services rather than trying to compete and replace. Such augmentation will be decision aids to people's financial decisions in the real world. The social capabilities would allow access to the social cloud in real time and create real time flash mobs that may not only benefit the businesses but also the consumers themselves by giving them power to engage in group optimizing purchases. In the next chapter we project further into the future and provide a framework to rethink communications from personal to social perspective.

Chapter 5

Social Communication Services: From Personal to Social

In this chapter, I would like to generalize social transactions and reflect on how communication networks, devices and interactions can change to support just-in-time social cloud. The thesis defined the concepts and architectures for mobile phone as a social influence platform and presented the architecture of the just-in-time social cloud. I demonstrated how social transactions can serve as a vehicle to utilize the social cloud and how the social cloud can affect people's decisions. The transactions served as a means to propagate social influence. We can generalize these transactions as a representation of exchanges that have been made by individuals in the social network. Revealing these transactions to each other transmits behavioral influences. This leads to the mobile phone serving as a platform for social influence. Traditionally, communication technologies focused on optimizing transfer of bits through the network. In the theory of mobile phone serving as a social influence platform, the phone is transmitting relational forces as the events and activities about others get communicated through the phone.

The thesis work leads to a social architecture for mobile interactions. The architecture inherently supports relationships through interest based networking on various dimensions of social, temporal and geographical proximity. User interfaces to query, vote and filter on

these dimensions are necessary to support interest based networking. Applications for such systems arise around social recommendations, social advertising and group coordination in the physical world.

The design of social communication service involves supporting the social cloud by providing multitudes of virtual connections rather than a single connection. Every layer of the communication system is designed to bring people and resources together to aid the current decisions or needs. The key elements of social communication service design are:

1. Interest based architecture where necessary entities are grouped by interest and based on the current interests (intentions, goals, activity) the connection is automatically established with the necessary entities.

2. Relationship based architecture where establishing, maintaining, updating and utilizing relations are an inherent component of the communication system.

3. Fluid architecture that makes the communication system evolve and adapt dynamically to the current goals, interests and context since supporting dynamics of mobility is essential.

5.1 Interest Based Networking

Interest based networking supports an open extensible architecture for community based mobile applications with dynamic participants in a geo-local context. It is an overlay network that supports hybrid (3G, WiFi, DTN's) connectivity. Nodes can join and leave by subscribing to interests from the client side. In the mobile case, interests are broadcast to notify the existence of interests. Clients can add or remove interests they receive. These actions manage their membership to interest spaces instead of explicitly joining certain groups.

There is a fundamental dichotomy between doing things for one self versus being a member of a community. Many computer and communication services have dwelt on the individual:

personalized media, personal services, personal communications. Traditional communication networks focus on connecting static end points or static groups whereas real world communities are fluid with changing number of members respect to the time, place, interest and sociability (Figure 5-1). With the mobile devices we are starting to hyper-coordinate people and resources, forming dynamic groups that grow, evolve and disappear with time[84].

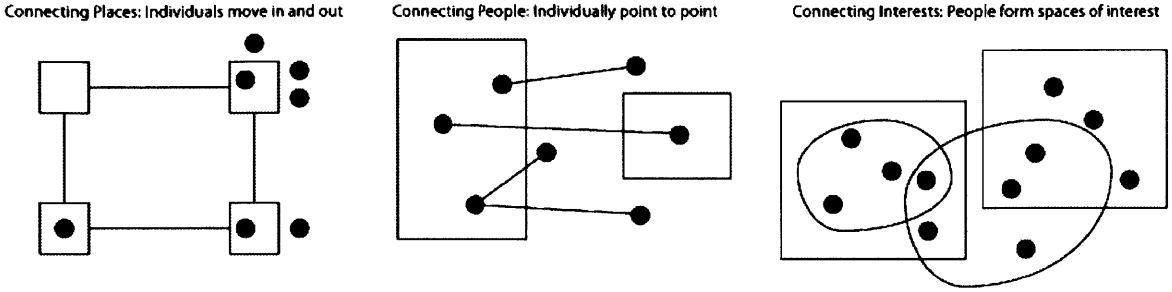

Figure 5-1: Traditional networks connected places making it possible to reach distances. Mobile communication directly connected people-to-people and interest-based networking attempts to connect to groups of people based on their current interests. Squares denote spaces and dots represent people.

Interest based networking uses three dimensions of proximity to negotiate sharing of interests and information. The social dimension determines the participants filtered by their interests, social network or general public. The geographical dimension determines the relevant location and range. The temporal dimension determines the time span that the interests or information is valid.

Interests are a set of tags that indicate short term and long term interests. In the Social Saver, long term interest would be "savings". Short term interests could be wish lists or things to do. Several sources are used for obtaining user interests: Manual user input like Twitter, transactions by users (Open Transaction Network), existing sources such as Facebook (for long term interests) (Figure 5-2).

Interest based networking design is conceived from people naturally aggregating towards homophily. Normally, it is difficult to captures users interest because of the need for people to manually enter this information. Over the years though, a lot of data has been collected and shared through online social networks, and also through the transactions people make

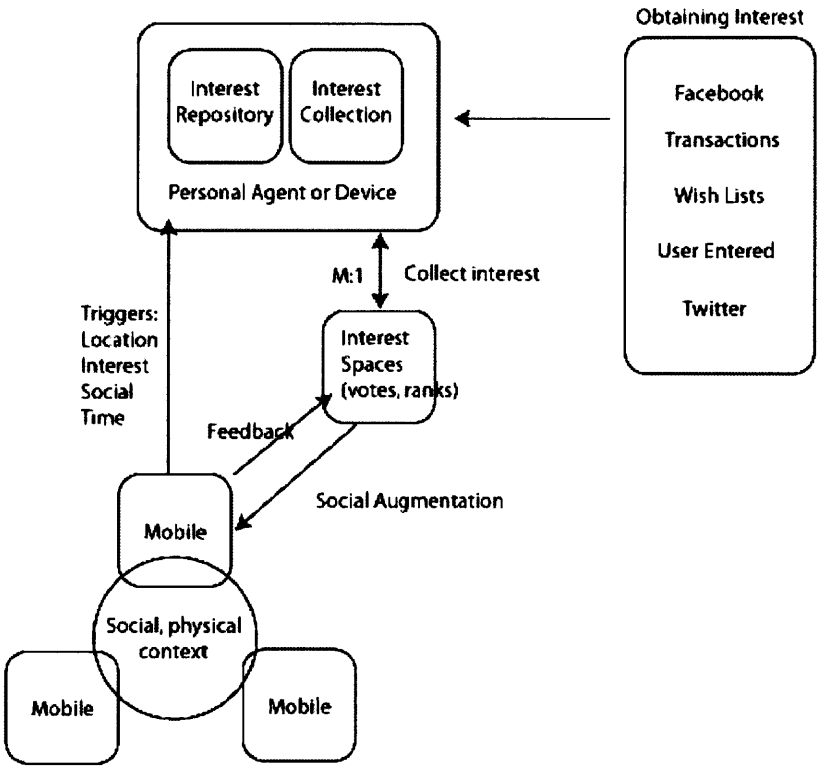

Figure 5-2: System architecture for interest based networking

in their lives. These data feeds are readily available with user's consent. Such information can be used in an open transaction network to match and find people with similar interest to help people in the following activities:

1. better informing people during their physical context or decision making
2. group coordination - purchase, political action, claiming warranties and rights
3. customer demand planning for businesses
4. location (in-time, in-place) based alert/recommendations

Interest based networking is used to manage dynamic communities that are formed based on individual's interests (Figure 5-3). In the case of Open Transaction Network, communities are formed around transactions. For example, we mentioned previously that Social Saver is an application around "savings" community. The community size and the members change with where you are, the time of the day and in different contexts. Some people may be always part of the community because they are very trusted. Networking and social networking is done in just in time manner.

These interest based networks that are goal driven can be useful for helping people change their behaviors. These interest networks will filter just-in-time social information to help with the goals of the user. Users may utilize push to listen interface to filter the people that they are more interested in listening to.

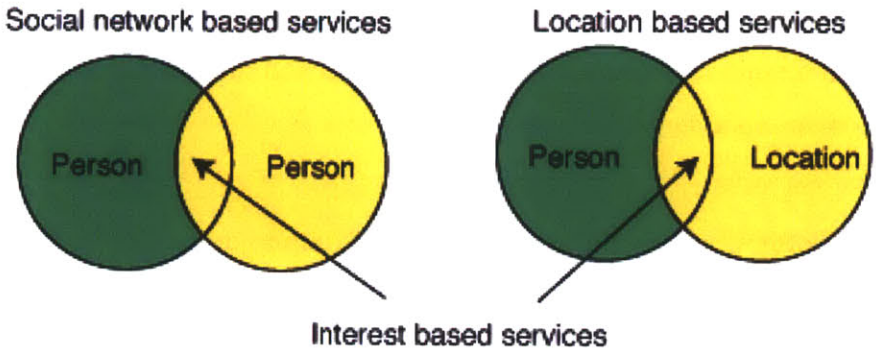

Figure 5-3: Location based service focuses on individuals and where they are. Social networking focuses on static groups of people. However, our interests change dynamically with people and location. Interest based services focus on the intersections that bring together people, device, and current context to support dynamic groups with common interests.

```
<interest>
        <category>savings</category>
        <content>Save $5 on baby stroller</content>
        <social>Public</social>
        <geo>City</geo>
        <time>Always</time>
        <id>23432555</id>
</interest>

<interests>
        <interest>
        </interest>
        . . .
        <interest>
        </interest>
</interests>
```

Members who have similar interests are assigned to common interest spaces. In the case of Social Saver, people will be related through "savings" space. Content related to those

interests (coupons, saving tips, alternatives, future sales) will be routed through brokers or epidemically as user moves around.

5.2 Comparison with Latest Mobile Networking Designs

Web services over existing data network (3G, WiFi) require users to explicitly request for content. Even though wireless connection is used, neighbors need to explicitly request this content again to get access to it. In the interest based networking case, devices broadcast public interests and neighbors who hear it can subscribe to it. When data for the interest space is available, it is delivered to those nodes that have subscribed to it.

Interest based networking provides a late binding publish/subscribe like service, so that subscribers are dynamic. The interest spaces can be registered with a global server, or it can be registered with a local broker that only serves a physical area, or among neighboring nodes in a distributed manner. Content who's metadata matches an interest space will be pushed to those nodes that are subscribed to the interest space.

Intentional naming system uses descriptive language query to discover resources in proximity without having to know specific addresses[1]. It is similar in that it expresses an intent instead of specific hosts for discovery. In interest based networking, we are using human interests to discover people.

The content filtered location based publish/subscribe system[22] has similar architecture but more distributed in delivering data and filtering it at the end point. When clients subscribe they specify the content and location filters to filter what gets received in what location. The published content is also directed to certain locations and it is matched with the location filters in location tables to determine whether to propagate the content further or not.

7DS[119] system has demonstrated the performance of e-mail and web content access in disconnected networks through collaboration of neighboring nodes to relay the content to

the Internet. They have shown reasonable performance for e-mail and better than nothing result for web access.

Haggle[117] provides a data-centric architecture of supporting opportunistic networking for data transfer applications. It presents pocket switched networking where data is transferred through the mobility of people. In the interest based networking architecture, we take it a step further and use the social interest information as the data sinks and sources. We also expect high availability of 3G wireless and WiFi for local broadcast of interests.

To better understand interest based networking, I compare it with publish/subscribe systems in Table 5.1.

Table 5.1: Comparison of interest-based with a location-based publish/subscribe system

Attributes	**Location-based publish/subscribe**	**Interest-based**
Discovery	Directory	Directory or Opportunistic
Channel	Unicast	Broadcast/multicast when possible
Address	URLs	Interest Spaces
Routing	Point-to-point	Epidemic, profilecast
Architecture	Client/Server or distributed brokers	Hybrid and distributed brokers
Proximity Dimensions	Location	Location, Time and Social

When people are on the move, the groups will dynamically change and existing static group models are not appropriate for such environment. [54] proposes a dynamic model that incorporates room model, friends model and tree model which can be used for different communication contexts. Interest based networking changes the group (interest space) dynamically with who they are with, where they are and the time of the day. By using interest spaces, participants can be aware of similar interests of other participants enabling social recommendations and opportunistic interactions with each other.

5.3 Relationship Based Architectures

Communication theory perspective on telecommunication[82] describes two models of communications. The *transmission or transportation* aspect of transmitting bits and the *community, cultural and ritual (CCR)* aspects that encompasses the sharing activity, participation, association and fellowship. The former is about movement of messages in space, the second is about continuity of human existence in time. Traditional networking on the telephone, Internet and the wireless has focused on the transmission aspects to make the connections. With the emerging social networks layered and hosted on top of these networks, supporting the evolution and understanding of the community nature of communication is becoming more important.

Focusing on the transmission aspects of the design has resulted in point to point connections that are transaction based. Ethnographic analysis of existing communication devices promote the need for a relational design[2] in new communication systems. I hypothesize that the communication networks with relational design can evolve with people's relation to other people and services to provide a better architecture for many communication modes, especially for mobile social interactions.

Relationship based networks are based on the premise that the information bits travel through the social links and that there is a social memory between people, resources and devices. These information have the social context based on who generated the information and that social context can create social influences that transmit relational forces. An example is transmitting the activities such as events that are happening, recommendations on job opportunities or purchases made. Those people that are related to a particular person through a relational network would receive that information. Such connectivity allows transmitting of relational forces.

If many people are transmitting such updates it becomes important for the user to determine which information they would filter and use. Such activity induces social influence as people are using the social information and navigating through the choices. On-demand "push to listen" interface allows one to have a manual means to select particular people whom one

would be interested in listening to and be influenced.

Relationship based networks naturally capture the communities that are formed in the real world by keeping track of time and history of encounters and individuals of different interests and cliques. The interests are represented as different information categories and user profiles that map to these interests so that those who have particular interests could be easily found. User profiles would filter, subtract, intersect or union interests from interest spaces to find out whether the particular user should be included or excluded from the interest space.

Where you are and who you are with influences the context. When users are always connected through wireless connections, there can be a mix of people in proximity and afar that can influence their actions. Mobile Internet makes information readily accessible and online social networks readily reachable. However, current usage patterns are dominated by people filling dead times during walking, traveling, and waiting[103]. The most actively used application is e-mail that is used to communicate with others who are usually unrelated to the current place, time and context.

In this thesis, I presented an architecture for social mobile systems to answer the following questions:

1. In what mobile context can social augmentations be helpful?
2. How can we use open social information to augment physical interactions?
3. How do you trigger appropriate social information from whom you trust, experts, friends or general public?

The answers to these questions guide the design of the future social mobile applications that fluidly merges the social network to the physical mobile spaces.

I approached the problem by collecting open social information from the social network sites and from mobile users and mapped it to the physical contexts of the mobile users to evaluate in what contexts the social information influences the physical world.

5.3.1 Small World

Recent research in social networks have shown that small world[97] phenomena exists in many real world networks such as the network of acquaintances, network of actors in movies and network of contacts in the physical world. It is very common for us to meet people in a party with common friends and backgrounds. This implies that information that one is interested in might be relevant to other groups of people that might be in physical, social, temporal or interest proximity.

Insights to these small world networks have been further enlightened by data from e-mail, the web and the telecommunications networks. This has implications in the spread of disease, news and rumors. These networks also show clustering behavior where neighbors have common neighbors. These clusters form community structures[100] where common interests drive the formation of these communities in social networks. Interest based networking takes advantage of these social structures by utilizing interest information to filter, negotiate and distribute content.

The set of social networks in the real world is a small subset of the larger sets of social networks. The virtual social network used for just-in-time social network that is projected into the physical world is also a subset of the larger social network. The important element is to access the most important virtual social networks related to current activity and influence actions in the real world so that people can make decisions that are beneficial or oriented towards their long term goals.

5.3.2 Necessity for Interest Based Networking

The social communication aspects introduce design challenges of rethinking existing networking from multiuser perspective and challenges of user interfaces to manage different events generated by people in proximity and local services. Any communication link between people usually require a negotiation model to decide on connectivity. Opportunistic communications require a negotiation model that is more dynamic than existing models

due to the changing mobile context, the changing number of participants[123] and possible common interests between those participants. In opportunistic communications, the communication is triggered by the change in physical, temporal and social settings and events. Traditional network architecture and protocols that make explicit connections and transactions are designed to be agnostic to such context.

Assuming every user has a mobile device that can detect the context and the relational history between devices, then the devices can have an open connectivity with each other to respond to any opportunistic events that can happen. If there is a fire in a building, one of the devices may send out an emergency broadcast so that neighboring devices can relay this message to others until the geographical region around the fire (in this case, the building) is notified about it. It also may notify people who are planning to head to the building to divert their paths.

In another case where people are trying to find time to reach each other, such as significant other's that want to connect regularly for 5 minutes few times a day, it can automatically alert the user about open availability of such channel. When a distributed family members want to quickly catch up 10 minutes once every week, it can automatically connect them.

Beyond connecting people, interest based communications could facilitate coordination between people and transporation. It can manage people and transportation more efficiently through micro-coordination: redirecting transportation to meet the needs of social groups and enabling micro coordination[84] to happen in real time. If a group of people need to go from one destination to another (i.e. commute ride share) it notifies the individuals at what time they may be picked up as the devices communicate with each other and the transportation system.

When an emergency situation happens, it must be possible to notify multiple entities in your social network to notify of the emergency. If a dear family member cannot be reached during Virginia Tech like incident, people should be able to notify others in the vicinity for information or ask the family members to be reached via alternate channels. Existing communication facility enabled by the cell phone can be programmed to notify people in

the contact list, but connections have to be made individually over the circuit switched network[18]. In the case of relational networking, users can define the information forwarding rules depending on their relational proximity, physical proximity and the expertise of the users.

5.4 Fluid Architecture to Support Proximity Based Interactions

Proximity based services become more prominent as the devices start to understand what we want in a physical local context. Mobile advertisements will be pushed to the device according to user's interests. People will be able to connect naturally with people of similar interests[134]. Devices will be able to detect presence of similar interests in proximity. Such proximity oriented protocols will help people through the formation and maintenance of connections among people, devices, resources and services of interest.

Existing publish/subscribe systems allow mobile devices to subscribe to certain news and services with ability to probabilistically forward to handle dynamic network topologies[109]. They are based on explicit publish and subscribe models, maintaining static subscriptions that do not take into account of where and when the users might want such information. Therefore, a more dynamically controlled publish/subscribe system is needed that accounts for location aware[22] and opportunistic needs.

If my car has slipped on the ice and requires towing, even though I am subscribed to an insurance I need to call them and report to them. With a more dynamic model it must be able to automatically notify this incident to a nearby towing service, notify to a set of friends for possible assistance, and if any of my friends pass by, notification is sent to them so that they can pick me up and drop me off at a nearby rental facility.

5.4.1 An Instantiation of Ad-Hoc Social Communication Service

In order to demonstrate the fluid and interest based social communication service, I have implemented Fluid Voice, a mobile group communication system that pushes centralized services to the edge, onto the mobile device. The system maps emerging and developing styles of social intercourse onto a technically responsive and realizable architecture. This provides an infrastructure free and extensible communication platform to foster community applications and social interfaces by presenting a novel group communication system which contrasts with the traditional model of point to point, hierarchical networking that assumes connectedness and static configurations.

The architecture and the user interface supports dynamic network configurations and disruption tolerant operations. It has the capabilities to handle contents in live and archived modes in parallel. The group communication environment that I propose takes advantage of limitations in mobile ad hoc networks by utilizing the inherent broadcast nature of wireless, the mobility of people for connected and disconnected operations and the incentives for cooperation in communities to share resources. The end points use socially mediated aggregation as the means to scale. Social mediation means that more demanded content will have higher priority over less demanded content when scheduling wireless channel access. It evaluated the impacts of cooperation of individual end points on the performance of communication, resource sharing and information dissemination. The value of an open communication system, its extensibility and its usefulness was explored.

Fluid Voice was conceived to be used in ad hoc network environments, but the interface can be extended to infrastructure and particularly it implements push-to-listen interface that allows one to push a user or service in order to access their activities or listen to what's happening to them in real time (Figure 5-4). It is a social communication service that provides real time communication with those groups of people that can help with current activity. The communication is less about connecting point to point, but a "we based" communication. "Push-to-listen" interface allows selective connectivity to those people, services, or groups that are most important to current immediate needs.

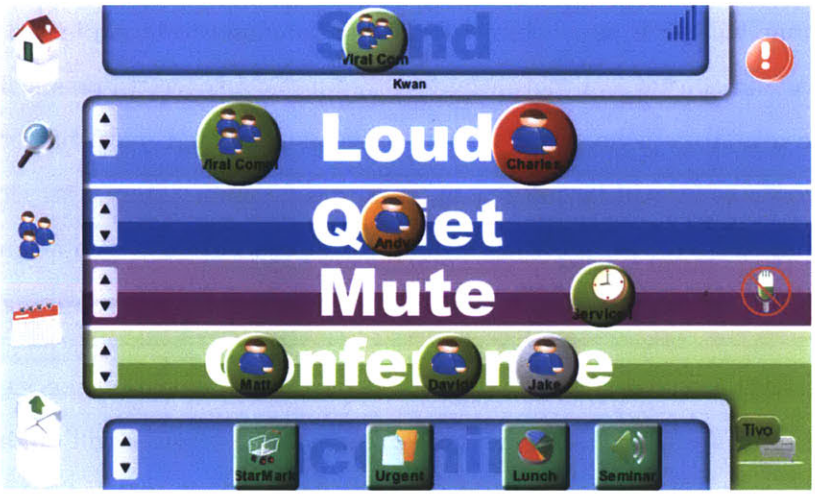

Figure 5-4: Fluid Voice: provides interface to push-to-listen, ad-hoc discovery of nearby people and services, and aggregation of people to groups.

The platform also provides a proximity based audio advertising. Stores can have their own audio messages that are broadcast from their particular location and advertised to those who pass by in the surrounding. The architectural benefit is that it can be setup easily with audio servers that are distributed, grass roots and decentralized. Fluid Voice can be aware of these advertisements through interest based networking and provide presence of them to the user. Those users that are interested can tune into the audio advertisement by push to listen interface. The more people tune in, the more bandwidth is provided to that particular store's advertisements. The control messages notify the server that there are n people listening in. Users can also provide a real time feedback so that the stores can adjust their offers to increase customer attention.

5.5 Discussion

Nowadays, many of the content we consume are being socially augmented. The news we read, the e-mail we read, the electronic books, the objects in the real world, the products that you are trying to purchase online and offline will be labeled with who else consumed it. The just-in-time social cloud will surround every object we access. In the short term,

the mobile phone will serve as a channel for the social cloud to be projected until a digital aura of social cloud can be easily projected to the physical space. Interests that match you will always be available to help you to be better informed and make better choices. The information you receive will be filtered by your social cloud. The social cloud will range from people you think of, people you care for with close intimacy, people that will hinder or encourage your decisions to just general population that have overlapping interests.

In this chapter we discussed how we can build a social communication services that provide an extensible application platform. Social communication services will enable capabilities that have not been possible in the past such as word of mouth tracking, automatically connecting to the people, objects and resources on demand while delivering filtered content through interests and social networks. The connections will be dynamically tailored to the current physical context, activity and the decision that is being made and projected onto the physical space.

The relationship based design allows creating and managing of different types of communities based on your activity such as purchase interest, hobbies and history of people and places visited. The relationship based networking optimizes on reaching and communicating with people that are related. It is most useful for diffusion when having to propagate news. However, for covert operations or secret communications, it would not be useful. It has been shown that in those cases the communication network structure is usually very hierarchical and star shaped. Indicating that traditional point-to-point architectures (telephone network) that form hierarchical architecture are more adequate for these communication patterns.

In the following chapter, I dive into the social transactions that was developed and deployed to understand people's transaction behaviors. The Open Transaction Network is a manifestation of interest based networking where financial transactions serve as interest elements.

Chapter 6

Social Transactions

After my internship at Bank of America in the summer of 2007, I came back realizing how much data is being collected through the transactions that happen through the credit cards we have. Those transactions include recurring payments, necessary purchases and discretionary purchases. Recurring purchases such as cell phone bill or utility bills are deducted regularly. The amount indicates whether a person has used these services beyond normal. Using this information, researchers have found out that people can be nudged to save energy when the energy consumption behavior of their neighbors are openly shared[124].

Necessary purchases such as grocery, food and transportation are necessary for survival. It indicates habits of a person. Discretionary choices such as clothing, entertainment and travel indicate potential trade offs that the user incurred in order to engage in these activities. Some of these necessary and discretionary transactions involve impulsive purchases. Impulsive in this context means unplanned and decisions made in a particular context in just in time manner. For example, one might have gone to a shop for some gloves and found a 30% sale on pants. The shopper did not need more pants but from past experience, the pants on sale was a great deal and the shopper decided to buy a pair of new pants for future use.

In this chapter I describe how I have been motivated to design social transaction systems to understand people's choices. My summer experience at the bank led me to realize how credit

card transactions embedded choices people have made through the value, the date and the location of the purchase. However, the information captured by the bank was mainly for accountability and had its limitations of not necessarily identifying what the purchased item was, what motivated the purchases nor particularly what time of the day it was purchased. The system was an artifact of old days when they could not transfer too much data, nor handle continual real time updates and required to batch upload transactions.

Also, it was impossible to understand how an individual's transaction behavior related to their friend's or their social network's transaction behavior. Finally, it made me envision the future of mobile commerce where people would use their phones to engage in purchase activity and the social cloud will be present to guide their decisions. And as they make these choices while navigating the world, richer information could be captured and shared through the social cloud. The impacts of this social cloud in those in-time and in-place decisions is an open area for research to better understand how social networks could impact human behavior.

These questions motivated me to develop a social transaction system, the Open Transaction Network that was used to capture people's purchases from the mobile phone and share it with the social network in real time. The results from the pilot deployment showed that food related transactions were the most easily shared and captured. Subsequently, two additional systems, the MealTime system and the SocialMenu system were developed to capture people's transaction behavior and just in time social influences. In the following sections, I will describe more in detail the design and implementation of these systems and the experimental approach that I devised to measure how people's choices relate to their social network and how others influence people's just-in-time choices.

6.1 Open Transactions: Benefits and Challenges of Sharing Transactions

In mobile commerce, numerous work has been done on providing people with just-in-time information for price comparisons, planning people's shopping routes and managing digital

payments and coupons. Location aware shopping[10] focuses on navigation and availability of products in shopping malls and delivering offers in proximity. Project Aura shows how tagging of the physical world items from the mobile can help acquire just-in-time information in mobile commerce settings[14]. The system had features to publicly share reviews and annotations with the public, but the effectiveness of such social information was not evaluated. Object aura[118] is an object annotation system that links physical objects in the retail environment with online content. It discusses the potential utility of extending it to social networks, but has not implemented it to investigate its implications of sharing and the possible data mining architecture for inferring user's interests. Through Open Transactions Network, I extend these efforts to understand the design elements of incorporating social networks in mobile commerce contexts.

6.1.1 Transactions as Experiences

In order to understand people's willingness to share with their friends and public, we performed an online survey that showed 10 products with their name, brand, price, location and asked whether people would share the purchase with their friends or public. People were on the average 15% more willing to share with their friends than with the public (Figure 6-1). For products that were on sale, people were 23% more likely to share with their friends and 10% more likely to share with the public ($p < 0.05$). Among the different attributes: product name, brand, location and price, people had the least inclination to share price with others. *This implies that when designing a system that shares purchases, it is best to keep the price information under user's control.*

To investigate this further and explore the implications of connected consumption, the Open Transaction Network was designed and deployed to capture people's choices in a distributed manner. People make choices every moment of their lives, but most of the time, it is not easy to capture their choices and moreover how they make those choices. However, their choices are captured through the actions they take. An aspect of their actions are represented through transactions. These transactions embed experiences about different products and services. Each transaction embeds an exchange with a third party and also a decision that

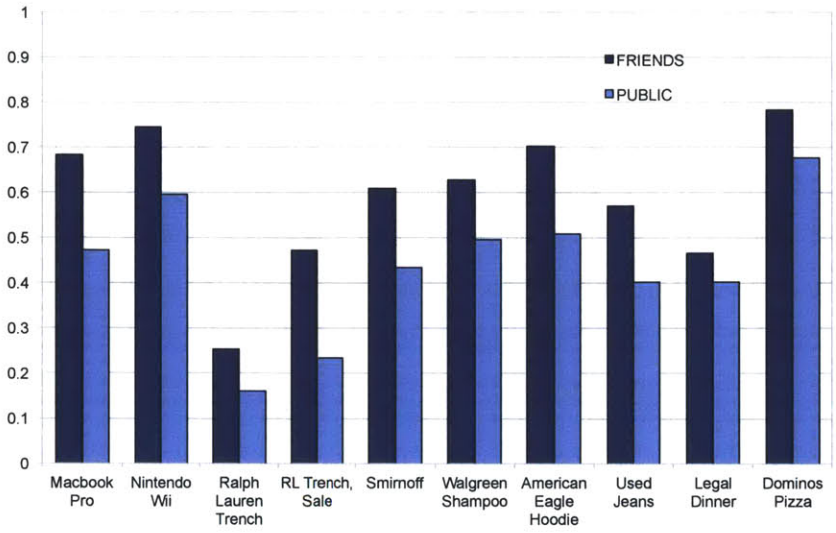

Figure 6-1: Survey of 240 students at MIT and Harvard on their willingness to share with friends and public for different products

a person made, sometimes trading off with other choices that one could have made. OTN is a platform for researching mobile social network and its impacts on commerce. The Open Transaction Network was developed to facilitate sharing of transactions and to utilize those transactions as links to enable connected consumption. OTN in the simplest sense opens up many of the decisions we make in the real world to other people. This experience is shared and made accessible to others, making it efficient to search for people with particular experiences.

The theory of embedded markets[41] describes how a purchase behavior is influenced by the social relations that are embedded in those transactions. The total return from the transactions increase or decrease the relationship strength between sellers and buyers depending on the satiation of the transaction. Data on these transactions can provide insights to these social relationships. Unfortunately, most of the time the seller maintains the history of these transactions with very fragile records (paper receipts or personal memory) maintained by the buyer. Amazon.com and Netflix has been successful in opening up transactions of people with similar purchase behaviors for collaborative filtering and provide users with recommendations during shopping online.

More importantly, the lack of social network information on the social relationships and the people who made similar purchases, make it difficult to understand the possible influences and social causes for the purchases. In the case of OTN like architecture, the open transactions and the social network of consumers can be used to investigate the horizontal embeddedness due to diffusion, gift exchanges or auctions that may bind consumers to each other.

Traditionally people are not open to sharing their transactions and the bank serves that purpose by tightly keeping data private. However, anecdotally people talk about their purchases of products and services with their friends, family, colleagues and coworkers creating word of mouth phenomena. This phenomena has been purely social and is considered one of the strongest influences that affect people's purchase decisions[13]. OTN is a means of systematizing this by allowing people to share their purchases when they make certain purchases. Such novel attempt introduces many questions. How can you quantify the benefit and weigh the harm against the benefits? What kind of privacy is lost by people?

6.1.2 OTN Pilot Study

An iPhone application to log transactions and a web service was developed as initial pilot of OTN. The system was used for approximately five months to collect over 600 transactions from over 20 people. This represents on average about 15% of transactions of the participants. Volunteers from Bank of America were recruited to participate by providing them an iPhone and a data plan for the length of the study. About 50% were married and details are described in Table 6.1. In this section I summarize the findings from the deployment and share the insights I gained from the collected data.

6.1.3 User Interface

The original goal was to collect itemized level data that is usually not available in credit card statements or online banking. However, the data we collected did not have desired details due to people's difficulty with manual logging on the mobile phone. For example, for

Table 6.1: Participant demographics

Parameters	Min	Max	Median
Age	23	55	38
Number of children	0	3	1
Total transactions[a]	50	over 400	250

[a] Approximate purchases made during trial period per person beyond those contributed to OTN.

Italian food, users simply recorded 'spaghetti' instead of the full dish name. For groceries, many people entered 'groceries' instead of specific items that they bought.

The application would have been more effective if data entry was minimal. A more user friendly design would be for a user to take a photo of his/her receipts and upload it. Details can be filled in through a connection with the merchant or via crowd sourcing.

The collected data contained geo-information for location based filtering. As shown in Figure 6-2, the purchases were geo-coded so that they would naturally be useful information for those specific locations. Our initial design did not proactively make other people's purchases visible at pre-sale. One could see the list of people who had purchased the same item or had the same item on their wish list after they have logged the item. People found it most helpful to know this information when they were buying gifts for others, or when they had to choose a wine at a restaurant. The main advantage beyond a Yelp like service was that a recommendation was available from *known* people and the system could be generalized beyond just restaurants.

At the time of the trial, 3G was not universally available and many indoor locations did not have adequate cell phone coverage or WiFi reception. Therefore, it was necessary to implement persistence on the device so that items logged were stored and uploaded the next time the application acquired a network connection. Since locations were not tagged due to lack of GPS coordinates when there were no GPS, WiFi or cell signals, it was necessary to estimate coordinates from the location name or previous entries. This constraint is a limitation with using the iPhone, since on Google G1 (Android phone), GPS coordinates

Figure 6-2: Geo-coded purchases

using background process can be regularly tracked and used to estimate locations.

6.1.4 Individual and Group Behaviors

The primary benefit of OTN is that it networks people with similar transactions and also informs of the social distance. Individual profiling can be performed from participants' open transactions. Each individual in the study was represented as a vector of 16 values representing normalized fraction of purchases in 16 categories. The basic use of this information is to create a signature of financial behavior. The transactions recorded in OTN are shared with friends and the public depending on the user's sharing preferences at the transaction level. Not only does this approach allow for comparisons with friends but also with other individuals in different dimensions. Participants in second degree and third degree friends are readily viewable through OTN.

Participants indicated it would be most useful to compare their information with people of similar income, similar family size, or lifestyle since these people would have useful information about stores of similar interest or sales of interest. In contrast to anonymous

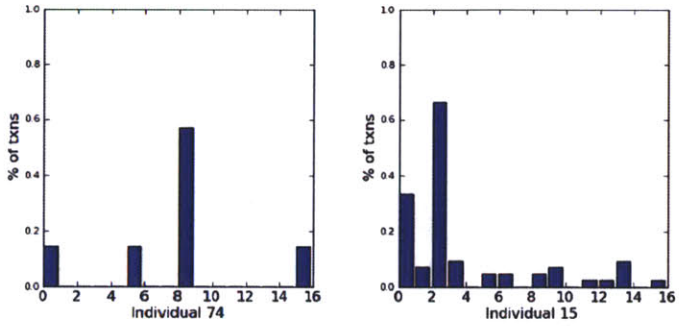

Figure 6-3: Two different individuals with purchase behavior in different categories. Individual 74's purchase is skewed towards electronics. Individual 15 is skewed towards groceries.

recommendations on the web, by adding the social distance information, it has the added advantage of judging the reputation of the recommenders.

In order to understand how purchase behaviors relate to social relationships, we calculated the mean squared distance between the transaction vectors. Transaction vectors can be calculated in several different ways. It could be based on the locations one visited, the category of items one purchased, the time of the day purchases are made or the day of the week. In the case of OTN we use the purchases in categories as vectors to represent individuals (Figure 6-3).

We found that the behaviors of individuals compared to their social network of different distance was divergent on average. Figure 6-4 show that the structure of the social network makes the second degree friends have more diverse experience than if it were a random network. By comparing the vector distances, we found that the social network relationship does not provide any information about how similar friend's purchase behaviors are. One could explain this from the fact that they are coworkers and each have very different life styles. However, this also means that new product/service related information could be easily obtained from the social network due to the social network having knowledge about products and services that one might not be familiar with.

We refer to the "second degree social network" of an individual user as the collection of users who are either friends of friends. This second degree friends are particularly special since

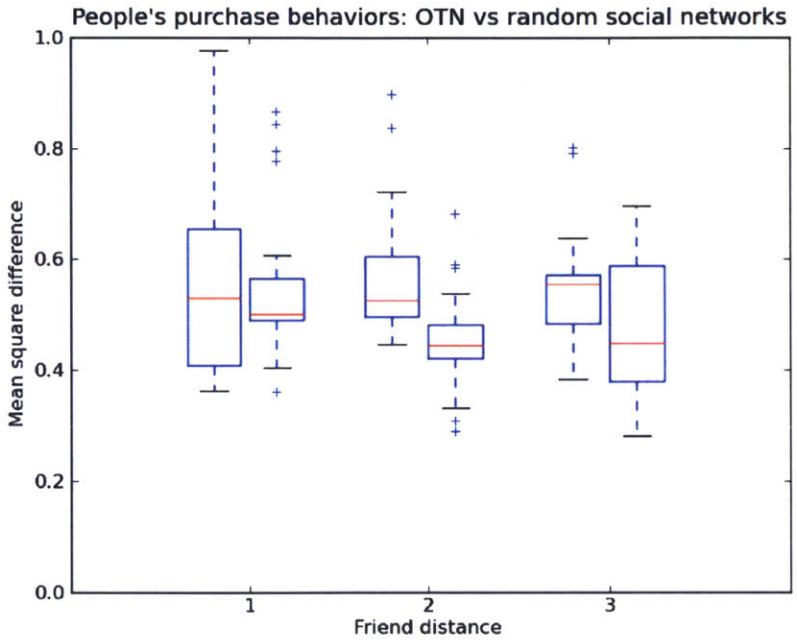

Figure 6-4: Second degree friends can provide most information. Transaction behaviors related to social distance (0 very similar, 1 very different). First set of box plots are empirical data collected from the real world social network of OTN participants. Second set of box plots are from participants connected through random networks. Second degree friends are significantly different from random friends ($p < 0.01$).

they can potentially provide significantly more recommendations. Compared to a randomly generated social network, the empirical data shows that the second degree friends can supplement the most amount of information (Figure 6-4). By comparing the empirical data with randomly generated social networks, we find that the purchase behavior of second degree friends in the OTN trial are statistically different ($p < 0.01$) from random social networks. Therefore being able to reach the second degree network more easily may provide more valuable information for the consumers. This is due to the real world social networks having hubs that bridge different groups in contrast to random networks.

The Open Transaction Network can also be used to analyze group behavior and identify the shared experiences from people's consumption data. The sequence of events also form a behavioral story of individuals and of the community. The transaction timeline (Figure 6-5) shows much more activity as the December holiday season was approaching. The 2 week cycles of large spending spikes, aligned with the bi-weekly pay cycle of the company in which the participants were employed, illustrates temporal group pattern in consumption.

6.1.5 Social Network of Recommenders

Figure 6-6 illustrates the social network of participants in the OTN. These were identified by participants adding people they knew through the OTN website. The color gradient shows the different number of friends with darker circles having larger number of friends. Subjects 15 and 19 form the hub of the social network.

The OTN community shows the benefits of open (shared) transactions versus closed (not shared or shared only with direct friends) transactions. Normally we are only connected by 1st degree friends in the real world or with a lot of random reviewers on the Internet and somewhat through word of mouth to 2nd and 3rd degree friends. By connecting people via transactions, we can see larger community (friends of friends) of people that can share their experiences for common category of purchases. Through OTN, people have trusted visibility to other participants' transactions in the social network and the OTN community.

In the small community of participants in current study, a range of 4 to 14 people purchased

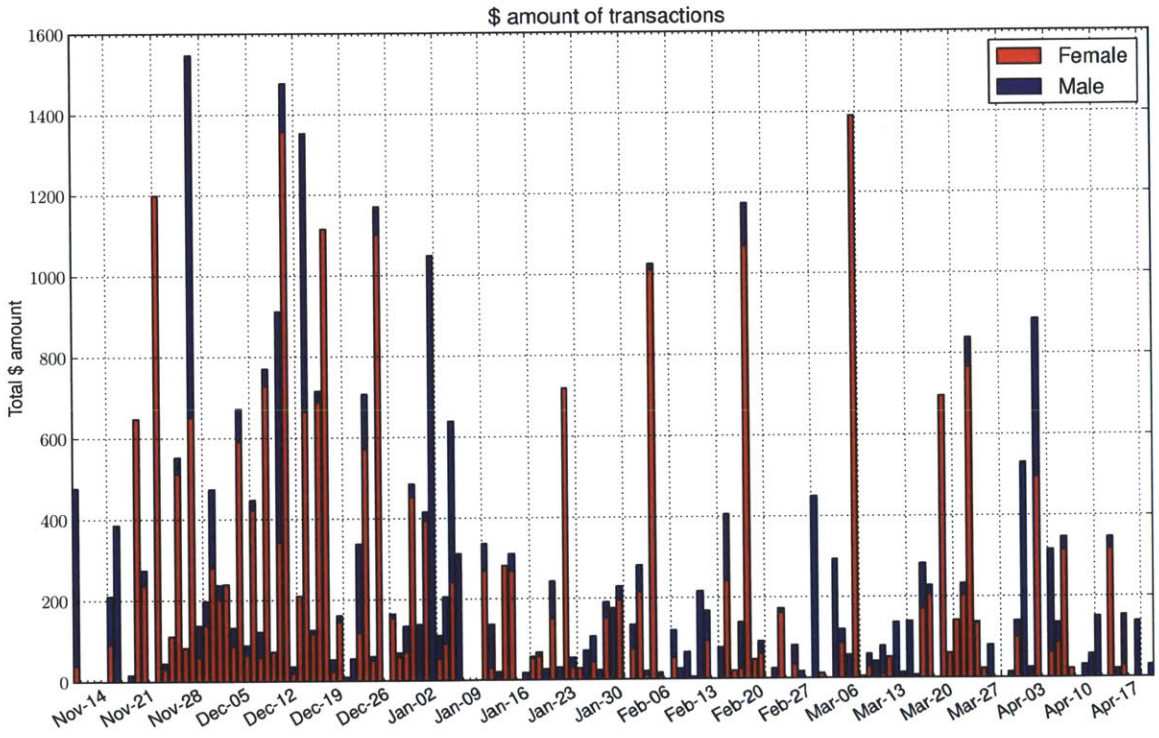

Figure 6-5: OTN transaction time line from November 2007 to April 2008

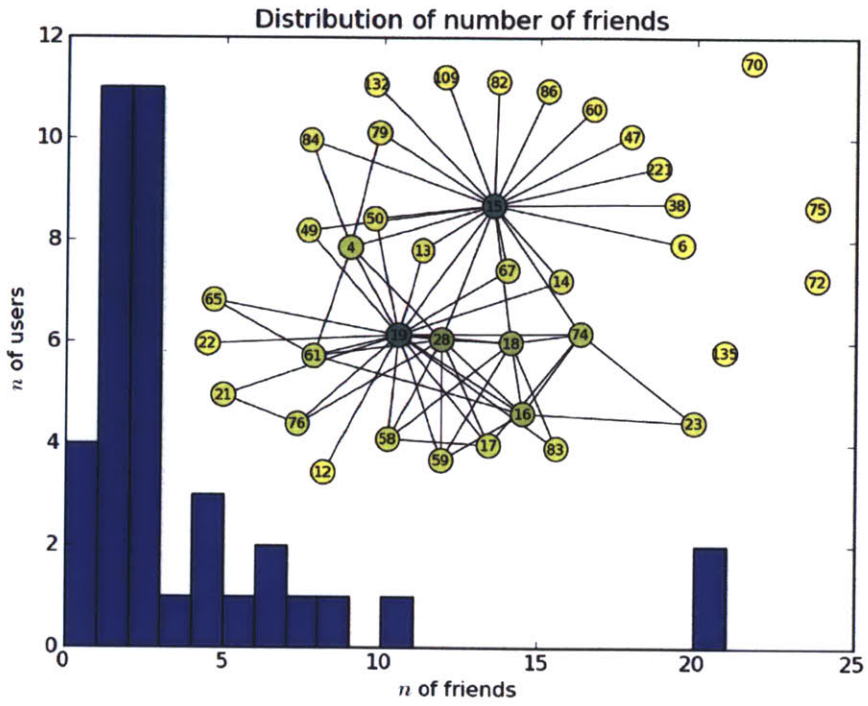

Figure 6-6: Social network of participants and degrees of friends in OTN

items in common categories (Figure 6-7). We define the *potential recommenders* for an individual to be the people in OTN who have a purchase experience in the same category before the individual's purchase date. The greater potential recommendations from 2nd degree relationships is especially noteworthy. If one were to seek information in a typical social network, one would have to ask a friend to refer a friend for information. However in OTN, the openness of the platform provides a direct link to a community of known, trusted recommenders and reviewers through similar transactions, making information equally accessible even to those who are socially disadvantaged.

The actual utility of these potential recommenders may vary depending on the product category. Those product categories that have greatest uncertainty about the quality would benefit the most from these recommenders who have past purchase experiences. Categories of products and services that require experience, denoted as experience goods[63], such as food, auto mechanics, medical services, plumbers and clothing would benefit from greater number of trusted second opinions. The benefit of OTN is that these are people who have

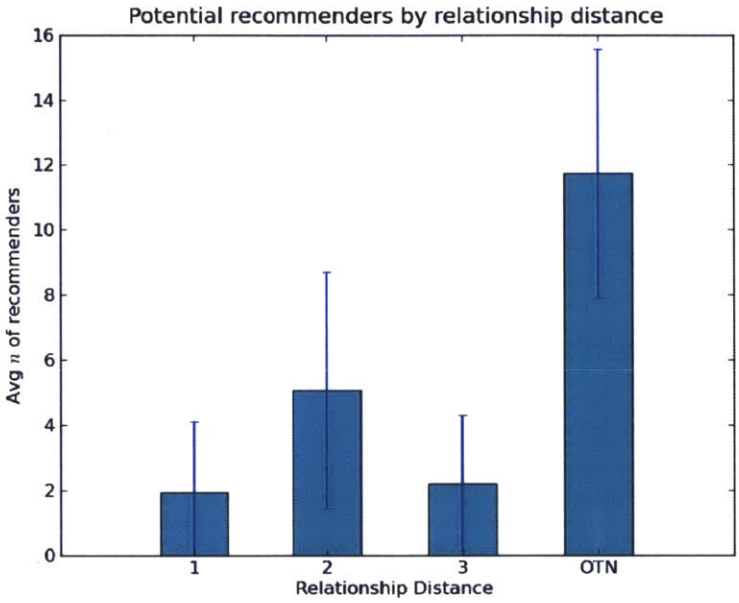

Figure 6-7: Mean potential recommendations from different social network distances (1st, 2nd, 3rd degree) compared with OTN (when connected through common transaction categories). Whiskers indicate the range of data.

actually purchased these goods or services and are potential friends or acquaintances. Also, if one has a high degree of friendship, each individual's opinion might not carry the same weight. As a result, those that have lower number of friends might actually benefit more from OTN by being able to filter information through first and second degree friendships.

6.1.6 Sociability Threshold

With digital mediation, we can capture the extent and the willingness of people to reveal themselves. Information revelation and self disclosure through computer mediation[95] show that reciprocity is a key factor in users' revelation. Development of online social networks has led to emergent styles of openly sharing one's personal information for various social motivations: ease of connecting to new communities, exhibitionism through open content, and lightweight maintenance of social relationships. Ease of connecting with people online is shown through Facebook where 30% of people are willing to accept strangers as friends permitting their profiles to become open and visible[52].

A key research question that results from OTN is about dimensions of people's willingness to share: if users are willing to contribute their data, then for which categories and under what conditions are they willing to reveal to others? Though the experimental trial was done with a small group of people in an organization, it revealed some insights to these questions.

OTN has four categories of sociability: private, friends, community and public. In the case of the mobile scenario, OTN attempts to allow users to control sharing of their transactions in different contexts since, unlike the online context, offline context is dynamic. Users decide whether certain purchases were shared between friends, community (people who purchase in similar categories) or the public.

OTN users participated in the sociability survey (Figure 6-1) after the OTN trial. The OTN users had an increased willingness to share with friends (20% increase) and public (30% increase) about their purchase information after the OTN trial as compared to the those that did not participate in the trial (Figure 6-8). The least difference between the

survey groups was observed in pizza and the most difference was observed in expensive items such as "Ralph Lauren trench coat on sale" and a MacBook.

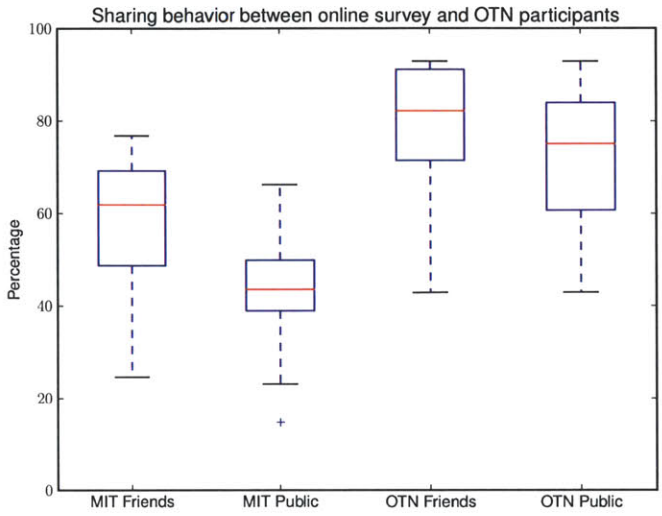

Figure 6-8: Online Survey: comparison of people's willingness to share with friends and public between OTN trial participants and non-participants ($p < 0.05$)

The sociability threshold is a measure that indicates that there is a price threshold for each category of products that users are open to reveal and accept recommendations from friends. Dining, coffee, groceries, entertainment, fashion were the top categories that were openly shared by people (Figure 6-9). Categories purchased less frequent, for example electronics, were less likely to be openly shared. From interviews we found that people were not willing to share their pharmacy purchases since these purchases may reveal personal health issues.

Post interviews revealed that people would like to be able to find other friends and community participants that are actively purchasing specialized items such as electronics, pet accessories or wine. Another subject mentioned that she wanted to purchase a gift for her 12 year old niece and it would have been extremely helpful to obtain recommendations from their friends who have experience with gifts for that age group. Finally, one participant commented about her avid wine consumption which she did not publish on OTN due to potential misinterpretation by her colleagues.

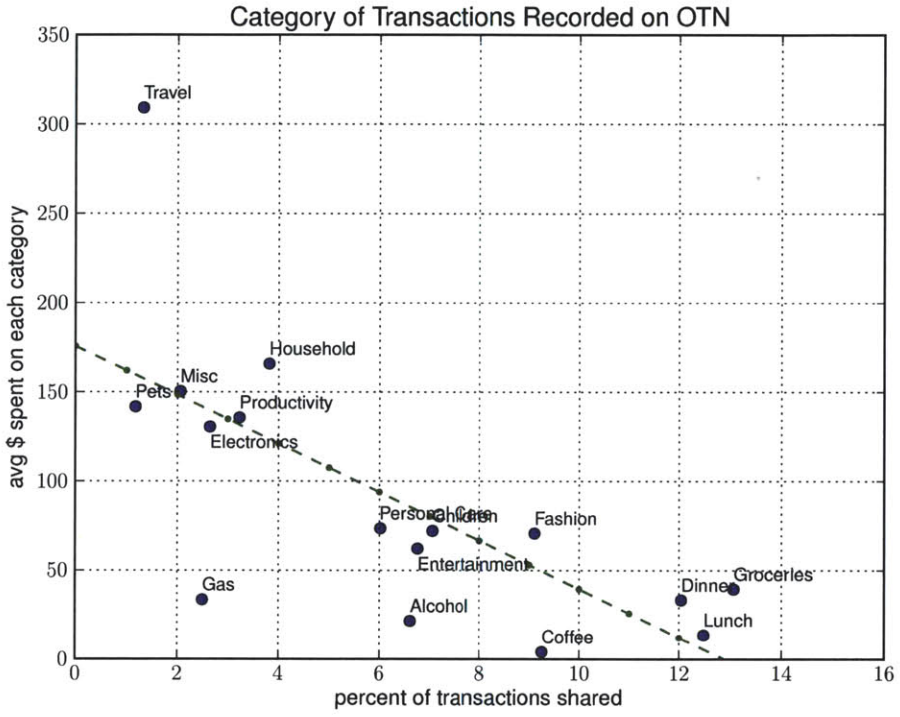

Figure 6-9: Sociability threshold: correlation between average price of product categories and percentage of items shared (Pearson r=-0.75)

Some people feel uncomfortable sharing every aspect of their activity but some people feel comfortable doing so. Our work focuses on identifying implicit advocacy through users posting their purchases on the OTN and making the purchase log happen at the time of purchase through their personal mobile phones. **When the Open Transaction Network was provided to share transactions over mobile phones, people were willing to share transactions in different categories with sharing behavior that was highly correlated with average price on each category.** In order to investigate this further I integrated with the MIT's TechCASH payment system and created MealTime to assess whether shared social transactions could provide just-in-time influences to change mobility behaviors. I discovered that there's a exponential distribution in the inter-visit behavior to same stores indicating that most purchase behavior is habitual, with very small percentage of behaviors that divert from the usual locations. This agrees with the previous studies in shopping trip behaviors where they find intershopping trips to happen mostly within 7 days to 14 days[70]. Due to habitual behavior driving people's mobility behaviors, just-in-time influence could be most useful for small set of these transactions. In order to understand further the dimensions of this social influence I designed the SocialMenu and deployed at a local restaurant to capture just-in-time choices at the restaurant.

6.2 System Architecture

Two systems were built on the principle of OTN and iPhone applications were deployed for the users. The MealTime system automatically logs MIT's TechCASH transactions among the participants and their social networks while providing a digital receipt (confirmation of purchase) and a view of their friends' purchases. The backend of TechCASH system was developed by CBORD to support prepaid card system across the campus. The SocialMenu system captures the choices (items ordered) and browsing behavior of a digital menu at a local restaurant (in this case Legal Sea Foods) and provides different social perspectives on previous orders. The main difference is on the data structures and the details of a transaction. In the MealTime system, the following are captured: the location name, the $ amount spent and the date time. Users have a mobile interface to comment and rate their

purchases.

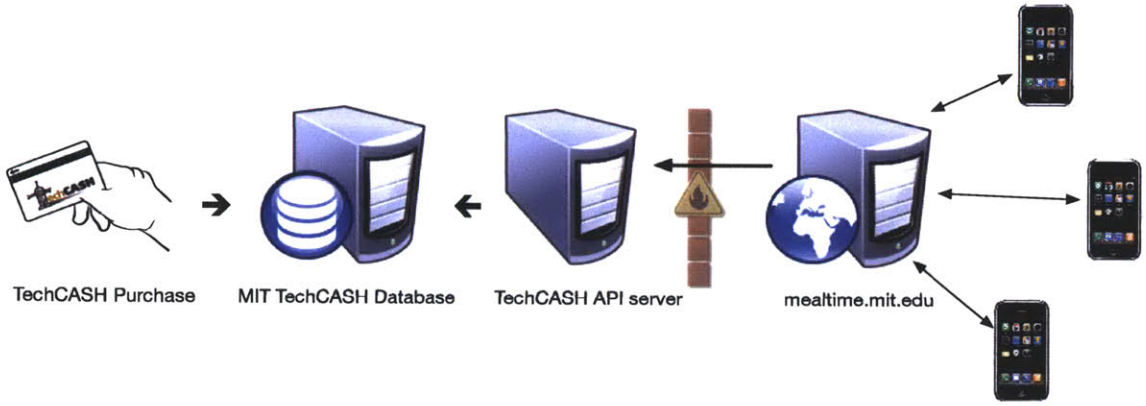

Figure 6-10: The architecture of the MealTime system. It was designed as a digital receipt system that allows people to track their history of transactions from their phones and get confirmations on their transactions.

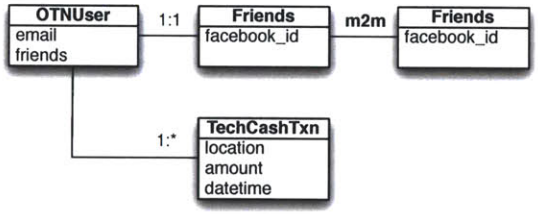

Figure 6-11: The core models of the MealTime system.

In the SocialMenu system, the dishes are pre-populated and users browse through the menu. The system captures their orders and the timestamps that capture when they have added the items to the cart. The architecture of the Social Menu system supports any type of menu allowing it to be extensible to any restaurants. The data structure contains Store, Category, and Menu Item that are a very common structure that applies to any restaurant menu. The system was not linked to the actual ordering system so we had to ask the participants to finalize their orders by manually adding items to the cart in the digital menu application.

The social features were made available randomly to certain patrons that were assigned to the social experimental group upon logging in to the menu at the restaurant. The just-in-

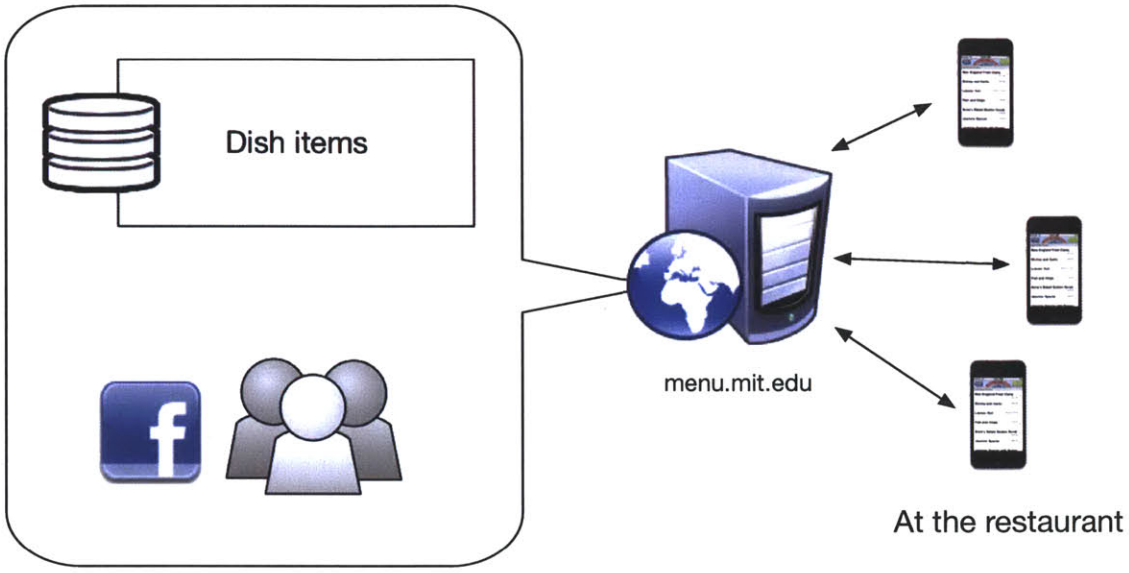

Figure 6-12: The architecture of the SocialMenu system.

time social cloud is presented by querying the orders made by others on-demand as people are browsing the menu. The social cloud is updated in real time as people add items to their order. Such feature would be useful in commercial settings where people can see in real time which dish is popular or what dish their friends have ordered in the past to guide their choices.

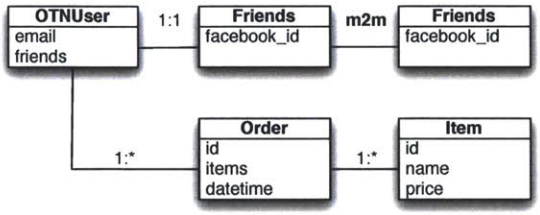

Figure 6-13: The core models of the SocialMenu system.

Figures 6-10, 6-13 illustrates the core user and transaction mapping. Beyond these models, there are supplementary models to support reviews, interaction events and surveys.

6.3 Experimental Approach

SocialMenu and MealTime experiments were conducted to measure the effects of mediated timely, virtual social influences. The SocialMenu application was used to experiment and capture people's in-place, in-time behaviors. The MealTime application was used to capture people's near future decisions of deciding on where to go for their meals inside MIT campus. Each experiment was composed of multiple experimental groups that have subtly different view on the mobile applications. Depending on which experimental group users were assigned at a particular time, they were presented with different social information. This setup allowed me to evaluate the differences by comparing the behaviors among the different experimental groups. Each experiment had a website (http: mealtime.mit.edu and http://menu.mit.edu) where subjects first signed up and consented to participation. Periodic surveys were also distributed through the website for participants to answer them. The website had an additional feature where people could rate and review their purchases if desired. Unfortunately, this feature was not widely used due to the narrow scope of the experiment.

[57] provides a framework from the literature of psychology on how people's choices are impacted by the internal and the environmental factors. These result in internal responses and external responses. Particularly, when people are making choices, conflict may arise internally and such conflicts lead to feeding back to revise values, beliefs, intentions and preferences. However, observing such internal revision of values is out of scope of this study. However, observing the external responses is the focus of this study. We observed this by capturing people's browsing behavior through the menu. As we compare the time to order, price of items, participant's social context and their resulting choices, we find that their external responses can be clustered into categories of behaviors.

Mobile phones have evolved from communication to computation and sensor network platforms. By capturing how users interact with their applications: queries, inputs, transactions and responses to social information on the mobile, we can learn people's behavior in the physical world. Through the mobile application, we can do reality mining[102] instead of

using surveys and imagined situations as existing research have done. We utilize our existing open transaction platform to collect data (location, communication, comments and access logs) from the mobile for different groups in commerce settings to measure and identify how the social information affects our decisions.

6.3.1 MealTime

MealTime is a digital receipt system in the real world that was piloted to investigate the effects of such augmentation to payments and in order to understand the effects of mobile social information on individual choices. The system consists of ways to capture user's just-in-time and in-place choices. We walk through the design, implementation, usage and learnings from the deployment of the system. The results show that mobile phones serve as interactive means for people to be aware of transactions in real time. The social information in various forms presents virtually mediated social influences that transfers over time and space. Existing theories of social influence do not apply directly due to the virtual influence lacking bidirectional forces when mediated through the mobile phones.

In the MealTime experiment people at MIT were recruited to participate in evaluating a digital receipt system that allows one to keep track of their transactions from their iPhones. Digital receipts are considered to be a great idea for the consumers. People collect receipts for accounting purposes, but also because usually they are not sure what to do with it. The current paper receipts are an artifact of legacy payment systems where they did not have the functionality to confirm transactions in a digital manner. Imagine all the paper that could have been saved if receipts were never printed. However, there are no clear business incentives for companies to generate digital receipts. One of the goals of the MealTime deployment was to evaluate people's reactions to such service.

However, the real intention of my research agenda was to capture people's choices and whether people being exposed to other people's transactions from the phone guided them differently in their transaction behaviors. Committee on Human Subjects was informed of this intention and approval was made before the experiment was deployed. The goal was

to observe people's behavior in the real world. The collected data can answer a simple question such as whether people's lunch times are regular or irregular. But also allow us to understand how it relates with their social network.

6.3.2 SocialMenu

Similar to MealTime, the SocialMenu study did not actively reveal the social experimental aspects when recruiting the participants. The participants were informed to participate in a Digital Menu trial to evaluate menu user experience on an iPhone. People were randomly assigned to 1) control, 2) friends, 3) popularity and 4) group of friends experimental groups when they logged into the digital menu at the restaurant after they were seated at the table.

The goal of the study was to **understand how timely, in-place social influences affect choices during uncertainty.** The experiment investigates the impact on choices when peer influence is virtually propagated through the mobile phones and presented in just-in-time manner. Effects of just-in-time social cloud and authority in in-place choices can be measured by capturing the browsing behaviors. Depending on the experimental group, the mobile application presented information of peer's choices made at the restaurant.

In the SocialMenu study, participants filled out a presurvey to indicate what their favorite dishes are before coming to the restaurant. This information was used to assess individual's taste and also to assess how people diverted from these choices when they were actually at the restaurant to consume and pay for the dishes.

The following were some of the hypothesis I believed could be investigated through the deployment. First time guests will be more socially influenced, while repeat customers will most likely have their tastes and favorites. Repeat customers may utilize the friend information to expand their tastes. However, they will not be as influenced in the popularity groups. I also compared people's choices during the presurvey with the choices they made in the restaurant when intervened by the just-in-time social cloud.

6.4 Collected Data

The following data points are logged at the time of purchase in MealTime. 100 people participated, but only 80 people actually had food related transactions.

1. Login to the mobile application
2. The latitude/longitude if the phone has location enabled
3. The views they see, the social cues and the choices they click through are recorded.
4. Transactions: location name, price and the timestamps from the transaciton.
5. Friend network through Facebook.

It enabled collection of 7647 transactions related to food and dining. In total of 15573 total transactions were collected that includes washer/dryer and other administrative services around campus.

The following data points were logged when users used SocialMenu. 326 people participated and over 700 dish orders were recorded.

1. Subjects will be given a table code to enter and login time is timestamped.
2. Presurvey data on people's favorite 5 dishes and their tastes
3. People's order browsing behavior based on the clicks of different categories and menu items that they considered.
4. Presentation of social cues: the number of people and type of social information presented
5. People's order time based on people's login time and the time when subjects finalize their order. The time difference since login time is used to measure uncertainty.
6. Friend network from Facebook.

Given the data, the following section discusses the potential insights that could be gained and its implications. I dive into deeper analysis in the following chapter where I attempt to answer some of the key questions addressed in this section.

6.5 User Participation

One of the contributions of this thesis work is building systems that could be freely deployed in the real world for user participation. However, this process did not come without pain. It required several iterations of debugging in order for the application to become robust and usable in day to day lives of people. However, multiple iterations of improvement led to a robust set of tools that would allow user to easily sign up, download the mobile app and participate in surveys without requiring too much human support.

Providing incentives for people to participate and letting people know about the existence of the service was a major challenge. For MealTime user $10 TechCASH was raffled each day. For SocialMenu, $10 subsidy was given to individuals. At the end of each trial an iPad was raffled to have people fill out post surveys. One of the issues found was that raffles are not effective when doing recruitments that involve social networks, because people are discouraged from inviting friends since it lowers the chances of winning the raffle.

6.5.1 MealTime Recruitment

The participants for MealTime were recruited through e-mail lists and posters across campus. The most effective recruitment happened when we had a flyer posted in front of each store that accepted TechCASH. Most participants were undergraduates that used TechCASH and had an iPhone. The two overlapping requirements limited the number of participants.100 people participated in the study and during the trial they were presented with different feeds that portrayed other people's purchases differently.

The control feed just showed the stores in alphabetical order. The popularity feed showed the most purchased locations in the past week. The friends feed showed what their friends

were purchasing and the friends group feed showed the group of friends that were purchasing without their real names.

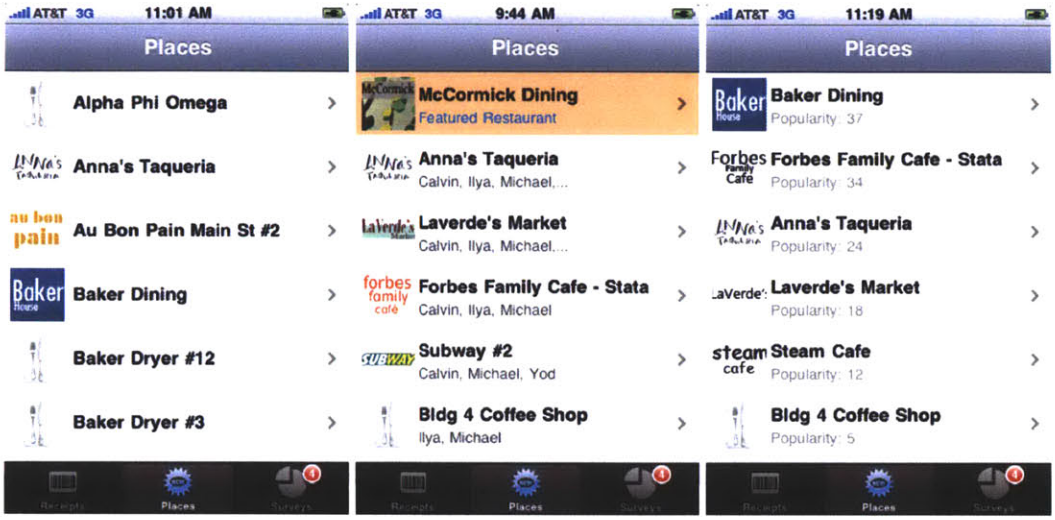

Figure 6-14: a) Control group, b) Friend's group, c) Popularity group

People would swipe their TechCASH card as usual and if they had their phone they would get a confirmation notification (iPhone push notification). If they opened the application they would be allowed to rate and review or see past transactions or view the feed page of other people's visits.

6.5.2 SocialMenu Recruitment

I recruited subjects through Craigslist, e-mail lists on campus and Facebook referrals. These people filled out the Facebook sign up survey (Figure 6-15) to collect demographic information during the research trial and their preferences on sea food. Every time a user consents to sign up and participate on the web, their Facebook friend id's are captured to map out the social network of the participants. Over 1000 people filled out the survey, and about 300 people came to the restaurant and dined to participate in the digital menu experiment. Participants were from MIT campus and Boston vicinity. The social relationships were identified through friends on Facebook. The age groups were mostly concentrated among people of 20's and 30's.

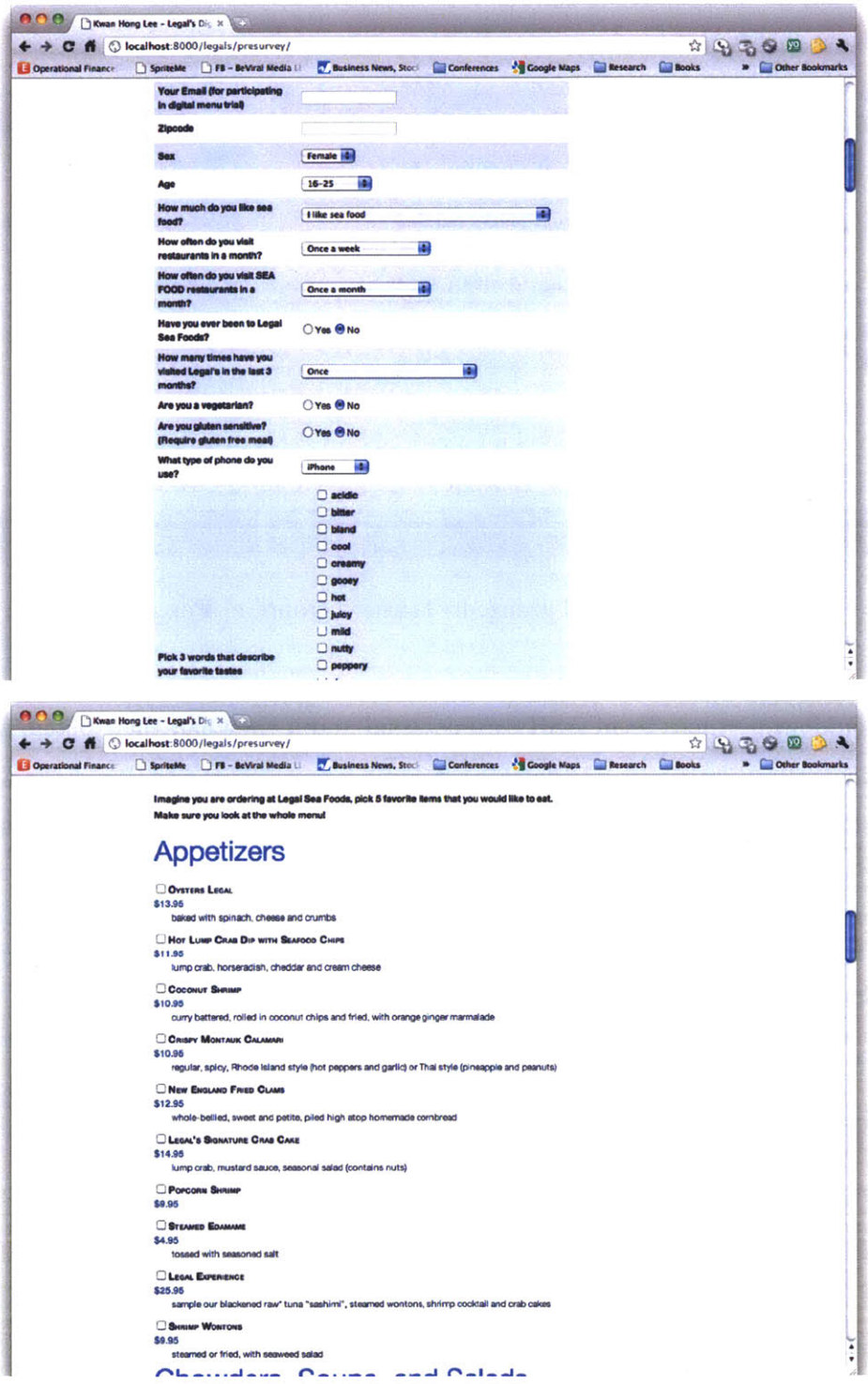

Figure 6-15: Participant presurvey: people filled out demographic information and selected 5 favorite dishes

When participants signed up, they were asked to select at least 5 favorite items they would like to eat from Legal Sea Foods web menu. This provided a base line taste for each person and seeded the experiment with social information.

The MIT SocialMenu application could be downloaded from the Apple App Store. The subjects were instructed to sign up on the http://menu.mit.edu website and create a PIN number to be used with the iPhone application. Once registered they could launch the application and access the menu. The menu was not accessible outside the restaurant because a table code was required to login. When they entered a table code to identify that they were at the restaurant it also was used to identify people in the same party that are seated together.

Table 6.2: SocialMenu experiment: all menu items were categorized and sorted in the same manner across the experimental groups.

Group	**Description**
Experiment 1 (Control)	Only see the regular menu.
Experiment 2 (Social)	Each menu item will show what their friends' have ordered.
Experiment 3 (Popularity)	Each menu item shows how many others have ordered indicating popularity.
Experiment 4 (Group Social)	Each menu item shows how many friends have ordered anonymously.

When the subjects were seated at the restaurant, they used the digital menu on the phone provided by the restaurant to browse the dishes. The experimental groups were manipulated with the choices people made from the pre-survey and any additional orders that were made by the past participants. Figure 6-16 shows how the different experimental groups would experience the digital menu.

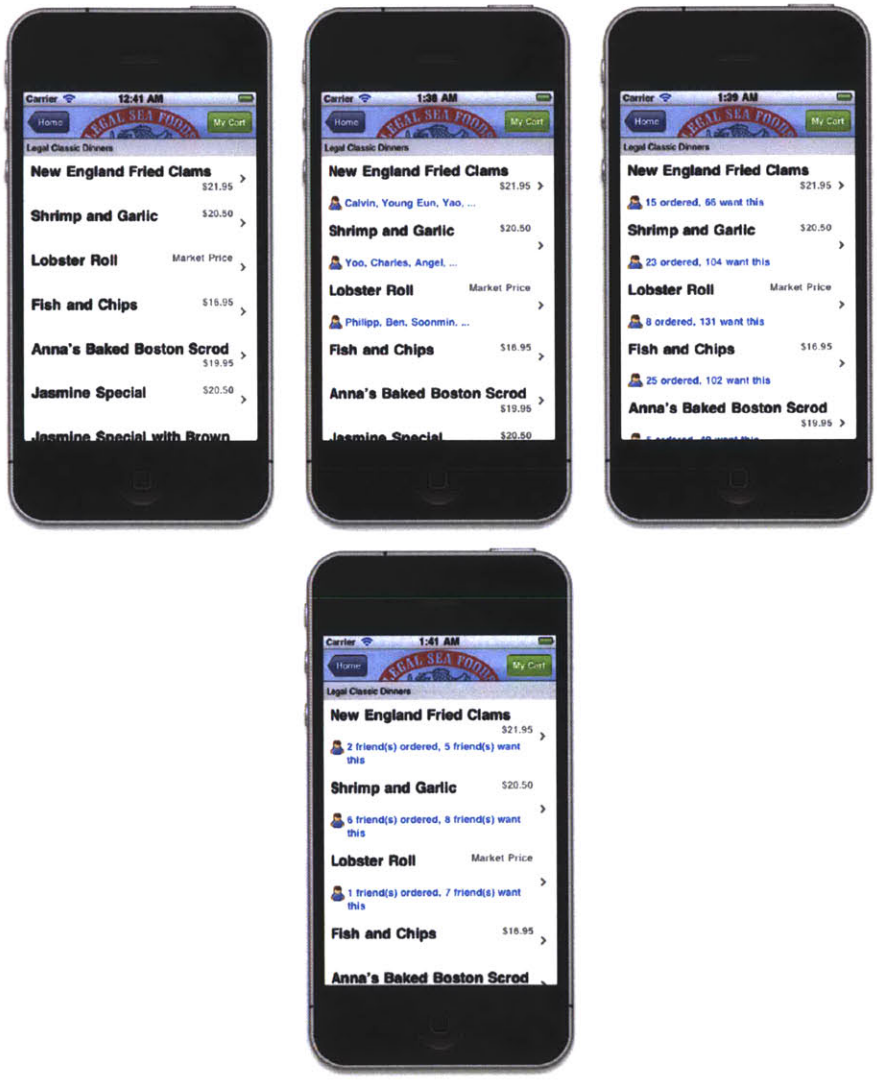

Figure 6-16: a) Control group, b) Friend's group, c) Popularity group, d) Group of friends group

6.6 Discussion

There are anecdotal evidence that Yelp like mobile applications influence choices based on the reviews of anonymous people in driving people to choose particular restaurants. One of the goals of my thesis is to answer how different types of social networks influence on the spot decisions. This is important since it reveals how effective last minute interventions could be and how influential just-in-time social clouds are. This is important because it allows us to understand the constraints and limitations when we try to impact people's choices at the last moment.

Until now phone has been used for communication, information access, and sensing the world. With the wider scale beyond just communication with individuals, but communication with the social network allows it to become a platform for social influence. As the mobile phones start to be used for commerce and payments, it will serve as a window to influence these decisions rather than being just used as plastic credit cards for payment.

6.6.1 Revealed Preferences

The revealed preferences play an important role in not only understanding individual's choices, but also serve as the main vehicle of influencing others. In the SocialMenu experiment other people's choices are revealed and an individual's taste is revealed through these choices. In the MealTime experiment people revealed their transactions that provide insights to their habits.

In the SocialMenu study, I correlate whether people's choices made in the experimental groups correlate with the specific individual, group of friends or popularity. High correlation will indicate that social influence affected the choices even though it was presented virtually. We assess whether the items labeled Chef's choice is selected more or less compared to those recommended by friends. By comparing the percentages that have been influenced across groups 1 to 4, we can measure the strength of influence between friends and anonymous.

6.6.2 Social Susceptibility

Individuals have different susceptibility to influence that affects their choices in the presence of social forces. However, the impacts of just-in-time social influences are difficult to capture and measure. More specifically, it is difficult to capture and measure in the case of real world decisions. Mobile phones have enabled people to be always connected at any time and though attention is the scarce resource in the current digital age[64], mobile phones have been successful in engaging people for short moments of time. Big question is what are the impacts of these short moments and how much can we influence or change people's choices in those short moments?

I attempt to make progress in understanding these question by capturing people's choices with social navigation on their mobile phones. This approach requires providing social information to people through sharing of transactions, a metric to measure an individual's social susceptibility in the context of the decision and measuring the effects of the just-in-time influence on the choices.

Individuals have varying degrees of social influence depending on the environment and the context of the current decision. I believe that every decision can have different means of measuring the susceptibility to influence. In SocialMenu one can measure an individual's social susceptibility by capturing the engagement time. As the engagement time increases, there is a greater likelihood of being susceptible. In MealTime one can measure an individual's social susceptibility by measuring the diversity index. Higher diversity index indicate that this person is open to exploring different options and opens up to greater social susceptibility.

By understanding individual's susceptibility and the susceptibility of those linked through the social network, one could predict the impacts of a particular influence such as advertisement or an offer. Diversity index of a social network provides a measure that can guide targeting of particular items or diverse set of items to the social network. The more people in the social network with diverse sets of tastes make it difficult to spread information about a single product. However, when there are homogeneous groups, it becomes a great target

for group selling. Similarly, if the diversity index is high, it is potentially a good target for spreading information about diverse set of products.

6.7 Summary

This chapter presented the motivation behind social transactions and the approaches I have taken to better understand the impacts of social transactions. The concept of connected consumption where people are continually connected to guide their consumption behavior through the social network was the initial inspiration for the social transactions. A pilot study was deployed by creating the Open Transaction Network to understand people's sharing behavior and their use of mobile phones. Food related purchases were the most captured during the OTN pilot study and this led to the design of the experiments with MealTime and SocialMenu. OTN showed that people were willing to share their transactions with their social network. People in aggregate had different willingness to share across different transaction categories, but it showed that the sociability threshold was highly correlated with the average price in those categories.

I have detailed the design of the MealTime and SocialMenu systems and the approach to understanding the impacts of virtual social influences on people's choices. The setup of the experiment and the participants were described in detail. The next chapter analyzes the results from the deployments and learnings from each experiment. Some questions that are answered are what is the distribution of repeat visit behavior of people visiting the stores. How do people feel about their transactions shared with their social network in MealTime. How does different manifestations of just-in-time social cloud affect people's choices? What were some behavioral changes observed due to the engagement of the mobile devices in people's choices? I will describe how these results could be applied in the real world contexts in the next chapter.

Chapter 7

Behavioral Networks

This chapter presents detailed quantitative and qualitative analysis of the insights gained from the MealTime and the SocialMenu experiments. The design and deployment of MealTime led to the Open Credit Card Application Framework. The experiments also provided insights on how social transactions can be useful and how it can affect people's transaction behaviors. Finally, I conclude with a discussion on the limitations due to running it as research experiments.

From the collected data I illustrate the overall time series behavior and analyze the individual and the aggregate characteristics of the participants. The social network effects are analyzed to understand the relationship between an individual's transaction behavior and the first and second degree social networks. I show how the structure of the network affects the results by comparing the empirical social network with different network structures.

The next section will detail the Open Credit Card Application Framework which was inspired by my advisors Andrew Lippman and David Reed as I was proposing the social transactions research. There are several components of it that are not realizable in the current commercial environment due to legacy systems and unavailability of a real-time API. However, it was possible to implement this on the MealTime platform, proving its feasibility.

7.1 Open Credit Card Application Framework

Currently, the credit card serves as a means to empower the people with the ability to pay for things on demand. However, the design of it makes it very easy for an individual to lose control of managing their finances. Through an open transaction network, we envision that we can reinvent the credit card experience by allowing it be an open platform for innovation. I denote the open credit card to include any form of card (debit, gift or credit cards) based transaction that can handle payment. Subsequently, I describe the Open Credit Card Application Framework (OCCAF) that I derive from the MealTime system. The OCCAF can be used to enhance the current transaction environment by providing access to transactions in real time and allowing one to build contextual mobile applications that augment the commerce activity. In this section I outline the technical requirements of OCCAF which can enable a more controlled experience of one's finances while enabling novel applications for future reinvention of payment.

The goal of the open credit card application framework are the following:

1. Allow applications to be built to respond at the transaction level
2. Allow timely applications to be built by making the time stamp available
3. Enable social transactions by having an API to the social network
4. Allow seamless interaction between the card and the mobile phone

The basic abstraction is to consider a transaction as a trigger. This trigger can be captured by any application to react to the transaction. This allows particular applications to be built based on specific conditions that the triggers satisfy. For example, a simple application could be built that triggers messages to a set of friends during 8 am and 9 am if a friend buys a bagel at Au Bon Pain. It wakes them up and allows them to also desire getting a bagel for their breakfast. This allows people who wish to have a more regular eating schedule to be influenced by their friends to engage in a more regular breakfast eating habit.

Also if your friend paid a monthly gym membership fee, it triggers to see those friends that are enrolled in a gym membership. This allows one to engage in more exercises and also coordinate in working out together. The trigger can be conditioned on three of your friends signing up so that you are notified only after three friends have signed up.

When a credit card is swiped at a coffee shop, it can immediately show the amount of coffee that one has consumed on the phone this week. One could also create an application where if one consumed more than 10 cups of coffee in a week, it will warn through the phone when the person approaches a coffee shop. It could also detect a pattern of coffee being purchased around 3 pm each afternoon and allow one to ping others who might be able to get a coffee at similar times.

The application platform would also provide value to business owners that sell products or service by making it easy to track digital word of mouth as triggers propagate among the users. Merchants could be given means to target their offers and deals based on the social network that would be most receptive to the offers at that time of the day. From the user point of view, applications could be built to communicate conditions where they would like to avoid receiving these offers or to filter out certain type of advertisements to help with spam filtering.

One of the concerns is on how to share it with third parties and providing conditions to share with the third parties so that appropriate offers may be made available to the user. Providing an environment where user feels a good control of their transactions, but trading off the access to the data with third parties and application developers to provide beneficial services has to be in the core of the design of the system framework.

7.1.1 Architecture

The architecture to support OCCAF require the transactions to be captured in real time and create triggers based on user and application conditions so that the application can respond to them. Figure 7-1 illustrates the major components of the architecture and how they would interact with each other. The application and user conditions can be modified

in real time by the user input or any sensory input from the phone, based on the location, time of the day and social proximity to others.

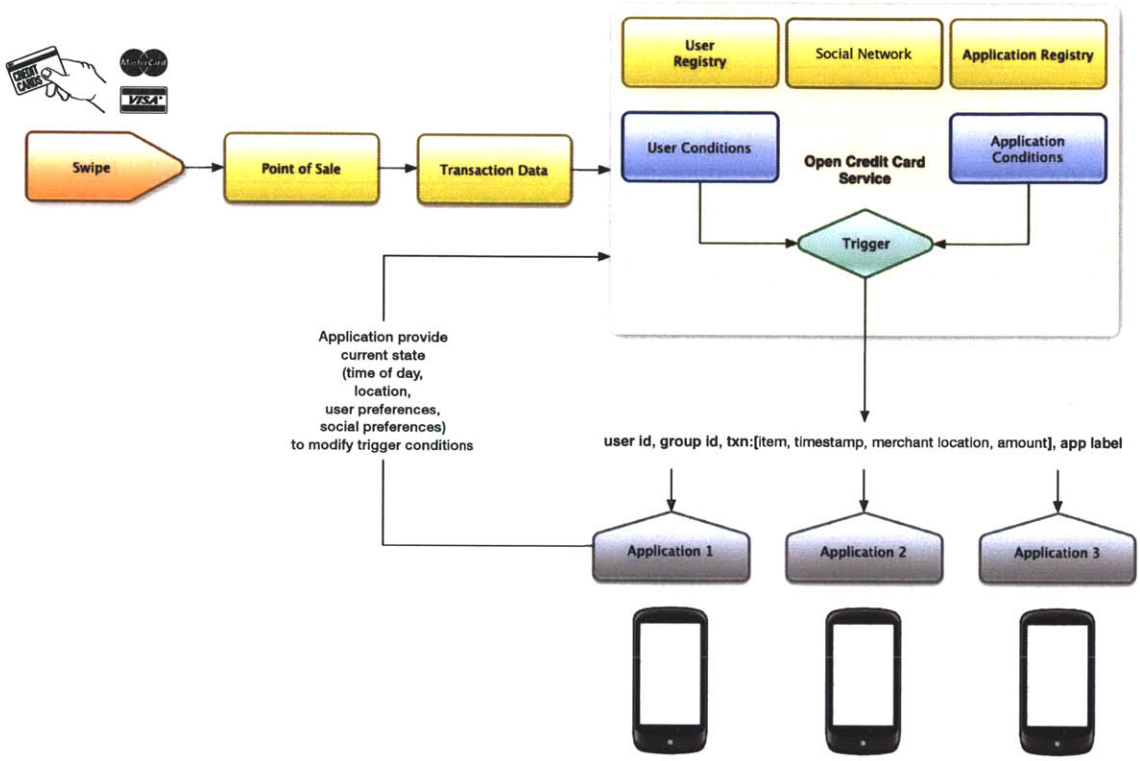

Figure 7-1: The architecture of Open Credit Card Application Framework. The applications would use the open credit card application framework to register and access the open card application service.

The open credit card application framework provides ways for the mobile phone to augment existing transaction process rather than replacing while allowing people to continue using their cards for payment. In the next section I describe how the smart phones can augment the current transaction experience and provide smarter transaction behavior.

7.1.2 Smart Phone as Augmentation to Payments

There has been work on mobile coupons, referral based incentive systems and secure electronic commerce, but less has been looked into open/sharing of transactions and using the

mobile phone as augmentation to payments. Mobile payments and mobile commerce have focused on changing and replacing existing payment systems, but have not fully explored the interaction of existing payment systems with the smart mobile devices. Although mobile phones are becoming smarter and people are excited about using the phone as a payment mechanism, the widespread credit cards will not be replaced in the short time frame. It is imperative to enhance the user experience and to think about combining the mobile phone with the existing payment systems such as the credit card. I argue that mobile phones can provide an interactive augmentation with rich interface to the existing payment activity. Mobile payment should be focused on creating augmented experience to existing credit card usage behaviors and help people make better decisions.

Mobile payment services range from the digital credit cards, digital wallet systems, micro payment systems, stored value payment system, accumulated balance digital payment systems and electronic bill payment systems[113]. Mobile payment research has focused on finding mechanisms to secure the transaction and less focus has been put into understanding how user's behavior changes based on the availability of digital receipts, proof of purchase and on demand warranty services.

Researchers and technologists have investigated and demonstrated the use of augmented reality to provide: augmented information about the product, different methods of payment and their benefits when financing is required, and the price of similar products. But less has been investigated deeply about complementing the existing payment experience with the mobile phones. By using mobile phones as augmentation rather than payment device, it may help people be more aware of their spending, provide time to review their choices and lead to a more conscious behavior.

Mobile commerce particularly is an alternative form of payment and people have choices such as credit card, debit card and cash which are still more convenient that the mobile phone. Cash is expected to never go away and the card system is much simpler and convenient. Therefore, the mobile phone and the card augmenting each other is a possible migration path that will provide consumers with convenience. It can be used in concert with the payment mechanisms to help users make better choices and provide real time and

anytime, anywhere feedback on their consumption behaviors. Mobile banking is somewhat related, but its a very passive means of providing access to the bank account and not directly related to the payment activity.

Transactions can also help us better track food consumption rather than self entry and life logging as in PmEB[127]. Though PmEB results show that mobile logging can have similar or better results than logging via diaries, it still does not facilitate the process significantly. If transactions can be captured regarding food consumption and people can easily label it at that moment, it makes the data significantly more accurate.

Mobile wallet solutions have been proposed as a means to make the phone the hub of personal transactions. However, the complexity involved in using the mobile wallet and the user interaction needed to authenticate/process/verify payments have slowed down the adoption. A better interface is proverbial wallet[75] that was designed to allow awareness of spending at the moment the user is trying to spend in the form of a traditional wallet. They had a design where the wallet buzzed (Bumblebee) when the credit card was swiped to make the user aware of spending or fraud. This is an example of a successful augmentation to an existing payment system.

During MealTime trial, people indicated how convenient it was to see one's spending habits and control their spending with one touch of a button, without having to login to a web site on their computers. Also, getting notified at the point of purchase made them more aware about their spending. Some students purposefully have been only using cash and did not use TechCASH because the card made them spend money without being aware of their spending. There is ample evidence that credit card usage potentially decreases awareness of spending[105].

For the Credit Card industry, the ability to augment the card with mobile can potentially allow new type of risk models that allow them to give more dynamic interest rates to individuals rather than based on the particular cards that they are subscribed to. People can publish their mobility behaviors to the Open Credit Card service that would help the credit card companies use it for better real time risk assessment and warn an individual in real time if they are diverging to more risky spending behavior.

An open credit card application could help people with healthy eating behaviors by driving people's spending towards healthier places and healthier food choices. By providing social augmentation in conjunction with payments, mobile commerce can focus on providing a payment system driven by personal goals and keeping people more easily aware of their spending. Social navigation and social influence on mobile will be able to guide individual choices towards one's personal goals.

7.1.3 Connecting with the Experienced

Nelson classified products into search goods and experience goods depending on the consumer's ability to obtain the product quality information prior to purchase[63]. With the availability of the Internet reviews on products and merchants, more products can be researched before a purchase is made. It is imperative for information to come from someone who actually has real experience purchasing an item. Friends and social networks have made it possible to easily communicate with a large number of friends to find anybody that have experience with certain products or services.

Social networks provide an additional level of trust beyond online reviews. OTN facilitates this further by allowing people to search for products or service and have immediate access to those who have experience in purchasing or have experienced the product or service versus potential reviewers that may not have such experience. OTN limits reviews by those who actually have transacted, making it easy to find the individual with the purchase experience in the social network.

Dimension of socialization in transactions provides novel means to think about transactions and how to utilize it beyond a record of where money was spent. Some of it is explored in cases where teenagers use parent's credit cards and parents get notified immediately about their children's usage of the credit cards to help family members be aware of their spending. This provides a regulatory mechanism and financial awareness to be fostered among teenagers.

In the SocialMenu study we extended this to just-in-time influences by virtual friends and

anonymous social information to understand how availability of just-in-time social cloud affects the decisions. Different products have different degrees of being purchased impulsively and it also has different magnitude of social influence. Such effects can be modeled by tuning the parameters related to the just-in-time social influence. These insights can be abused by the merchants to influence people to purchase at a higher price or make people purchase quickly, but with an appropriate architecture, this can be utilized to serve an individual's goal.

7.2 Meal Time Analysis

The MealTime study gave further insights beyond OTN on how much of transaction information people felt comfortable sharing. I identified the potential effects of mobile social information on transaction behavior by mapping out an influence graph of mobile access events to the transactions that followed and identified the properties of such network. The usage of the application was sparse and no clear conclusions were made, but the platform allows us to capture the time sequence of events if larger population were to participate. The choices made among the social network were compared to identify people with common behaviors that are separated in the social network.

Several measures were created to understand people's behavior. Diversity index was defined as a measure to show how diverse a set of places a person had visited in a week from the MealTime data.

The following lists the summary of the results from the Meal Time study:

1. The diversity index of the first degree social networks are more similar to an individual's diversity index than the diversity index of the second degree social networks.

2. The transaction behavior can be described by different parameters and depending on the measure, the first degree social network and second degree social networks can be significantly different.

3. In the context of the campus, people have regular habits on where they visit and this habitual behavior can be described by the time interval between repeat visist to same locations. The intervisit interval forms an exponential distribution.

4. Feeds showing transactions of friends or popularity do not significantly change the diversity index of where people visit indicating that the influence either reinforces people's choices or does not have impact.

5. An individual's frequency of transactions at each hour of the day is significantly similar to their first degree social network (friends), but not to the second degree networks.

Figure 7-2 shows the aggregate transaction behavior of the participants. At a high level the time line shows that the transaction activity during the semester has a regular periodic pattern. There's more activity on weekdays compared to weekends and there is a significant drop in activity during the winter break (before Feb 1), spring break (3rd week of March), and summer session (after May 15). The weekend drop in activity can be explained by the students eating out and cooking at home. There was a limitation to collecting data since we were able to pull transactions for only those people that opted-in to participate in the trial.

The heat map of people's visits and the $ amount transacted in each location during lunch time (10 AM to 3 PM) is illustrated in Figure 7-4. It shows that La Verde's (index 5) is the most popular location for people to each lunch at. It also shows that the number of visits and the $ amount spent is highly correlated. Also half of the locations captured has very few transactions indicating that people do not go to eat at those locations regularly.

The time vector view (Figure 7-3) shows that most of the transactions happen at particular times of the day and there is a diurnal pattern to people's transaction behavior. This is due to the TechCASH being used by the students to buy food. However, it indicates the importance of the time of the day in deploying interventions. People's behaviors are also very different between weekdays and weekends. These need to be particularly taken into account when mobile influence is designed.

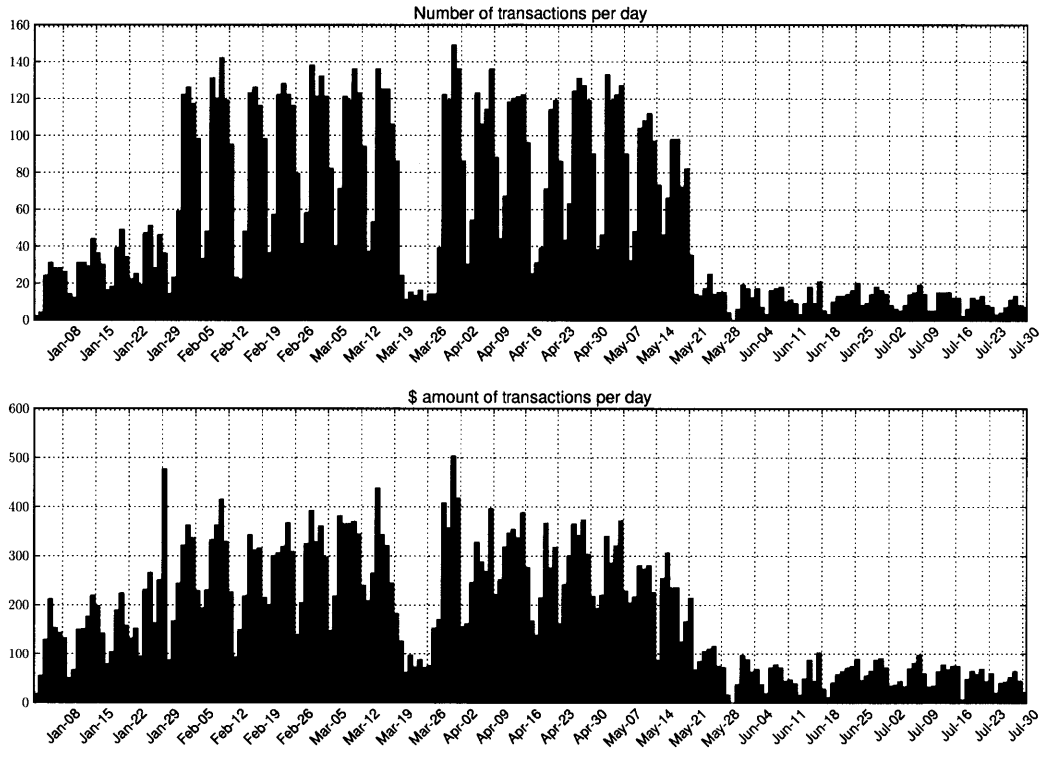

Figure 7-2: The number of transactions and the dollar amount of transactions over time

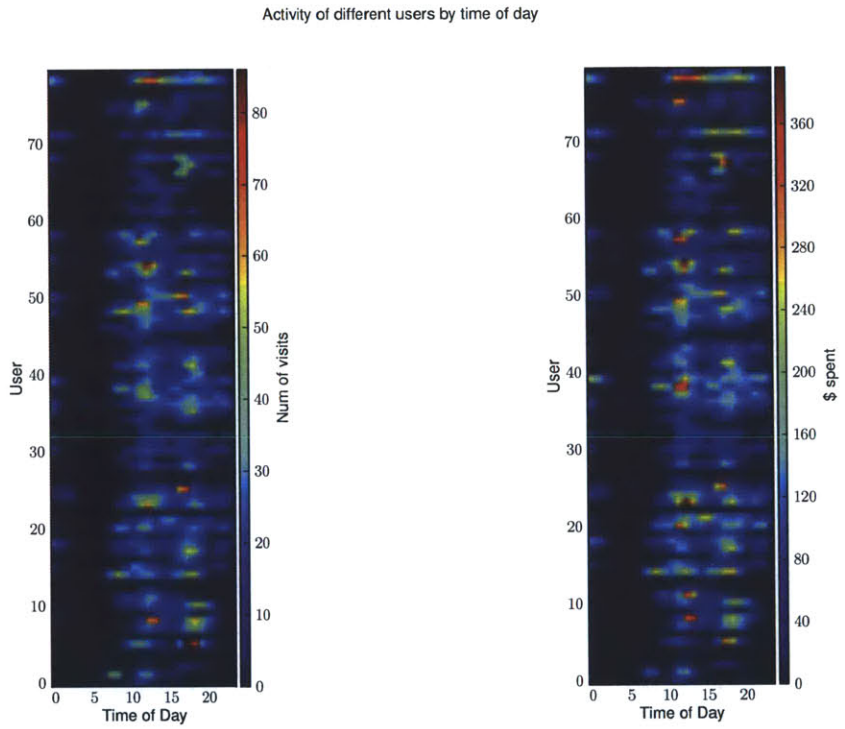

Figure 7-3: The number of visits and the amount of $ spent at different times of the day during the trial

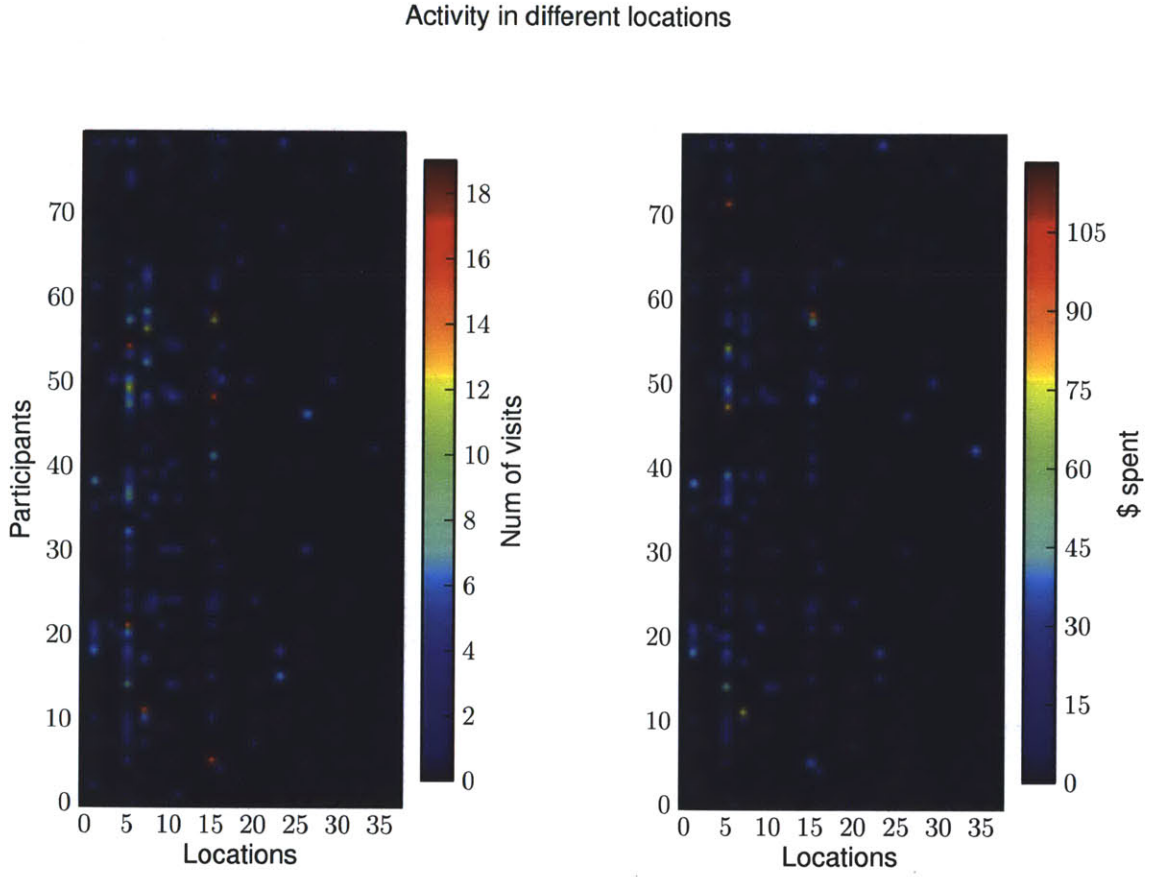

Figure 7-4: The first graph shows the number of visits and the amount of $ spent in different locations during the trial

The structure of the social network among participants is described in Figure 7-5. The degree distribution show a regular social network where many have few friends and a few have many friends.

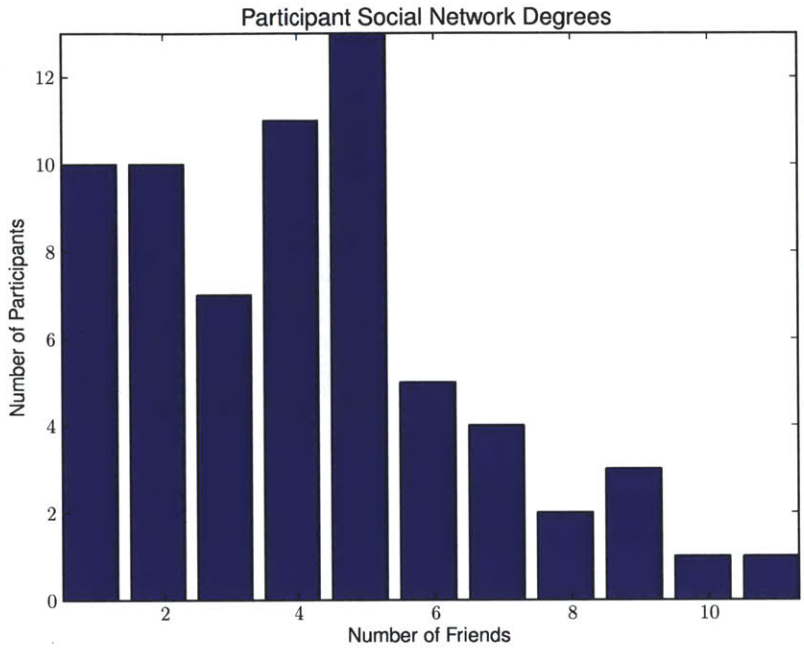

Figure 7-5: Distribution of the number of friends per participant shows that it is a regular social network where there are a few with many number of friends and many with small number of friends. This is common in real world social networks.

7.2.1 Transaction Behaviors in the Social Network

The first analysis is to understand how a transaction behavior of an individual relates to one's 1st degree and 2nd degree social network. One way to measure how the transaction behavior relates inside a social network is to generate a vector for each user and create a comparison measure that describes the relation with each other. An individual's feature vector can be generated by the following manners:

1. The average frequency of transactions per week during the duration of study.

2. The average $ amount that one spends per week during the duration of study.

3. The $ amount of transactions that one engages in on different days of the week: 7 element vector for each day of the week.

4. The $ amount of transactions that one engages in different times of the day: 12 element (every 2 hours) and 24 element (every hour) vector.

5. The location of transactions per hour by each participant.

6. The average number of visits to the locations per week during trial.

Each of these measures are calculated among the participants and I calculate a similarity measure that describes how similar or different one is to their first degree and second degree social networks. For the first two metrics, I used the mean absolute difference. For the last two vector metrics, I use the cosine similarity to measure how different people's vectors are. Understanding the similarity and dissimilarity measures allow us to identify those that may be able to help, or be available to help or encourage transactions (push) or those who may be able to identify new opportunities to spend money (pull).

7.2.2 Diversity Index

Another way to look at an individual's transaction behavior is by finding a measure for the different stores that they visit. I denote this as an individual's diversity index. The diversity index describes how diverse a set of location one visits during a given period of time. It is a value between 0 and 1 where 1 is the most diverse and 0 is the least diverse. In this case we look at a week's time frame and measure how many different places a person went versus how many transactions they have made (Eq. 7.1). A person's diversity index is a function of all the places one visits in a week, and the relative frequency between those locations. The more they visit a particular location, the diversity index is reduced. The diversity index is maximum when they visit each place equal number of times. The diversity index is distributed normally (Figure 7-6).

$$D = \frac{n_{loc}}{n_{txn}} \tag{7.1}$$

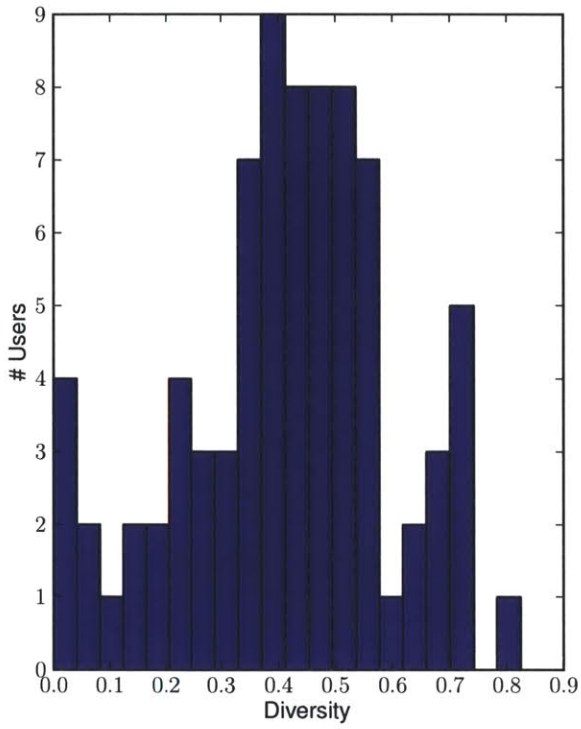

Figure 7-6: Distribution of the mean diversity index (per week) for all participants result in normal distribution.

I identify whether there is any correlation between accessing the mobile application and an individual's transaction behavior. Comparing the diversity index between people who have had access to social information via mobile phone shows that there was no statistically significant difference with people who did not have social information. The mobile social information did not have any effect in changing people's behaviors because the habits that they have had is too strong to be influenced by the virtual social information.

I believe that the higher the diversity index, higher the potential for influence because of their willingness to consider other options. This suggests that the diversity index is related to the potential susceptibility to influence and that people who have higher diversity index may be more susceptible to influence. This indicates that it is beneficial for the advertisers to understand the diversity index of an individual in order to target them with potentially different options. The second implication is that when targeting a social network, the diversity of the friends in the network should guide how diverse a set of advertisements or

recommendations should be targeted versus a more uniform set of advertisements.

Finally, I attempt to measure the influence and the potential influence of friends on one's transaction behavior. The influence can be directly measured by those viewing other's transactions and identifying how similar they are. The diversity index did not have significant difference among the people viewing the popularity information versus people who were seeing their friends' choices versus those who were seeing just list of places. An identifiable result was that the people who were using the mobile phones had more number of average transactions and these people had a slightly more diversity than average people who did not use the mobile phones. These were both statistically signifcant ($p < 0.01$).

7.2.3 Network of Potential Influencers

Despite there being no difference in diversity index due to virtual social influence, we can map out the potential influence between the participants by linking the transactions made and the Feed access log. The Feed view shows past transactions made by their friends that are shown when they view the Feed view through the mobile phone. The potential influence is a hypothetical measure that I attempt to illustrate by mapping out a directed graph between transactions that get viewed by their friends. Figure 7-7 shows the influence graph among the participants in the MealTime study.

I also map a network of potential influencers by finding 1st degree, 2nd degree and 3rd degree participants that visit common locations. Such graph maps out an affinity network where people who visit common locations have an affinity. The network of influencers are very reciprocal for the 1st and 2nd degree networks, but when it comes to 3rd degree network, there are many common 3rd degree friends, so that the network changes to a more broadcast network with few individuals that reach many common people.

You might ask why the first and second degree networks are similar in structure, but becomes different in 3rd degree network. If people are given direct access to the third degree network, they reach a lot of common people, making the receivers receive multiple influences from a few people who are hubs. Those few people who act as hubs will receive

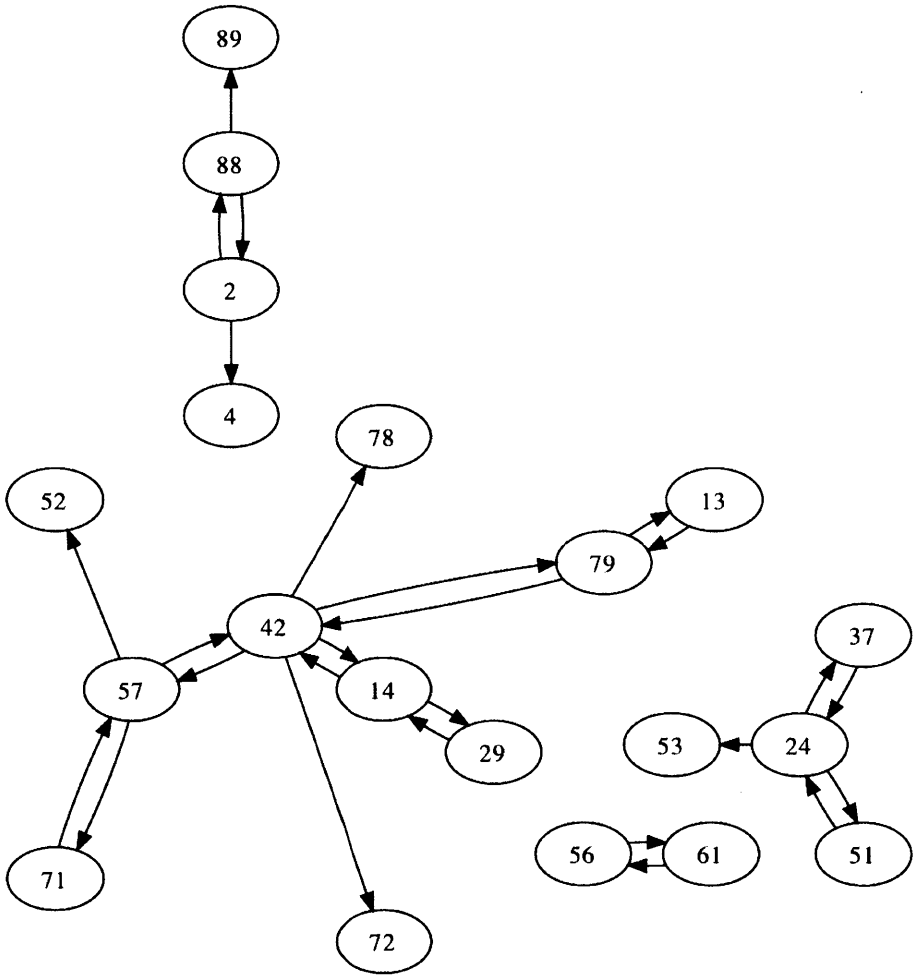

Figure 7-7: The influence graph calculated by linking people who saw their friend's transactions through the MealTime Places view.

and transmit potential influences to and from many more people. However, previous work such as the Cyworld case shows that the influence is usually from the more connected to the less connected. Therefore, the hub receives many influences back, but they would be weaker in strength.

In order to calculate the strengths of each individual influence, we normalize by the number of friends (there are many more third degree friends than the first degree friends), so the influence becomes weaker. Therefore we can have a model for virtual social influence that decays in strength based on the friend distance. However, one could potentially receive more information from the third degree network due to the increased difference in diversity measure.

We would naturally expect that propagation happens from friends to friends, but more effective propagation would be to skip over to the second degree friend network. Advertisers may increase the performance of targeting by utilizing the second degree network. If second degree networks are similar and more common in transaction behavior, then we maybe able to make the second degree friends information more available. By making 2nd degree networks available, it may be more efficient in finding people who may be interested in group buying due to better matching of needs.

7.2.4 Qualitative Feedback

I collected some qualitative feedback from users to understand how they felt about the MealTime application and sharing of transactions. People who did not use TechCASH commented that they do not use it because they do not know where they use the money so they use cash (similar to credit card behavior). The benefits of MealTime is demonstrated by one of the frequent feedbacks regarding the MealTime application being useful because it gave them on-demand access to how their TechCASH was being used.

7.2.5 Summary

The MealTime study showed the behaviors and relationships among people's transaction behaviors and their social network. The experiment results have shown that there is an aggregate weekly periodic behavior over months of the study. I described how an individual's transaction behavior relates to the transaction behavior of their social networks. One measure is by creating vectors that describe people's behaviors during hours of the day and during days of the week. Another measure we call diversity index is by capturing the diverse locations that they visit. Individuals have very different frequency and amount of transaction behaviors, but when compared to their social network of people, their behaviors are not very different in aggregate. Finally, I investigated the network of potential influencers and the structure of such influence network when there is a MealTime like service that can provide just-in-time social networks and convey influence through the mobile device.

There were limitations due to running it as an experiment. There was limited participation and limited usage of the mobile application. The instrument was limited to capturing how much the decisions were actually influenced due to the need to open the application before the transactions that happened. Also there were no consistent usage pattern prior to a purchase since most alerts on the mobile were triggered by the transaction. Therefore, the application was most adequate for reviewing one's transaction behavior.

7.3 SocialMenu Analysis

With mobile phones we carry that provide anytime, anywhere access, we are not only capable of acquiring information at our convenience in the context of a physical place, but also we are opening ourselves to potential influences by third parties. The SocialMenu study was performed to understand the impacts of different social cloud and the social networks in people's just-in-time decisions. The results show that different social information modalities cause different decisions to be made during in-place, in-time decisions. The virtual social network can provide constraints, signals, shortcuts, attractive or repulsive forces that shift

people's decisions depending on whether it is presented as individual friends, group of friends or as anonymous groups of people.

In SocialMenu, I investigated the browsing behavior among the participants to identify clusters of behaviors. In SocialMenu we characterize the browsing behavior with uncertainty index by tracking the number of cells that people click and the time they take to order to identify how much they are uncertain and are in dilemma. We identify how this uncertainty index relates to friends and the second degree social networks. We also cluster people by the uncertainty index to identify the characteristics of people who are most affected by the social information.

In order to extend the investigation of just-in-time-social networks and identify how the virtual social information affects people's choices in-time and in-place, the SocialMenu study was carried out at a local restaurant. Below summarizes the findings from the study.

1. Diversion of choices: about 56% of people made on the spot decisions that did not include any of their favorite dishes from the online pre-survey menu. This implies that people's choices can be changed by the current context and is in agreement with studies on shopping where people make 70% of purchase decisions in the store. Therefore, mobile guided just-in-time decision systems could have significant influence on people's choices.

2. Second degree friends have experienced as many common dishes as the first degree friends indicating that the friends of two degrees of separation can provide people with reinforcement in their choices.

3. Scale of influence: empirical data indicates that the availability of social information across time and the scale of virtual social information may affect 2 to 10 times more people in their considerations compared to physical social influence by co-present party on the table.

4. Time of engagement: name of friends (individuals) on the menu made people spend longer time to decide indicating that seeing other people's choices encourages one to spend more time to evaluate their choices before making a decision.

5. Price factor: average price comparison between different experimental groups show that the anonymous group of friends had strongest influence in pulling people to choosing cheaper items.

6. Individual friends increase engagement, group of friends affect price choice and popularity serves as shortcuts to decision making.

7.3.1 Diversion of Taste: Pre-selections vs. Actual Orders

Over 50% of orders were dishes that diverted from pre-selections in pre-survey. People have different tendencies towards ordering sides and main entrées (Table 7.1). Among the 270 people that completed the pre-survey, we see that different social information had different impact in their choices at the restaurant. Control group had more people maintain their pre-selections. Friends group (Group 2 and Group 4) had more people divert from their pre-selections and Group 3 (popularity) had more people who maintained their pre-selections.

7.3.2 Social Effect: Co-present and Virtual Influence

We compare the potential social influence in people's choices by identifying whether a person's order at the restaurant was same or different from their preselected dishes during the pre-survey. People chose 5 favorite dishes during the pre-survey which are used as pre-selections to compare against what was actually ordered at the restaurant. The metric I used for quantifying the social influence in menu choices was by counting the common dishes ordered between people's preselections and their actual orders.

Co-present and virtual influences across time are compared. Co-present influence occurred when people were seated at the same dining table. I can track whether they were seated together by the common table code that they entered when they sign-in to the menu. Across-time influence occured when people are able to see the past choices of others through the menu and clicked on that menu item to consider the dish.

Table 7.1: Categorical differences: correlation between the distribution of pre-selection and the distribution of orders in different categories.

Category	Pre-selection vs Order
Sides	0.274
Chowders, Salads	0.985
Surf, Turf and Beyond	0.592
Seafood Bar	0.892
Legal Classic Dinners	0.739
Legal Lobsters	0.704
Fish	0.547
Fish w/o Rainbow Trout	0.921
Appetizers	0.801
Completely Legal	0.505

[a] The different categories have different amount of deviation from the pre-selection with sides having the greatest deviation.

In order to quantify the contextual social influence I defined the scale and the strength. The *scale* of one's influence is the number of people that may view one's choice. The scale of virtual influence is 2 to 10 times larger than local influence due to that many more people being exposed through the menu on the phone. The *strength* of influence is the magnitude of the likelihood that can change people's choices when someone is co-present or virtually present through the menu. We can measure the strength by finding out how many of the people in each group followed order of someone present virtually or followed someone present physically and changed from their pre-selections.

In our study, we find that over 50% of the control group had diversion from their pre-selections (diverted taste) indicating that more than half the time, people's choices could be changed from their favorites. If we investigate further what caused these diversions, we see that virtually mediated social information was influential in diverting people's choices beyond the 18% baseline diversion that occurred in control group (Divert Virtual, column

2, row 1 in Table 7.2).

As we see from Table 7.3, Group 3 particularly has smaller overlapping choices indicating that the wider scale of popularity information served as a means of influencing people's choices. It is also noteworthy that in friends groups (Group 2, 4) there are more diverts through virtual information (comparison of columns Maintain virtual and Divert virtual) indicating that friends' choices make one divert from their choices. In contrast to how friends affect information consumption where people use friends as guides for discovering new content[122], in the menu choices friends information encouraged people to try something different from what friends have ordered.

Table 7.2: Relative strength of virtual and local social influences that affected people maintaining or deviating from their pre-selections.

Group	**Maintain Virtual**	**Deviate Virtual**	**Maintain Local**	**Deviate Local**
Control Group 1	**40%**[a]	**33%**[a]	11%	7%
Group 2	24%	29%	11%	5%
Group 3	30%	19%	7%	10%
Group 4	10%	36%	5%	4%

[a] Control group results serve as baseline

There were various types of patterns of virtual influences observed during the trial. When a person A orders an item X and a friend B orders the same item in a future time, we create a link from A to B indicating that A could have potentially influenced B to order the particular item X. The future time could be few seconds or minutes from the same table or days as the information is transmitted through the SocialMenu. Such patterns were collected among the participants.

1. one to one: one person has influenced another person

Table 7.3: The non-overlapping percentage is the upper bound where this segment did not have any virtual or local social influence in their choices.

Group	**Non-overlapping**
Group 1 (Control)	**9%**
Group 2	31%
Group 3	34%
Group 4	45%

[a] Comparison with baseline show that social information makes people choose more non-overlapping choices.

2. one to many: one person has influenced multiple friends at same or different time instances
3. many to one: many friends from same or different time instance have influenced one person
4. many to many: combination of the above
5. feedback loop: person A has influenced another person B and person A is later influenced by B

Co-present influence is captured by looking at how table size affects people's choices. We see that when one is dining alone, one tends to choose what one desires and there are few diverts (<10%). However, when there are two people eating together, there are twice as many diverts as maintainers. This is because the social influence is strongest due to one other person influencing the choice of the other person. In larger groups we see that there are more people who maintain their choices than divert, as each individual on the table become weaker social influences.

When people are co-present, the influence is usually bi-directional since they might have communicated as they were ordering from the table. When they are using the social menu,

the influence is uni-directional since the participant is receiving the signal through the SocialMenu.

7.3.3 Price and People's Choices

In this section we determine the extent price affects people's decisions. The participants are potentially sacrificing their tastes due to economical reasons. By comparing the average price of the pre-selections with the price of the actual item that were ordered, one can find out whether they have diverted in selection due to price. The results show that the people who diverted from their pre-selections chose items that were on average $4.50 cheaper than the average price of those items selected during pre-selection (Figure 7-8, $x = 0$). The results show that 33% of the orders had items that are cheaper by more than $4.50 from the average price of the preselected entrées. This indicates that the price had strong effect on people's selections when they were paying real money at the restaurant. 26% of people were a standard deviation away from the mean $4.50 indicating these people most likely diverted from their pre-selections completely due to price.

We also investigated whether sitting in groups or having virtual influence made people choose different price points causing price matching behavior due to social influence. We compared the average price of a person's order when individually ordered versus average price when ordered in groups. When we compared people in different table sizes, the median price increased among those who dined in larger groups. Therefore, it is beneficial for the restaurant to engage larger groups.

Among those that diverted due to price, different social information showed different magnitudes in diverting people from their pre-selections. The following percentages diverted due to price in different experimental groups.

- Group 1: 30%
- Group 2: 33%

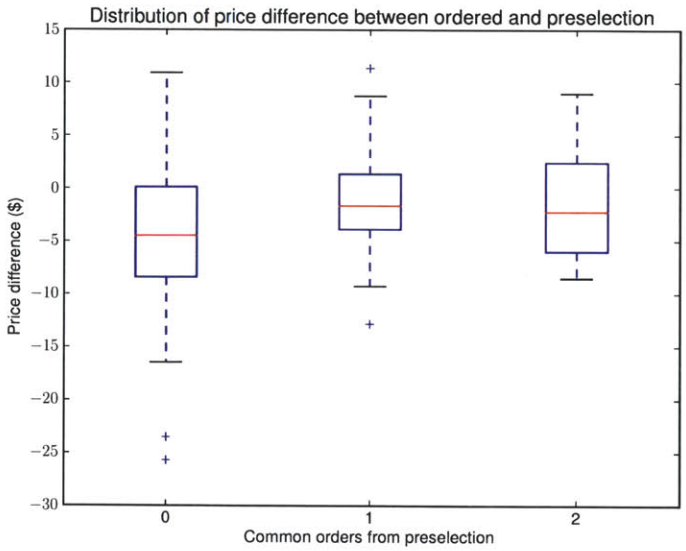

Figure 7-8: Effect of price on the ordering behavior of the participants. People who deviated from their pre-selection chose dishes that are on the average $4.5 cheaper (-$4.5 for $x = 0$). Those who selected common dishes from their pre-selection had lower median price difference (-$1.6 for $x = 1$ and -$2.2 for $x = 2$) that was statistically different ($p < 0.01$) from those who deviated. This result indicate that people who deviated sacrificed their taste for economical reasons.

- Group 3: 39%

- Group 4: 43%

Although the results were not statistically significant, the comparison between experimental groups showed that control group ordered more expensive while the social groups ordered cheaper items possibly guided by other people's cheaper choices present on the menu. This indicated that individuals had least influence in people choosing cheaper items and that normative influence of group of friends had the strongest impact. People are ok with choosing cheaper items when anonymous groups of people make such choices, but when they see particular friends that have chosen cheaper items, one does not want to be categorized with that particular friend's behavior.

7.3.4 Effects on Time to Order

The ordering time provides an aggregate metric of people's browsing behavior. We can categorize people into three different groups based on the time it took people to order (Table 7.4).

1. Segment 1: 0-300 seconds (Up to 5 mins - Knows what to order or decided to follow someone)
2. Segment 2: 300-700 seconds (5 to 12 minutes - Exploring through the menu in dilemma)
3. Segment 3: 700-1200 seconds (12 to 20 minutes - Uncertain about their choices)

Table 7.4: % of participants in different ordering time segments in each experimental group.

Experiment Group	**Certain (<5 mins)**	**Dilemma (5-12 mins)**	**Uncertain (>12 minutes)**
Group 1 (Control)	51.4%	33.3%	15.3%
Group 2	35.9%	40.2%	23.9%
Group 3	35.7%	46.9%	17.3%
Group 4	36.1%	47.5%	16.4%

[a] SocialMenu (Groups 2,3,4) induces longer usage of the menu for people to finalize their choices.

Those that took shorter time either knew what they wanted or converged on choices quickly because they saw others who have ordered on the table or among the virtual peers from the past. Those that took longer in time had the tendency to divert from their favorite dishes.

The people in the control group generally finalized the dishes to order in less time. On average people took 130 seconds (~2 minutes) less to order when they had bare menu versus social menu. Between the experimental groups we see that the social menu increased the time for people to order. People who had their friend labels (Group 2) took longest time to order (Figure 7-9).

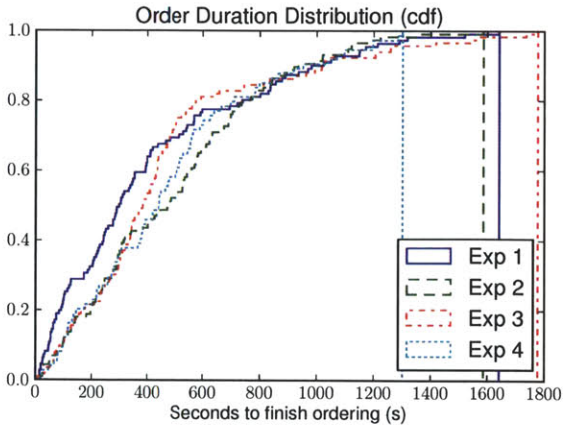

Figure 7-9: Social menu affects people's ordering duration, resulting in more exploration time through the menu.

Order duration was compared between the experimental groups (different virtual social influences) to analyze the effects of just-in-time social information on the menu. Control group (Group 1) had their order duration increase with the table size. In the friends group (Group 2) the ordering time was also statistically different for the different table sizes with ordering time decreasing as table size increased ($p < 0.05$). I believe this happened because of the social information providing real time feedback as one of the friends on the table decided on an order, allowing one to see all of them on the menu and make one's choice accordingly.

The ordering duration was compared between table sizes (number of people dining together) to find out the effects of social influence by the co-present diners. Table size had effect on some groups with respect to their ordering time. In the case of different table sized groups, groups with two people differed significantly in their ordering times ($p < 0.01$) with other table sizes and took shortest average time.

7.3.5 Memory Effect: Choices in relation to time between the pre-survey and the order

I also investigated whether the time between the pre-survey and restaurant visit had any effect on people diverting from their pre-selections at the time of ordering. For example, if one filled out the pre-survey long time ago they could divert more. The results show that we cannot make any conclusions regarding the relationship between the time of the pre-survey and whether people diverted from pre-selection.

The time difference between when they took the pre-survey and when they came to the restaurant is denoted as δt. I correlated whether δt has any correlation to people diverting from their pre-elections. If it turns out that people who had done pre-survey much earlier (larger δt) had diverted in their orders, it can be hypothesized that over time taste changed or people's memory of their pre-selections were lost. If they stick to items in their pre-selection, it means that their taste were retained over time or they remembered what they had chosen during the pre-selection.

Although there was no statistical difference between the distribution of δt among those who diverted and those who selected from preselection, comparison of the distribution of δt shows that when people diverted in their orders, median of δt was the greatest. This leads to the hypothesis that longer the time difference between the pre-survey and the actual order, the more likely people will divert. People choosing items from the pre-selection indicates that they either have more stable taste or they remembered what they preselected. The results from the current dataset provides no significant correlation between δt and people diverting from the pre-selection.

7.3.6 Reactions from Users

People raised several interesting issues while using the phone as the menu. People felt that the phone screen was not sanitary when utilized by many people as the menu. People also used the camera to record their experiences during dining which indicated that people

would be willing to share their experiences at the restaurant through digital pictures. The hierarchical menu was not easy to browse as it made it difficult for people to get a whole picture of the menu. The current SocialMenu design of embedding social information on each menu item was designed to measure the just-in-time social cloud, and it helped serve as social navigation queues through the menu.

I collected the following comments from the post survey after the participation in the digital menu trial. The following summarizes the positive and negative feedback from the digital menu experience.

The following were negative comments:

1. Menu decreases social interaction (due to the interactivity required to browse the menu)
2. People felt having a global view of the menu was beneficial to compare prices, however people did not realize that there was a way to add to order and compare.
3. Half of the people preferred paper menu versus having to use a digital device to order, mainly due to the ability to see the holistic menu.
4. The menu was hierarchical in that items were grouped into various categories. Some thought it was intuitive to use and others thought it was difficult to compare items.

The following were positive comments:

1. It was cool to use a phone as a menu at the restaurant.
2. People would have liked the order to be automatically placed after they selected from the phone. The current system did not integrate with the operation of the restaurant, so after selecting, people had to order the dishes through the wait staff.
3. People were surprised that a menu on a small screen like iPhone would work well. Normal menu size is 16"x11" (2 letter sized paper).

The following ideas came from the users and can be applied to the future digital menu design.

1. The menu should be designed with the restaurant's ambiance in mind.
2. Digital menu would be more adequate for restaurants where people would like to order quickly, or places where it is difficult to get the attention of the wait staff.
3. Larger screen and ability to compare more easily would be beneficial for a digital menu.
4. Typing username and password to login created some trouble for people who were not familiar with typing on smart phones. This would be resolved if people were using their own phones.
5. Providing users with the questions to guide the recommendation of dishes would be possible with the digital menus.

7.3.7 Real World Challenges

There were few challenges in performing the study. I had to run the experiment without interrupting the operation of the restaurant. The host was informed so that the patrons could check-in with them and be escorted to the tables with only the digital menus. The waiting staff were asked to disengage as much as possible when people were using the digital menus. Due to the transient nature of the waiting staff they were not trained to deal with any technical issues that involved the digital menu. Few people commented that they were having trouble with the menu due to the WiFi turning on automatically and freezing the application. People thought WiFi connection would be better, but the restaurant did not have it's own WiFi and the available WiFi networks had poor connections so only 3G connection was used. To resolve this, I made sure to turn off the WiFi completely.

In the process of choosing the item using the phone as menu, we lost some data points because people did not know that they had to add items to the Cart in order for us to

verify that they had ordered an item. People also forgot to create their PIN numbers before coming to the restaurant so we lost some data collection opportunities.

7.4 Summary

The Open Credit Card framework I described in this chapter provides an architecture for utilizing transactions for consumer good rather than just for the benefit of the businesses. By developers providing interesting applications related to transactions, consumers can find creative ways to control their spending behavior individually and in groups. When social cloud is integrated with the Open Credit Card framework, it provides social finance applications. This will also allow more detailed measure of social forces and understand the value of friends in people's finances.

The results from the two studies MealTime and SocialMenu were discussed in detail. MealTime showed people's habitual and on the go behavior. The actual MealTime mobile application did not change people's behaviors significantly, but by logging the mobile application access behaviors, we are able to map out a network of potential influences where if the influence was more stronger could affect those individual's choices.

In the SocialMenu study, we further explored how the social information affects the choices at the point of decision making. Depending on how the social information is presented to the user at the time of decision making, it changed how people made choices in the dimensions of taste, price and time. The friends' information increased the time that people made their choices. The popularity information reduced the time to making choices serving as short cuts. The group of friends information had the strongest influence in moving people's choices in price dimension.

The studies from the mobile behavioral change leads to the following principles of utilizing social networks for influence. The following reactions can be triggered by engaging the social network in different modalities from our communication devices. Shortcuts help when people have to make quick decisions. Engagement is for helping people take more

time to decide. Following is a reaction where people will imitate and becomes strongest when group norms are presented.

Chapter 8

Conclusion

> "[Technology] allows us to create awareness interfaces that may warn of potential influence or harness the social forces to prevent unwanted influence."
> – Cialdini

The thesis argues that mobile phones are becoming platforms of social influence enabled by the following elements:

1. Sharing transactions provide a means to easily access experiences of others
2. Real time availability of social transactions creates just-in-time social influences
3. Mobile decision points enable scalability of social influences across time and space

This leads to a framework to rethink the design of communication systems from transmitting bits to transmitting relational forces. This framework fosters design of mobile communication systems that can serve as social influence platforms. Every entity participating would contribute their choices so that this information can be aggregated at different levels: first degree, second degree, anonymous group of friends, and anonymous popularity. The transactions or interests would serve as a means of filtering the appropriate social network. The availability of different social networks and the way we connect to them at different scales

at anytime, from anywhere create opportunities to trigger social influences. The goal is to utilize them to help with individual's choices and provide social support to confront persuasions that can derail from one's long term goals.

I created the Open Transaction Network (OTN) to capture people's transactions in the real world and their sharing behavior. To facilitate easier data collection, I extended OTN and created MealTime system by integrating with MIT's TechCASH payment system. This MealTime system made transactions available in real-time, enabling new applications to be built by using transactions as triggers. The use of transactions as triggers led to the architecture of augmenting of existing payment systems with mobile phones instead of replacing cards with mobile phones as current mobile payment industry is attempting to do. In order to assist people's decision-making, Open Credit Card Application Framework was conceived from MealTime to seamlessly fuse traditional card-based payments with interactive interfaces on smart phones. OTN was also extended to SocialMenu application in order to further understand the impacts of the just-in-time social cloud on people's in-time, in-place decisions. The SocialMenu experiment was deployed in a local restaurant to probe how people's real choices were influenced by the activities of the social network that propagated across time and space.

My research has extended previous work by investigating the architecture and the impacts of the just-in-time social cloud on real world choices. The first key contribution is the design of a realizable and extensible architecture for dynamically selecting the just-in-time social cloud to guide people's current choices towards their long-term goals. The second contribution is creating an open platform for capturing data that maps social networks and their activities as a time series. The third contribution is in designing and deploying the experiments so that different kinds of social information can be presented to the user at the time of decision making and measuring how the just-in-time social cloud affects people's choices. Finally, through the deployment and experiments, I have discovered how to utilize the just-in-time social cloud to protect us in our in-time, in-place decisions against the marketers and better guide us towards our long term goals.

8.1 Summary of Results

Though social network applications are widely used on the mobile phones, it has been unclear how they affect people's choices in the real world. In this thesis, I have investigated how mobile phones can impact people's transactions and their sharing behaviors. Impacts of just-in-time online social networks on real world human decision making was investigated by capturing real decisions through mobile applications and contributing to the mobile social behavioral research. I have designed the architecture of the social cloud services that can benefit people in their decisions in real time, on the go. The social cloud provides social navigation functionality to the mobile users from the highest level. The different modalities of the social information that can be projected from the social cloud can be used for different purposes depending on the goals of the user. Just-in-time availability of the social cloud is important due to people making unplanned decisions or changing decisions on the go.

In this thesis I investigated how virtual social information projected onto the physical world affects people's decisions. In order to investigate this question I had to identify decision points in our daily lives and design applications that people can use during those decision points. In particular, the applications have to be designed for convenience and simplicity. Incentives also have to be well thought out so that they do not confound the results. Low incentives not only hinder initial participation, but also create word of mouth effects that cause inertia in future participation. Despite creative design and long hours of development, motivating large numbers of research subjects to use the application in their daily lives was difficult. Quick iteration of prototypes with a small number of people can help develop a more useful application that can fluidly be utilized in participants' daily lives. However, the limited deployment and data collection still enabled me to gain insights into how people behave around their financial transactions, how social information gets integrated into our daily lives and how the just-in-time social cloud affects our choices in the real world.

Open Transaction Network showed that for different categories of purchases there is a strong negative correlation between people's willingness to share and the average price of that category. This result showed that the sharing behavior would be different for different

types of products and each product category would have a different social network that would influence an individual's decisions. OTN identifies those social networks that can be helpful in each product context and dynamically makes them available when needed.

The MealTime study showed the value of OTN in the category of food. Whether people were influenced to switch venues due to social influence on the phone was not statistically significant. However, people who carried the iPhones had more frequent transactions than those who did not have an iPhone. This result could be an artifact of the incentive system where a daily raffle of $10 impacted their frequency of purchase. It could also be due to iPhone users having a higher spending pattern.

An individual's inter-visit behavior to different locations represents distinct habitual versus impulsive signature for the individual. People are more susceptible to influence when they are in the more impulsive mode than the habitual mode. The signatures can be used to identify how often and when just-in-time social cloud can be most useful in intervening with people's choices. If a person is trying to avoid impulsive shopping, OTN provides a measure of how often one engages in impulsive shopping and presents the just-in-time social cloud that may increase reflection during regular impulsive shopping trips. If a person is trying to avoid eating at fast food places they habitually frequent, one can set one's goals to avoid those places and just-in-time social cloud can recommend healthier places people ususally eat as person's dining hour approaches.

Beyond understanding people's habits, the MealTime study showed that people want to be informed of their spending behaviors and when made available in real time. Real-time availability of transactions provide on-demand awareness of their spending behaviors for continual reflection. The MealTime application showed that the mobile phone can augment existing payment or financial transaction services to facilitate more regular interaction and provide on-demand feedback to guide people's financial behaviors. People were concerned about revealing the details of the transactions and particularly the exact time of their transactions due to potential privacy invasion. This concern suggests that the exact time should be hidden or obfuscated by providing a random variance to the timestamps. However, no significant change in engagement with the mobile application was observed when social

transactions were made available to the users.

In order to more accurately measure how the social information influences individual's choices in a just-in-time manner, I deployed the SocialMenu study at a local restaurant to capture people's choices. The menu was a tool for presenting the just-in-time social cloud to see how social navigation influences people's choices when time and space constraints exist. The different kinds of social information (individual friends, popularity and group of friends) imposed different effects on the dimensions of taste, price and time. The popularity information provided short cuts to making decisions, reducing the time to decide when people were uncertain. The individual friend's information led to people taking the longest time to decide, allowing people to consider their choices longer. These results help people to use popularity for quicker decision-making while utilizing individual friends for choices that benefit by inducing longer reflection time.

Those people that had peer information had departed more from the favorite choices they made in their pre-survey, which is in agreement with Ariely's work in sequential choices in group. However, popularity information which had the widest scale of influence led to the least number of people departing from their pre-survey choices. This result can be explained due to popularity information including people's likelihood to choose particular menu items. It also implies that popularity information can be effective in helping people follow through with their prior choices or commitments. Finally, the group-of-friends information had the strongest impact when the average price of the pre-survey choices was compared with the average price of the actual items ordered at the restaurant. On average people ordered items that were $4.50 cheaper. This effect is due to group-of-friends information reducing the cognitive load on decision making and because cheaper friends seem to also have cheaper friends. This result implies that group-of-friends information could be most effectively used in helping people save money. In contrast, people usually spend more when they go out to eat with their friends. On the other hand, the individual friends experimental group did not experience as much impact on price, indicating that people did not follow individual friends' information on cheaper items.

In Chapter 3, I discussed the applications and the contexts when just-in-time social networks

could provide effective interventions when driven by the goals of the users. The experimental insights helped us understand what works and what does not work when trying to leverage social networks to influence people's choices. The proposed architecture of the just-in-time social cloud provides a platform to achieve further understanding of the power of just-in-time social cloud, but more experimentation is needed to measure the strength and the scale in varying contexts.

8.2 Limitations

The App store and smart phones have made it easier for us to deploy real world experiments in large scale, but the lack of sufficient development resources and time imposed limitations. The novelty of the experiment also created unforeseen problems. For example, 3G network reception in the restaurant was not great and required waiting 3 months for MIT to install an extra cell tower on campus. Repeated design, deployment and iteration of the applications were necessary in collecting the data that was needed to derive the above conclusions. Some data were lost during the study due to bugs that made the application crash, the uneven coverage of 3G network, and the users' misunderstanding the procedures. The procedures could have been better communicated if a short video clip were played back on the phone before they engaged in the decision process.

I attempted to measure the tie strengths of the participants through a post survey, but completion rate was low due to the late distribution of the survey. Only midway through the study did I realize the tie strengths were an important feature that needed to be captured among the participants. Due to late deployment of the tie-strength survey, it was difficult to encourage people who had already filled out post surveys to fill out an additional survey. However, the current system now has the ability to capture the tie strengths if the experiments were deployed in a new setting.

Collecting good quality data on human behavior through mobile phones is challenging. It requires designing applications that people are willing to download and use in their daily lives. Identifying the decision points and focusing on a simple and convenient design

led to successful deployment of the applications. Identifying real world settings where interventions can be presented to the user in a controlled manner holds challenges and requires creativity. However, pervasive use of mobile phones makes capturing people's real world decisions more possible.

Social information has stronger or weaker impacts depending on the kinds of decisions involved. Larger scale studies in different product categories would be beneficial to generalize some of the findings from this thesis that primarily focused on food-related decisions. Larger scale studies could also provide more insights on how strongly social information affects individual's tastes, which did not show statistical significance in SocialMenu study. Fake social data could also be used to design a more controlled study with clearer results, though the method can be risky due to the users noticing the manipulation.

Just-in-time decision research will help us better understand how people's in-the-moment choices are affected by the interventions and how much people are susceptible to in-the-moment influences. According to the findings of this thesis, the just-in-time social cloud can be designed to promote reflection or efficiency in people's decision process. Understanding people's just-in-time decision process not only help us better understand people's vulnerabilities, but also help us create new tools to benefit their long term goals. By helping people to be more reflective or efficient in their in-the-moment decisions around eating, spending and exercising, just-in-time interventions can benefit their future selves.

8.3 Future Work

Different goals will require tuning of parameters of the just-in-time social cloud to encourage or discourage certain decisions. The results from our study show that the social information mediated through mobile devices can allow people to make more efficient choices or help them reflect on their choices in the categories of food. Particularly when a person is uncertain about their choices, the just-in-time social cloud can influence people to make choices faster or more slowly. The just-in-time social cloud provides access to friends, family members and extended social networks that can help with current decision making. Chapter 3

presented clear examples on how the just-in-time social cloud could help with one's goals in savings, eating, exercising and time management.

The thesis opens up grounds for future research in the following areas:

- Designing new and improved experiments to better observe behavioral changes
- Comparing the effectiveness of the just-in-time social cloud versus other means of influence (using personal data or using games)
- Extending social interventions through channels beyond mobile phones
- Commercial applications of the just-in-time social cloud
- People's just-in-time susceptibility as a function of time
- Evolution and interaction of the virtual social networks and physical world behaviors at larger scales

In the following sections, I summarize some of the approaches to guide future research in each area.

8.3.1 New Experimental Designs

Social influences affect purchase decisions differently for different products. My research was confined to the categories of food due to the limitations in conducting experiments in a limited time frame. Understanding the product space and how social it is can help map out the product-specific parameters. This could be facilitated by doing experiments online instead of using mobile phones. Heuristics gained from online experimentation may guide the mobile application design. However, mobile phone applications are needed to probe real-world decision-making for each product category and to measure long-term impacts of just-in-time influences in real-world settings. Different product categories have different time lengths to decision, different frequencies of purchase, and different risk tolerances due

to their average price. These dimensions need to be taken into account to determine when to intervene, how often to intervene, and how strong social influences are needed for an effective the just-in-time social cloud for particular product categories.

An example of a new experiment would be in the category of shoes. ShoeRace is a presale experiment capturing and sharing items that people are interested in purchasing. Participants will use the mobile application to take pictures of any shoes that they like, are possibly interested in purchasing, or have purchased. They will additionally enter the brand name and discount percentage if the item is on sale. ShoeRace allows people to browse through items other people have found and rate them hot or not. The feedback and social information can be selectively displayed to see if they shift the behavior of people towards purchasing certain brands or to wait for sales before making purchases. Depending on the engagement level, we can determine a measure for a participant's susceptibility to influence and would warn if they behave like those who make too many impulsive shoe purchases. People that regularly (impulsively) purchase shoes will be recruited to participate.

Each application can also have a goal-driven interface. For example, in the case of the SocialMenu, the first screen could ask the user whether the participant is trying to optimize spending, health or taste. After they make this choice we can capture their browsing behavior on the menu and how social information affects their choices. Finally a post survey would be used to help rate the dishes.

We could also control the time to selection and use the post survey to capture how satisfied each person was regarding their selection when participating in control group versus the different social cloud groups. This will help determine whether the just-in-time social cloud creates more satisfactory choices in limited time. Finally, the post survey could display the people that have chosen the same dishes that a participant has chosen, to observe whether the availability of the just-in-time social cloud when rating the experience increases the satisfaction of the consumer.

Designing experiments with different demographics in different decision contexts can help map out the different types of decisions and the types of people that are most susceptible

to influence. Adolescents have a higher susceptibility to influence than adults and they are more active on the mobile phones. Therefore there could be strong potential in changing their behaviors with mobile phones.

Individuals may differ in how sociable they are and such personality differences can affect how much the just-in-time social cloud may have influence. Some people may prefer a more sociable approach to gathering information (more socially influenced) and others may prefer to search for information themselves. Capturing data on this dimension can help map out the impacts of the just-in-time social cloud.

8.3.2 Future of Interventions

The peer influences in the world many times can lead you to engage in a more hedonistic life-style. However, there's a saying that making good friends will make you do good things, while making bad friends can lead you to trouble. The same risk exists when utilizing the social cloud. The potential is that it can be effectively used for good behavioral changes even though you might not be in physical proximity to good friends or good people. It provides greater access to the social network beyond your first degree of friends to guide you in your decisions, if you desire. However, it can also lead you to encourage and justify certain behaviors that might not be socially desirable.

Let's say we had a friend in common who we both respected but tended to force us to drink too much when we went out. When we see he is going out, we will know that we will have a great time, but there could be a disclaimer along the side that says: "Don't forget! When you go out with Bob you spend 50% more than when you go out with other friends."

Although we have indicated that habitual and impulsive behaviors could be used to determine the timing of the intervention and those moments could be learned over time, the best moment to intervene can be better understood through further real-world experimentation. The challenge with determining the right time to introduce the just-in-time social cloud to mobile users is that the time of the day and the location continually changes as one moves

from one place to another. If the mobile phone can continually notify the just-in-time social cloud about the current context, a dynamic set of the just-in-time social clouds can be generated to help in each context.

8.3.3 Beyond Mobile Phones

In the future of ubiquitous computing, any display or devices that can most effectively be utilized in the user's decision can be used to mediate the just-in-time social cloud. In the context of this thesis, smart phones have been the main means of deploying decision aid applications. This expands the application of the just-in-time social cloud beyond mobile phones. In the future we envision that devices will be able to seamlessly communicate among themselves and with services in the cloud. Choosing the best channel to help guide one's choices will depend on what kinds of displays, devices and computing capabilities are at hand in the user's context.

The thesis discussed the design of future of communications where the surrounding devices and the network know and learn about the social relationships of individuals. This can help people better manage communications and increase throughput of not just bits but also relational connections and on-demand influences. Relationship-based networking is a crude term that was defined to describe such networks. Such a communication network would maintain a memory to access the social cloud. The communication network also would become more efficient with time as the necessary associative networks (social clouds that matter) for different decisions and contexts are identified over time. Just-in-time access to the social cloud would allow users to access these associative networks when desired so that they may be guided closer towards their personal goals.

8.3.4 Commercial Applications

The deployment of Open Transaction Network showed that people are willing to share certain categories of purchases, given enough incentives. Two years after OTN was conceived, startup companies like Blippy and Swipely introduced web based applications that linked

people's credit cards and transactions from electronic commerce sites to encourage people to communicate their purchases to others. The basic assumption under OTN was to use such information for just-in-time social navigation during shopping. Engaging the application at decision points is critical to encourage usage. However, the above commercial services did not launch any mobile applications that may serve as better decision aids, nor did they provide deeper insights into the quality of the products. Currently, they are struggling to sustain their businesses.

OTN can be established as a third-party service by which businesses and consumers can participate to provide the just-in-time social cloud services. It would be difficult to ask businesses to contribute their data to OTN, since for some retailers these data drive their marketing analytics and supply chains. However, if OTN becomes a more informative data repository, businesses will no longer have incentives to silo their data. OTN can also track usage of the data by businesses and reward people when their data are used.

In the last five years, online businesses have caught on to the importance of social media in influencing people's choices and have been utilizing open social data to continually influence our decisions. However, the goals of the business may not necessarily align with the goals of individual consumers and these social influences may lead one to make choices that one may regret later. Websites that integrate Facebook friends may induce us to engage with the site, but it may waste our time and distract us from what we were intending to do. It may even make us buy music online that we would never listen to again.

Beyond the online world, Foursquare and American Express have recently partnered to provide location-based offers based on the check-ins people make at a particular store. This attempt supports my thesis of augmenting existing payment mechanisms with more interactive mobile applications instead of trying to replace existing payment mechanisms. When a user checks in with the Foursquare application, it shows them an offer from the store that influences them to pay with their American Express card to redeem the offer. Again, this scenario is enabling the businesses to encourage consumers to perform those transactions at that moment without knowing the particular goals of the customer.

The just-in-time social cloud can be embedded in these online and mobile applications to

help users be more informed about each offer presented to them and provide social signals that align with users' long-term goals. This can encourage or discourage taking action on these offers for personal benefit. Beyond location-based applications that influence one to make purchases at a location, presenting offers or interventions at the right time to users will also become very important to help guide and increase awareness of their choices.

8.3.5 Just-in-Time Susceptibility

Understanding a user's just-in-time susceptibility is different from understanding a user's inherent susceptibility. Previous studies on information cascades assumed that individual relationships stay static, meaning that when a pair of nodes A and B are connected, they stay connected over time. In reality, these people move around, make new connections, and transmit information to different groups of people. Traditionally, influence has looked at individuals, but we now have the tools to look at it from a network point of view. In the past it was believed that there were opinion leaders that were most influential, but today individual choices shared through the social network allow multiple people to influence an individual over varying time scales and locations. What determines the impact of the influence is the susceptibility of those individuals to these multitudinous forces. My research led to an attempt to assess susceptibility to influence beyond just a probability number, since people have different susceptibilities to influence at different times and they vary for a wide range of real-world decisions. Uncertainty measured by the time to browse through choices (e.g., a menu) and the diversity of locations one visits are both potentially good measures of susceptibility that take into account the time.

8.3.6 Behavioral Changes on a Larger Scale

This thesis has investigated how micro decisions are affected when social networks become available across time and space. However, it is an open question how this would change people's behavior on a larger scale. Also, different people have different levels of influence towards each other and we were not able to measure those levels. Watts and Dodds explain

that it is generally the case that most social change is driven not by influentials but by easily influenced individuals influencing other easily influenced individuals [131]. They believe that cascades are driven by easily influenced people. Based on these results, they argue that, although their models are at best a simplified and partial representation of a complex reality nevertheless, highlight that claims regarding the importance of influentials should rest on carefully specified assumptions about who influences whom, and how.

Mobile phone-based data have created ways to capture people's contact networks and communication patterns in the real world. These advances have allowed understanding of the tie strengths and how information flows through them. The wide availability of social networks on mobile phones and the sharing of behavior across these networks have increased the scale at which people's behaviors can spread through the real world. This provides understanding of how social networks behave and allows modeling of how epidemics spread, but it does not help predict how an individual makes a decision to accept and propagate information at the moment. My thesis focuses not on the natural propagation but on how those social networks can be harnessed to assist a person's progress towards long-term goals. Businesses are already influencing people through social information which may not align with goals of consumers. The just-in-time social cloud empowers people to counteract these forces and serves to benefit each individual's goal achievement. Such use of the social cloud leads to artificial and dynamic manipulation of social information by individuals and groups. Widespread usage of such influences can lead to a sophisticated network of behaviors that create feedback loops beyond what has been observed in existing social network dynamics. Modeling this interplay of virtual and physical networks on larger scales must await future data collection and experimentation.

Appendix

The source code for the iPhone, Android and web applications can be found at:

- https://svn.media.mit.edu/r/socialsaver/trunk/
- https://svn.media.mit.edu/r/otn/trunk/fcn.media.mit.edu (Legacy, includes Twopons)

The anonymized data will be made available at:

http://www.media.mit.edu/~kwan/jitsocialcloud/

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