

The Broadcast Marketplace

Designing a more efficient local marketplace for goods and services

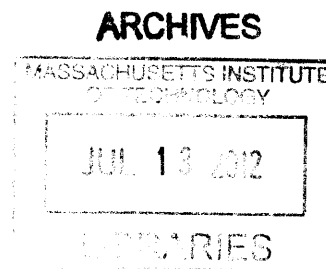
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B.S. Computer Science
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May 2008

Submitted to the
Program in Media Arts and Sciences,
School of Architecture and Planning,
in partial fulfillment of the requirements for the degree of
Master of Science in Media Arts and Sciences at the
Massachusetts Institute of Technology

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Abstract

Today's online marketplaces for goods and services are imperfect. Participants make an initial post expressing their intention to buy or sell an object, but all offers on this post are private. These offers can be seen as expressions of other participants' intentions to buy or sell the same item. What if these offers were as public as the initial post? Would this decrease market friction and enable participants to close transactions more efficiently? What if every post and offer were tagged with a location enabling a real-time proximal picture of supply and demand? In this thesis, we explore a different kind of marketplace, a broadcast marketplace, where a combination of public post, proximal awareness and mobility decrease the friction of information flow and facilitate efficiency. This thesis explores the design, implementation and deployment of a system which enables users to efficiently view, understand and act upon this proximal picture of supply and demand.

To test the viability of the broadcast marketplace we deployed Peddl, an implementation of the idea, in the MIT and Cambridge, MA community. Over the course of the trial we collected data on 5,839 unique visitors and 805 registered users, who made 726 posts totaling \$234,913 in value. From this data we show that the additional transparency of supply and demand afforded by our design results in increased marketplace activity.

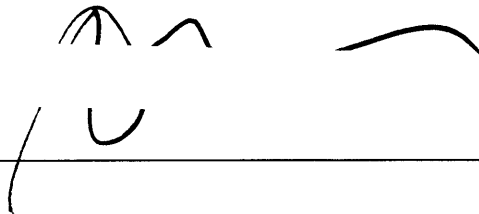
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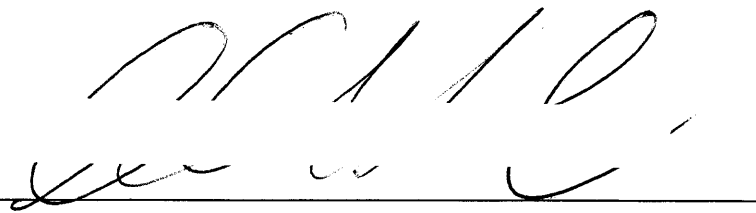
Program in Media Arts and Sciences

The Broadcast Marketplace

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Matthew Blackshaw

Thesis Reader

A handwritten signature in black ink, appearing to read 'César Hidalgo', is written over a horizontal line.

César Hidalgo

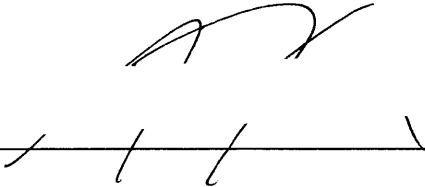
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Introduction

Background

According to economic theory, one of the key structural characteristics of a perfectly competitive marketplace is perfect availability of information amongst its participants [1]. Many point to the stock exchange as an approximation of such a marketplace. Today, the stock exchange achieves efficient flow of information through electronic trading systems, but many years ago the same effect was achieved through the open outcry system. Traders and stock brokers in the pit of the trading floor would use a combination of shouting and hand signals to announce information about buy and sell orders. Because all participants in the pit were able to hear the price and intention of others, they all had access to the same information. In this thesis, we explore how some of the characteristics of the trading pit and open outcry system could be approximated in the design of a more efficient local marketplace for goods and services.

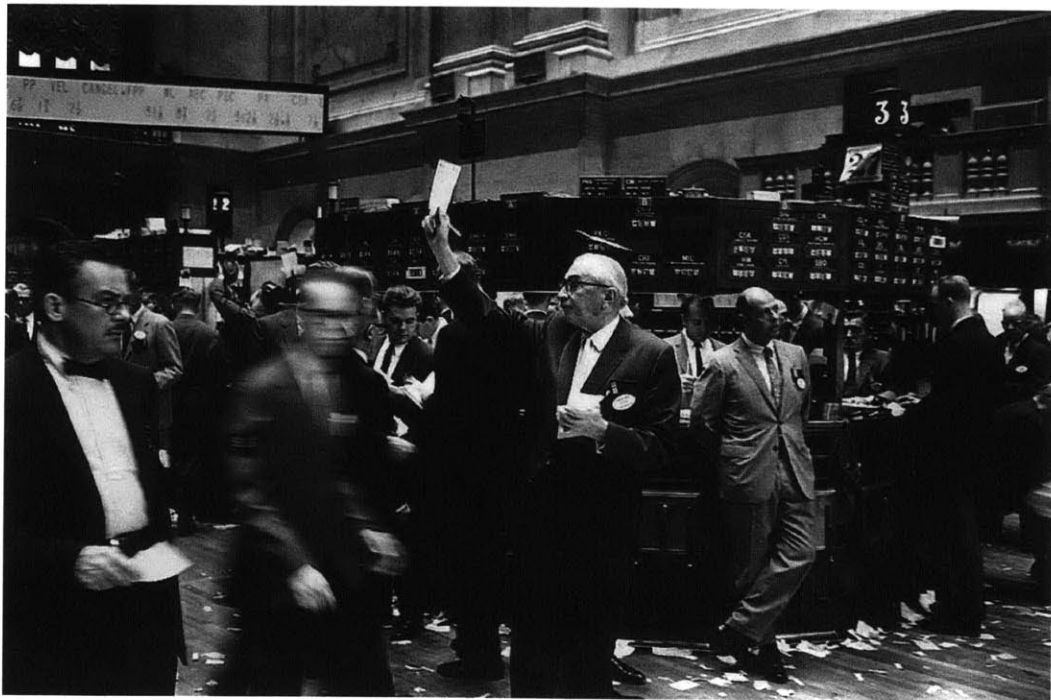


Figure 1: Trading floor of the New York Stock Exchange, 26th September, 1963

Missed opportunities

Unlike the stock exchange, today's online marketplaces for goods and services are far from perfect. Most services allow users to declare their intention to buy or sell a good or service through an initial post, but all subsequent offers on the post are private. This means that each post exists in its own private bubble and therefore opportunities for successful transactions could be missed. Take the scenario below:

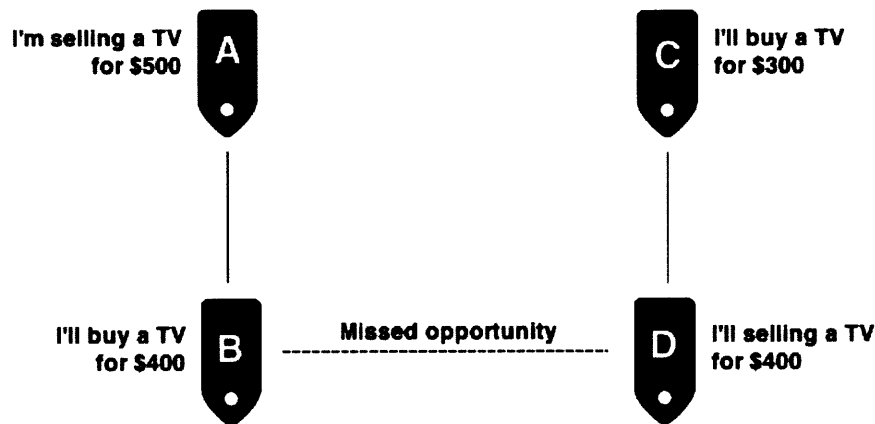


Figure 2: Missed opportunity

1. Participant A posts his intention to sell a TV for \$500.
2. Participant B responds to participant A offering to buy his TV for \$400.
3. Participant C posts his desire to buy a TV for \$300.
4. Participant D responds to participant C offering to sell his TV for \$400.

Here participant B and participant D agree on price, however they have no knowledge of each other's offer, so the opportunity to act on a potentially successful transaction is missed. Of course, while these participants agree on price, products in traditional marketplaces are often not homogeneous so there is no guarantee that the transaction will be successful. We consider the fact that these participants have no knowledge of each other to be a flaw in marketplace design. In economic terms, the flow of information is imperfect because participants do not have complete knowledge of others' price or intention.

Today's marketplaces are also imbalanced. Craigslist [2] and eBay [3], arguably today's most prominent online marketplaces both focus heavily on participants posting what they want to sell. Responses to these posts, which are expressions of intent to buy, are entirely private. This creates an imbalanced picture of the marketplace where supply is public and demand is private.

Additionally, communication is not frictionless in today's marketplaces, largely due to their technical implementation. Both Craigslist and eBay rely on messages and offers posted on websites, which users are in turn able to respond to when they return to their computers. This friction is decreased by always-connected smart phones and mobile email, but the experience is far from seamless. High friction of communication can create information asymmetries between parties, reducing market efficiency [4].

Lack of context

A secondary issue that exists on today's online marketplaces is the lack of contextual information about trust and geography. Similar to the lack of information about price and intention, this lack of context results in less information when users make purchasing or selling decisions. Often users must engage with the poster to find out more about identity, location or seller reputation. Trust is a significant problem on anonymous marketplaces like Craigslist, where the identity of the poster is obfuscated. This lack of identity means users are forced to make decisions based on what little information they can glean from conversation.

Solution

In this thesis we evaluate a design for a more efficient marketplace by borrowing some key structural characteristics from the stock exchange and applying them to an online marketplace for goods and services. In essence, we build a marketplace where all posts and offers are public broadcasts of an intention to buy or sell an object or service. The primary difference from existing work is that offers on existing posts are posts

themselves; just another expression of an intention to buy or sell in the marketplace. This transparency allows us to surface additional contextual information about the temporal, social and geographic proximity of posts. We hypothesize that this increase in transparency of supply and demand, coupled with additional context will result in increased liquidity in the marketplace.

During the spring of 2012 we deployed a trial of the broadcast marketplace concept in Cambridge, MA under the moniker of Peddl. Over the course of the trial we attained 5,839 unique and 805 active users who made \$234,913 in posts. Despite this quantity of data, we were not able to formally prove that additional transparency results in increased liquidity. However, we were able to show that the mechanisms by which we increased transparency did result in a greater number of posts in the marketplace, thus demonstrating viability of the idea.

Terms

In order to set common ground for discussions in this thesis, we define the following terms:

- **Balanced marketplace** – A marketplace where both supply and demand are afforded equal visibility throughout the marketplace.
- **Liquidity** – The rate at which transactions are cleared in the marketplace.
- **Geographic proximity** – The spatial distance between two users or two posts.
- **Temporal proximity** – The time between which two posts are submitted to the marketplace.
- **Social proximity** – The social distance between two users, as measured in the number of mutual first degree real-world contacts.

Related work

Theory

Central to the broadcast marketplace is the idea that increasing information about price, intention and proximity will result in faster matching and reduced friction. In other words, by allowing both supply and demand side posts (have and want) and making them proximal responses to each other, we hypothesize that:

- There will be an increase in the number of posts compared to a traditional marketplace.
- The increase in number of posts on both the supply and demand side of the marketplace will give participants more information about price and magnitude of supply and demand.
- The increase in information will aid users in finding a match for their post, reducing friction in the marketplace.

Unlike financial marketplaces, where products are liquid and homogeneous, goods and services marketplaces tend to have non-homogeneous products meaning that the individual preferences of participants play an important role. Smith [5] indicates that participants in a market pursue their own interests according to the information available to them, so achieving closer to perfect information can aid competition and efficiency.

Economic and mathematical works on market efficiency and forecasting are grounded in the empirical study of marketplaces for financial commodities rather than marketplaces for goods and services. This is true of both Fama's study of random-walks [6] and Mandelbrot's analysis of expected returns [7]. We believe this is due to the ample historical data for financial transactions, the homogeneity of financial products and the total transparency of supply and demand due to the mechanics of the stock exchange. However, the core idea that better information results in increased efficiency is still

applicable to traditional goods and services markets. Fama's work on efficient capital markets [8] summarizes these ideas and states that a market in which prices always "fully reflect" available information is called "efficient." By this definition, today's goods and services markets are inefficient, because historical data on prices is generally unavailable to participants. Craigslist does not offer (or collect) data on the price of successful transactions and while eBay does offer such data through their API [9], they do not reflect it on their site for participants to see. Additionally, both services only publicly reveal the supply-side prices of items sold. The prices and quantity of offers made on the demand-side are only visible to supply-side posters. The broadcast marketplace is, at the very least, making both the demand and supply-side prices of an item visible to all participants. By Fama's definition, the broadcast marketplace could at least achieve weak-form efficiency.

Bakos [10] indicates that internet-based economic marketplaces leverage information technology to better match buyers and sellers and facilitate better price discovery through agents [11] and search engines, resulting in more efficient "friction-free" markets. Similarly, the broadcast marketplace aims to build a more friction-free market by increasing the availability of data about both supply and demand price, and proximity of posts, allowing users to participate more effectively.

We argue that the broadcast marketplace can be more friction-free and achieve greater efficiency because of the increased transparency of supply and demand and information available to participants.

Implementations

While the broadcast marketplace is a novel approach to a balanced and inherently proximal system for the exchange of goods and services, it is most definitely not the first attempt at improving on existing marketplace models.

In the academic space, a number of studies have been conducted on the use of ad-hoc communication technology and natural language processing algorithms, to link

geographically and semantically proximate buy and sell posts. PeopleNet [12] and FleaNet [13] utilize Bluetooth, ad-hoc wireless and vehicular ad-hoc networks to determine matches with people nearby. Related is Kasbah [11], an agent-based system in which software determines the best match in a system of posts based on a number of specified attributes. Reach [14] allows users to post a request for help with a task and have it routed to the nearest person best able to fulfill that task. It is a proximal request routing service similar to Zaarly and TaskRabbit and focuses on the demand side of the marketplace, but unlike those services it uses artificial intelligence to make the best match. Bringy [15] aims to generalize the notion of person discovery by allowing people to share information about themselves as key/value pairs creating a generic platform on which proximal applications can be built.

In the commercial space, Craigslist [2], eBay [3] and Alibaba [16] dominate online marketplaces in the United States. Craigslist allows users to post free online classified advertisements within specified categories and geographies. Similarly, eBay allows users to conduct online auctions for goods and services they wish to sell. Focusing on business-to-business transactions, Alibaba has become the world's largest online trading platform for small businesses. In Bangladesh, CellBazaar [17] has emerged as the dominant marketplace for goods and services, but unlike Craigslist and eBay, CellBazaar utilizes SMS, wireless application protocol (WAP), a web site and interactive voice response (IVR). This is largely due to the mobile phone becoming the ubiquitous computing device [18] in developing countries. Posts on all three of these marketplaces are weighted toward the supply of goods and services.

Zaarly [19] and TaskRabbit [20] are two emerging demand-side marketplaces in the United States, in which participants are able to post goods they would like to purchase or tasks they wish to have performed. Unlike eBay and Craigslist, these services focus on the mobile device as the posting and browsing tool, and capitalize on the availability of GPS to tag posts creating some of the first widely available hyper-local markets [21].

PeopleNet and FleaNet

PeopleNet [12] focuses on decentralized distribution of classified ads or queries through device to device interaction. It uses the natural movement of people and devices in a geographic area to allow epidemic query dissemination. It is an inherently decentralized model of propagation where the dissemination of queries is a function of the movements people make. When a query is made to PeopleNet it is forwarded over centralized infrastructure (in their implementation the cellular system) to a random selection of users in

the associated bazaar. Each bazaar occupies a defined geographic region (*Figure 3*) and has a specific topic (e.g. sports bazaar) where associated queries are sent. The geographic specificity of the bazaar is not associated with the query, but is rather part of the system design for storage and propagation. In other words, PeopleNet was designed to create a new type of database where the underlying storage medium and index is not a centralized server, but rather a large number of decentralized user devices. PeopleNet depends on devices monitoring and passing data between neighbors using an ad-hoc technology such as Bluetooth. While not called out by Motani et al, such technology does place tremendous strain on the battery of today's devices, prohibiting constant use.

Similar to PeopleNet, FleaNet [13] explores decentralized query dissemination, but uses vehicular ad-hoc networks (VANETs) as the communication medium. It also relaxes the concept of the bazaar by allowing people to specify a region of interest along with their query. Like PeopleNet, FleaNet focuses on a novel approach to query propagation rather than focusing on underlying economics of a two-sided marketplace.

The broadcast marketplace is similar in spirit to these services in that it seeks to match buyers and sellers close in proximity. In the technical design of the broadcast marketplace we opted for a more centralized approach, but used similarly public bipartite

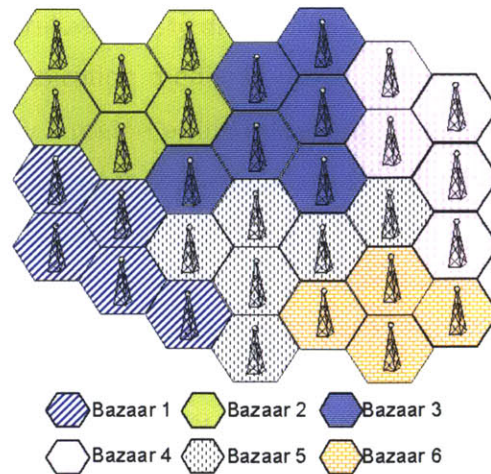


Figure 3: Geographic structure of PeopleNet bazaars

queries. Unlike PeopleNet and FleaNet, our approach focuses not on a novel technological approach to query dissemination, but rather a solid balance of centralized matching and simple user experience to measure the economic implications of a two-sided marketplace.

Kasbah

Kasbah [11] originated with the notion of reinventing classified ads through decreased cost of discovery, negotiation and price information. It is a system which attempts to automate the process of buying and selling goods through software agents that act on behalf of the user. These agents act in the marketplace without user intervention and attempt to negotiate the best deal for an item, taking into account desired date of sale, desired sale price and lowest acceptable sale price. At time of writing, Kasbah agents did not make decisions based on geography or social distance, though the authors do mention that these sorts of parameters are a future possibility. Similar to Kasbah, we build upon the idea of automating the process of matching buyers and sellers, but unlike Kasbah we present our best guesses at a match, allowing the user to make the final decision themselves.

Reach

Reach [14] explored a system which routes messages to the best known recipient based on relevance of message content and proximity of the sender. The system uses natural language processing to understand the topic of a message and then relays the message to the closest user who is known to be interested in the topic. If the message is a request, the user can choose to accept the request or pass it on, in which case the message is forwarded to the next best recipient. Similar to Reach, our system tries to best route requests and responses based on topic and context, but instead of focusing on communication we focus more directly on facilitating transactions of goods or services.

Bringy

Bringy [15] allows people to form dynamic groups based on shared interests. Users are able to express bits of information about themselves as key/value pairs. For example 'programming' and 'python', or 'buying' and 'ipad'. Anecdotally these could be people who can program in Python or are interested in buying an iPad. Users are able to filter based on these key/value pairs to discover people who match certain criteria. Because the keys and values are free-form text fields they can be used to express anything from the name of a book to the serial number of a good or the location of an entity. Bringy is an attempt to identify the minimal subset of components which can be used to build today's proximal services. Bringy is similar to the broadcast marketplace in that it's building a platform for proximal discovery, but our system is different in that it focuses on transacting in a marketplace and facilitating discovery of other people through matching posts.

Craigslist

Craigslist [2] is the best source for local classified advertisements in the United States. According to a paper published by 3taps [22], roughly 1.5 million posts are made to the service daily, totaling nearly 687.7 million posts in 2011. The service is entirely anonymous allowing posts to be made with only an email address. Beyond categories and search, the service employs no intelligence to match buyers and sellers. Additionally, the service is very supply centric, with fewer than 0.5% of their posts being made to their help wanted (Gigs) category [22]. Posts to the service require a title, price, urban location and optionally description and photos.

The broadcast marketplace seeks to evolve the classifieds model of Craigslist by surfacing demand in the marketplace and offering additional geographic and social context. Additionally, our implementation notifies users if matches are made in their neighborhood.

eBay

eBay [3] is the best source for online auctions in the United States. It was founded in 1995 and quickly grew to 2.25 million auctions by September 1997 [23]; statistics on current usage are not shared by the company. The service is pseudo-anonymous through use of an alias which allows users to build a reputation based on feedback from previous auctions. As of writing, eBay supports 3 types of auctions: auction-style listings, fixed price format and fixed price format with best offer. These types allow for traditional auctions as well as instant purchase of goods. While eBay only allows users to make supply-side posts, the bidding history offers some transparency into the demand for a listed item. Listings consist of a title, description, urban location and price. In addition to notifications on listings, eBay allows users to watch auctions and be notified of activity even if they're not an active participant.

While similar in the spirit of buying and selling goods, the broadcast marketplace differs in that it seeks to make demand not only visible, but also actionable to users.

Zaarly

Zaarly [19] launched in early 2011 and has quickly become one of the most prominent demand centric marketplaces in the United States. Users are able to post goods or services that they want to buy along with price, location and expiry. Sellers are then able to make private offers on posts indicating a location and counteroffer. Zaarly places great emphasis on geographic proximity and unlocking sorts of transactions that weren't possible on existing marketplaces. In early 2012 they added seller alerts [24], which allow users to be notified if posts matching specified keywords are made within a radius of a location. Posts to the service can be either associated with a real world identity or anonymous.

Of all related work, our work is most similar to Zaarly due to the emphasis on geographic context of posts. Like aforementioned services, but unlike the broadcast marketplace, Zaarly is one-sided through absolute focus on the demand side of the market.

TaskRabbit

TaskRabbit [20] was launched in 2008 and allows users to post tasks or errands they want performed by people in their neighborhood. The service differs from Zaarly in that tasks are completed by 'runners' who are pre-approved by the company through reference and background checking. TaskRabbit focuses solely on services and the demand side of the marketplace. Once approved, TaskRabbit runners are notified of posts in their neighborhood matching their skill set.

Transactions and social organization

While today's major social platforms predicate their existence on the social incentives and utility people derive from sharing information and 'keeping in touch' online [25], there are an increasing number of nascent services which encourage participation through the economics of reputation. In this chapter we discuss how these platforms function as social organizers and how the broadcast marketplace differs through use of transactions as the underlying organizational principle.

Facebook [26] has become the canonical social graph; an online recreation of our offline social connections. Every 'friendship' on Facebook is an edge indicating the mutual agreement to share information between two people. It is a platform allowing us to contribute photos, comments and 'likes,' with increasing accessibility and ease. Unlike Facebook, Twitter's graph differs in that edges are directional – users exclusively choose to follow one another. This difference frees users from the necessity of real-world social ties and permits people to follow others whom they find interesting. Fundamentally, these platforms rely on the social incentives [25] and social capital [27], [28] derived from sharing, as the underlying principle of organization among people.

Reddit [29] and Digg [30] explore the coupling of information sharing and reputation. Users can contribute articles, photos or videos which can then be voted upon, increasing the standing and influence of a user in the community. StackOverflow and its associated network of StackExchange sites allow users to ask topical questions and receive answers from domain experts. Users can vote on the quality of each answer, increasing the reputation of its author. On all three platforms users seek to increase their standing in the community through contribution of high quality content. Similar to social services these sites predicate their existence on the sharing of information, but instead of relying on social incentives for participation, they rely on earned reputation. While the notion of earned reputation hints towards the economics of a marketplace, it falls short in

definition, as reputation cannot be redeemed or spent. As such, we define reputation as the underlying principle of social organization.

Kickstarter [31] is the most recently successful crowd-funding platform. People are able to contribute money to an artistically or socially motivated project in return for a small reward from the creator. Essentially the creator is being loaned funds for some task that will be completed in future. TaskRabbit [20] and Zaarly [19] allow people to post tasks or services they wished to have performed along with the amount they're willing to pay. These platforms are some of the first to explore transactions between people as a principle of social organization. People are able to spend or earn material value for their participation in the community. These services are the true beginnings of the transaction as an underlying principle for social organization.

The broadcast marketplace, similar to Barter [32], takes the notion of the transaction as a principle of social organization a step further. Barter explores a information marketplace where users can spend virtual currency in exchange for answers to questions. Users are rewarded for the quality of the answers they provide. The creators of Barter believe that the scarcity of virtual currency encourages higher quality information to be contributed to the community; people must transact in order to participate in the community. In designing the broadcast marketplace, we envision a similar platform for transactions where participants can couple verbs expressing their desire for something to occur, or their ability to fulfill a task, with a monetary value. This coupling forms a method of social organization that, unlike traditional social or reputation-oriented platforms, shifts the primary use case of the underlying graph from observational to actionable. It is a graph of intentions that looks to future interactions rather than past happenings. It makes the transaction or fulfillment of intention the organizing principle among people and creates a very real material incentive for participation. In this sense it is a marketplace of opportunity where people are materially compensated for participation. Unlike other services where the information shared is valuable to the service provider due to the insight it offers into their users, we seek to build a platform where our users are able to derive monetary value from the intentions others share.

Our ultimate goal is to explore an online society organized around shared intention rather than shared archive. We seek to create a community where the value is not in the

information shared, but in the opportunity offered to others. The incentive to participate does not originate from the social reward, but rather the material reward for transacting.

Marketplace Design

Summary of the system

The broadcast marketplace is founded on two fundamental principles of balance and proximity. It is a marketplace where the balance achieved through transparency of supply and demand, coupled with additional geographic, temporal and social context, enables more perfect information for market participants and better informed decisions. If viewed as a graph, every post is a node, while negotiations are the edges existing between any two posts of opposing type (*Figure 4*).

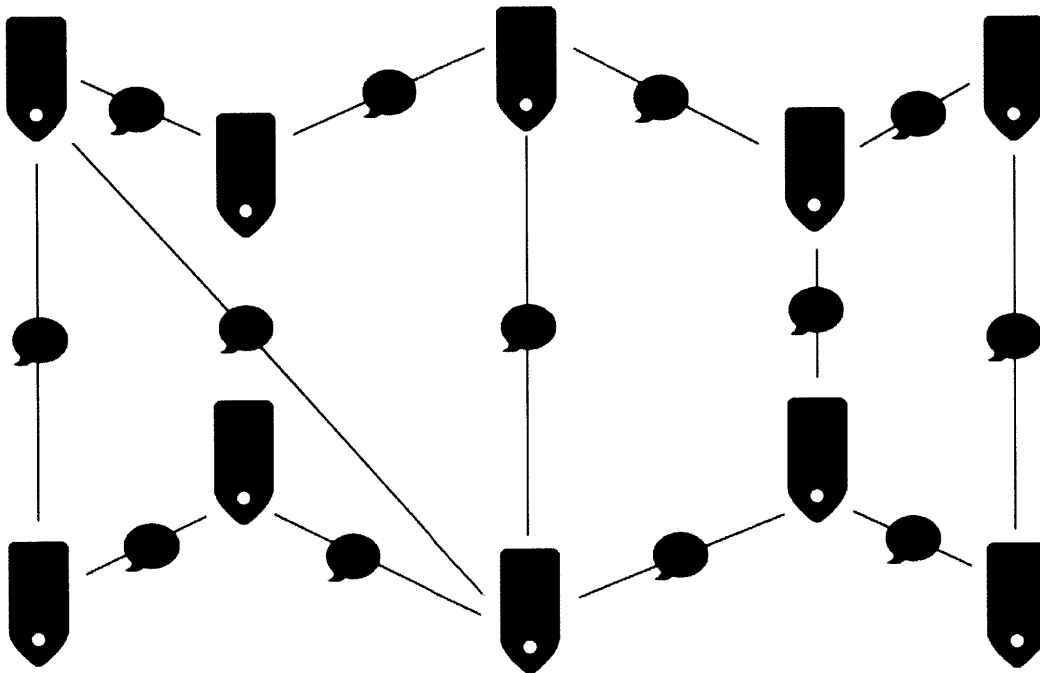


Figure 4: The Broadcast Marketplace

Timeline

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Ideation	■	■							
System design	■	■	■						
Implementation		■	■	■	■	■			
Community launch						■	■	■	■
User feedback						■	■		
System iteration						■	■	■	
Evaluation							■	■	
Writing thesis							■	■	■
Committee feedback								■	■

Post

When considering the makeup of a post, we drew inspiration from the model of a bid-ask marketplace, the most exemplary implementation of which is the stock exchange. Before electronic trading systems, buyers and sellers would announce their bid and ask orders for financial commodities on the trading pit floor. We borrow this notion of public outcry, but apply it to a marketplace for goods and services. The post is a public announcement of a user's intention to buy or sell a good or service at set price and is the atomic unit of our marketplace – the nodes of our graph. While this is conceptually similar to the stock exchange, our system must be more nuanced because unlike financial commodities, goods and services are not homogeneous. To mitigate this issue, users are not obligated to buy or sell at their announced price, but rather can converse with other posters to find middle ground. This difference should be noted – the broadcast marketplace doesn't presume to know the best match for a post, instead it offers its best suggestions along with contextual information on which users can make informed decisions.

To simplify the experience of the marketplace, posts are of two types: 'want' or 'have'. These types of posts can be used to easily express buy and sell scenarios:

- I'm on a plane, I've got a middle seat, I want an aisle seat, and I'm willing to pay \$20.
- I'm on a hike, I want bottled water, and I'm willing to pay \$50.
- I'm at a Red Sox game, I want a seat behind home plate, and I'm willing to pay \$300.
- I want a parking spot here, now. I will pay \$50 for it.
- I have a car I'm willing to lend out for \$20 an hour.
- I have an iPad I'm willing to sell for \$200.
- I have 30 Roses that will wither tomorrow, I'd accept \$30 for all of them.

We chose the terms 'want' and 'have' because they fit common intentions, can apply to both goods and services and are polar responses to each other: If a user has an item, then a natural response is to want that item.

To ensure that every expression is public, replies to posts are themselves another post. For example, if someone has a bike to sell for \$250, then a natural response would be a 'want' post for a bike at \$200. This response is public to other people in the community as it is our belief that if others could act on this demand, they might be willing to sell their bike for less than \$250 – a form of counter-offer. To frame this another way: the bulletin board at a local supermarket allows a community to post things they're selling and interested buyers can tear off small tags that list a seller's phone number. Every buyer that tears off a tag is expressing interest in buying the listed item, but the only community member aware of this intent to buy is the seller. The broadcast marketplace allows the entire community to be aware of every buyer and provides the chance to act on this demand. We believe that this transparency coupled with additional proximal context enables a more liquid marketplace.

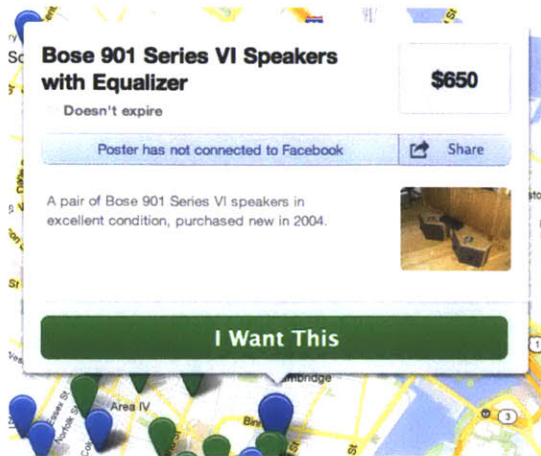


Figure 5: Have post details (web)

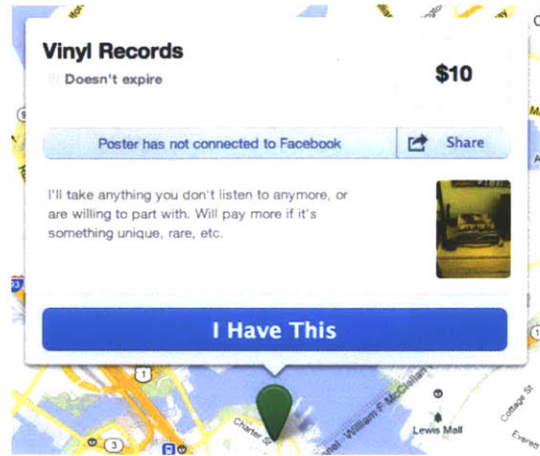


Figure 6: Want post details (web)

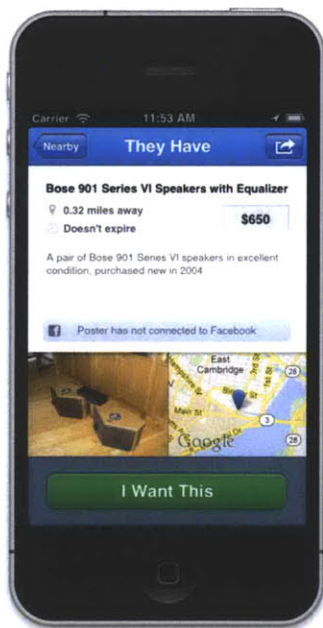


Figure 7: Have post details (iOS)



Figure 8: Want post details (iOS)

Post attributes

A post consists of the following attributes:

Name	Required	Value
Owner	Yes	Unique user identifier
Type	Yes	Want or Have
Location	Yes	Latitude and Longitude
Title	Yes	Short text string describing a post
Description	Optional	Long form text offering additional detail about a post
Photos	Optional	Array of image URLs
Expiry	Optional	Date indicating the time at which the post expires

Negotiation

In the trading pit of the stock exchange, brokers are able to communicate face to face enabling rapid dissemination of information. We seek to make communication of details of a potential transaction just as immediate through real-time messaging and voice calling. Conceptually we group this functionality into negotiations. Negotiations exist between two posts in the broadcast marketplace and can be thought of as the edges of our graph. Unlike the trading pit, where brokers can see the transactions as they occur, both the existence and all actions taken in a negotiation are kept private. The goal of the negotiation is to decrease the friction of information dissemination, meaning users can close transactions faster.

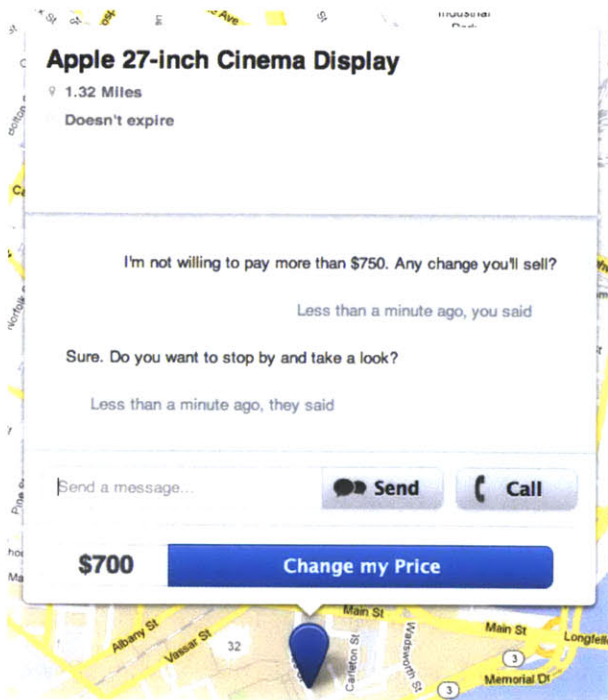


Figure 9: Negotiation from the perspective of the buyer (web)

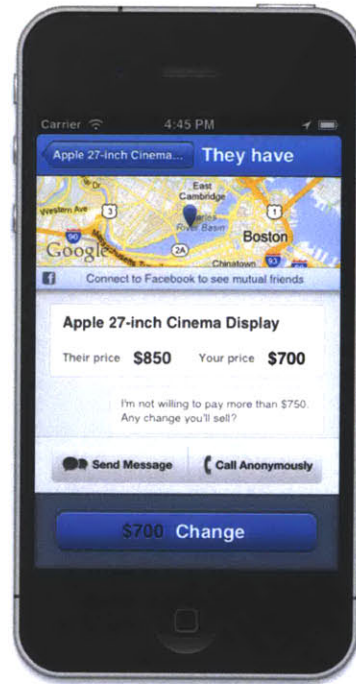


Figure 10: Negotiation from the perspective of the buyer (iOS)

Message and voice calling

To allow users to discuss specifics of a transaction and ask questions about the conditions of a good or service, we allow messaging and voice calling. Messages are limited to text and can be sent and received instantly between participants of a negotiation. Voice calling permits users to talk with each other without either party revealing their own phone number. Our servers execute an outbound call to both parties, allowing them to chat with each other without revealing any personal information.

Price

To assist users in a negotiation and ease the understanding of the bid-ask model, we offer formalized price negotiation and acceptance. When a negotiation begins the seller is able to accept the buyer's offer price or ask for something higher. The buyer is able to raise their price until it is acceptable to the seller. Changes to a price are only for purposes of a negotiation and don't alter the post price. We chose to make price changes isolated to negotiations as even for items of the same type, the price can vary depending on quality. In other words, having a per-negotiation price allows us to cater for goods which tend not to be homogenous. In our initial design we planned to log the price changes and the final acceptance of every negotiation to gain insight into the rate and way in which users agree on price and test whether this differs depending on the type of good.

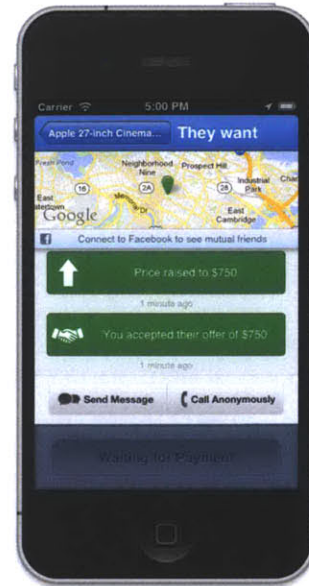


Figure 11: Negotiation from the perspective of the seller (iOS)

Negotiation user flow

1. A negotiation is created when a user clicks 'I Want This' or 'I Have This' on an existing post.
2. Users are able to converse over details of the transaction through messaging and voice calling. The seller is able to accept offers made by buyers, while buyers are able to increase their offer price incrementally.
3. If the seller chooses to accept the other's price, then the other user is notified of the acceptance.
4. The other user must then confirm this acceptance. We require this step, as agreement on price means both users' posts are removed from the market. Without this confirmation sellers could accept the buyer's price, maliciously

removing their post from the market – this is a complication of allowing posts to engage in negotiations with multiple other posts.

5. Users then message each other to arrange a meeting time and place to exchange goods and payment.
6. Once the transaction has occurred, either party can mark the post as complete.

Negotiation Attributes

A negotiation consists of the following attributes:

Name	Required	Value
Posts	Yes	Set of two unique post identifiers
People	Yes	Set of two unique user identifiers
Price	Yes	The current price of each user
History	Yes	Array of communication events which comprise the negotiation.

Proximity

The broadcast marketplace allows participants to better gauge the proximity of other posters geographically, temporally and socially. These dimensions of proximity provide additional contextual information to users enabling them to make more informed decisions.

Geographic proximity

Posts in the broadcast marketplace are tagged with a user specified location. This enables users to indicate where they intend to buy or sell a good or service. For example, while at work a user may wish to indicate their intent to sell their couch located at home or while

on a hike in the forest a user may indicate their intent to buy bottled water. This coupling of intent and location creates a proximal picture of supply and demand in the marketplace.

By giving posts street-level granularity of geography (as opposed to metropolitan-level granularity in existing marketplaces) we can begin to quantify how the distance between posts effects price or exactly how much users are willing to pay for the nearness of a post. This data could also help us understand the value users place on nearness for different types and categories of products.

We realize that fixing precise geographic location to more expensive items could dissuade users from posting them to the system, so we offer the ability to manually alter the posting location to a public landmark or street corner affording an additional privacy.

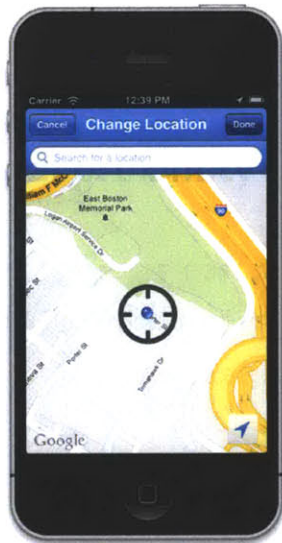


Figure 12: Altering location manually (iOS)

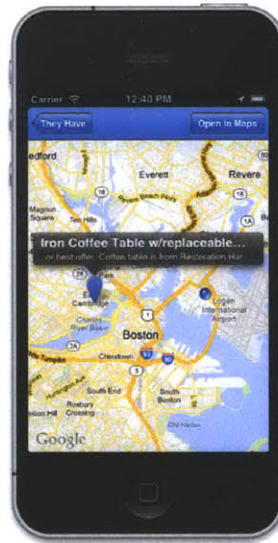


Figure 13: Gauging geographic proximity (iOS)

Temporal proximity

We believe there is a class of transactions for which there is no marketplace today because the high friction of posting and discovery make the opportunity cost prohibitive. In other words, there are categories and types of goods where participants are unwilling

to post because it is not worth their time. Canonical examples are perishables like flowers, left over foods or movie tickets – goods which are of no value after expiration. In order for these goods to be sold there needs to be measurably close geographic and temporal proximity to reduce the opportunity cost of sale.

In the design of our marketplace we seek to lower this cost, making these transactions feasible. We seek to lower the friction of posting through a simple 4-step process accessible from mobile and web applications. We seek to lower the friction of discovery through efficient visualization of nearby posts and pushing actionable post matches to the user. Finally, we decrease friction of communication through integrated messaging and voice calling. These features are fully specified in the technical design section.

Social proximity

To increase trust in the broadcast marketplace we allow users to see the number of first degree connections shared with a poster within their social graph – the number of friends they share on Facebook. While this offers a measure of trust through awareness of social closeness, it also provides insight into the social groups to which a poster may belong. Indirectly, this allows users to see if the poster works at their company or studies at their university. Often many of these micro-communities have informal marketplaces that exist between employees or students on bulletins or mailing lists. By increasing the context of social proximity we increase trust and hope to formalize many of these informal marketplaces.

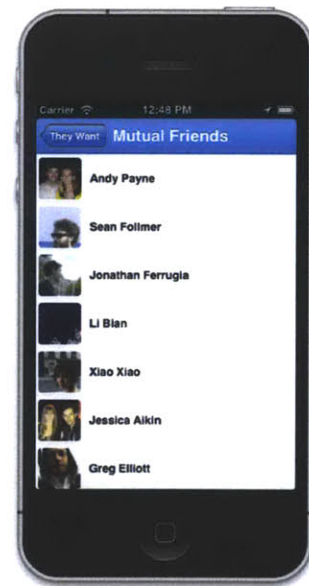


Figure 14: Viewing mutual friends (iOS)

Identity

A complication of making all posts public is that market participants may be hesitant to respond to other posts out of concern for their privacy. To mitigate this risk and ensure participants are comfortable broadcasting their intentions, all posts in the marketplace are anonymous.

One could argue that this anonymity dissuades activity, as public identity allows association of reputation through user recommendations or feedback and thus increases trust in the marketplace. While reputation must be associated with a user, it could be revealed free of identity on the posts that they've made. Our current design of the broadcast marketplace does not include a ratings system, though is something we plan to investigate in future.

Matching

Because every post in the broadcast marketplace publicly expresses a person's intention to buy or sell an item, we need to be careful to ensure that each user's expression isn't represented multiple times. Take the following scenario: A user makes a post indicating that he has a bike to sell. Later he finds a post in the marketplace for a bike and taps 'I Have This,' prompting the creation of a new post. Without the intelligence to recognize he already has a post for a bike, he will create an additional post over-representing supply in the marketplace. To mitigate this issue we use natural language processing (NLP) to check if a user has already made a post for an item when they tap the 'I Have/Want This' button. Because NLP algorithms are imperfect, we display our best guesses at a match and ask the user to confirm accordingly, or if they want/have something else.

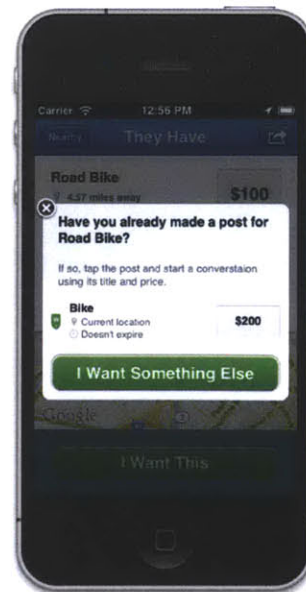


Figure 15: Reviewing potential matches (iOS)

When a user posts a post, our system uses NLP to find potential matches and notifies the user of potential matches and take action themselves. Our marketplace will notify users of potential matches simply by making a post.

When a post is made, our system uses NLP and proximity to find and notify users of matches. Unlike systems such as Kasbah [11] and Reach [14], the broadcast marketplace doesn't presume to know the best match of a post, but instead offers its highest ranking suggestions, taking into account temporal, social and geographic proximity. Immediately notifying users of potential matches through push notifications, WebSockets and email means that participants are able to engage more quickly, opening the potential for aforementioned transactions that depend on close temporal and geographic proximity.

Craigslist and eBay are comparatively passive marketplaces where buyers must explicitly setup alerts or actively browse for potential matches and take action themselves. Our marketplace will notify users of potential matches simply by making a post.

Initial user experience flow

All possible user states in the broadcast marketplace are shown in *Figure 16*.

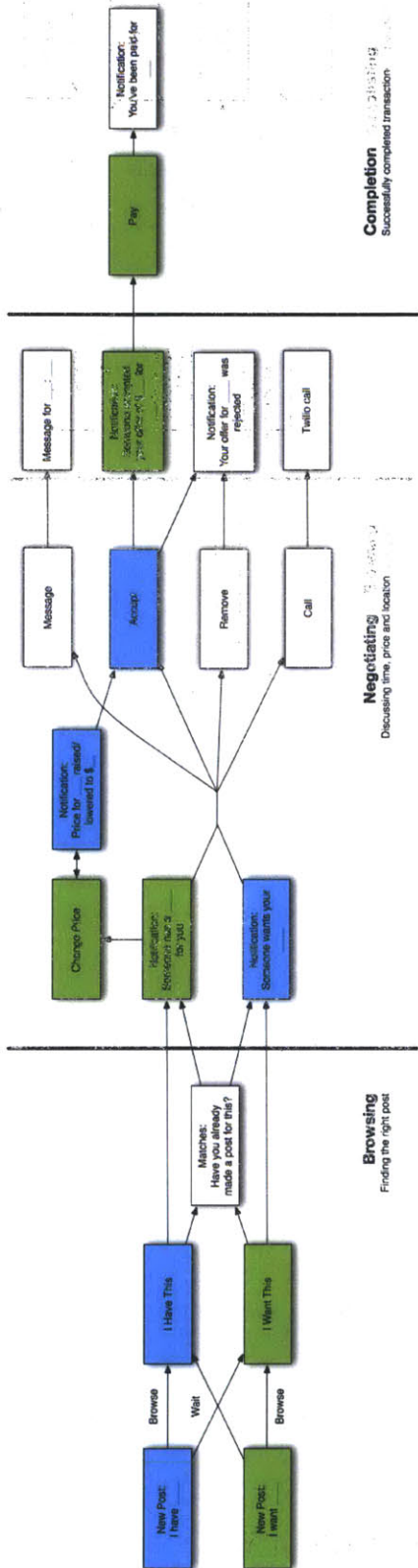


Figure 16: Initial Peddl user experience

What is the model number so I can check specs? Thanks.

5 weeks, 4 days ago, 4f517b said

Dmp-bd35

5 weeks, 4 days ago, 4f2b29 said

Sounds good. I'm interested.

5 weeks, 3 days ago, 4f517b said

Meet in the middle at \$25?

5 weeks, 3 days ago, 4f2b29 said

Sure.

5 weeks, 3 days ago, 4f517b said

Ok. How about central at 7:15?

4 weeks, 6 days ago, 4f2b29 said

Sure. Where would you like to meet? Starbucks? Clear Conscience Cafe?

4 weeks, 6 days ago, 4f517b said

Starbucks works. See you at 715. I'll be the guy carrying a bluray player

4 weeks, 6 days ago, 4f2b29 said

Great. I'll be the guy with \$25 in his pocket.

4 weeks, 6 days ago, 4f517b said

They took their post off the market

3 weeks, 4 days ago

Figure 17: Using messaging instead of price negotiation

Evolution

Soon after deploying the broadcast marketplace we observed that very few users actually used the price negotiation feature the way we had intended. Instead, users would discuss price and terms of a transaction purely through our messaging and calling channels. When users were finished with a post, they would remove the post from the marketplace rather than marking it as complete. This polluted the data we collected, because we were unable to differentiate removed from completed posts.

To lessen impact of this issue, we simplified negotiations. First, we removed the price negotiation feature from our marketplace entirely, as people were seldom using it or not using it the way we had intended as shown in *Figure 17*. Instead we chose to rely solely on messaging for negotiation over the price of a transaction. Upon completion of a transaction users would remove their post.

We observed from our initial dataset that the number of messages and the time between the last message and the removal of the post correlated with whether or not the negotiation was successful. Thus, we differentiated between truly successful and removed negotiations by marking each as successful if they have 3 or more messages and the time between the last message and the end of the conversation was less than a single day. This simple logic showed 80% accuracy compared to human evaluation of whether or not a post was successful, however it did not account for situations where a user would hedge two offers against each other, transact with one and abandon the other. Due to a manageable number of negotiations we also checked and marked their success manually.

Serendipitously, this evolution of the negotiation also permitted users to use a single post to buy or sell a good or service multiple times. Before simplification, the acceptance of a negotiation would result in both associated posts being removed from the marketplace. If the buyer or seller wanted to transact further quantities of a good, they would need to make another post to the marketplace. After simplification, the user could mark a single negotiation as over and wait for additional responses with their existing post.

The summary of these simplifications and the resulting user experience flow can be seen in *Figure 18*.

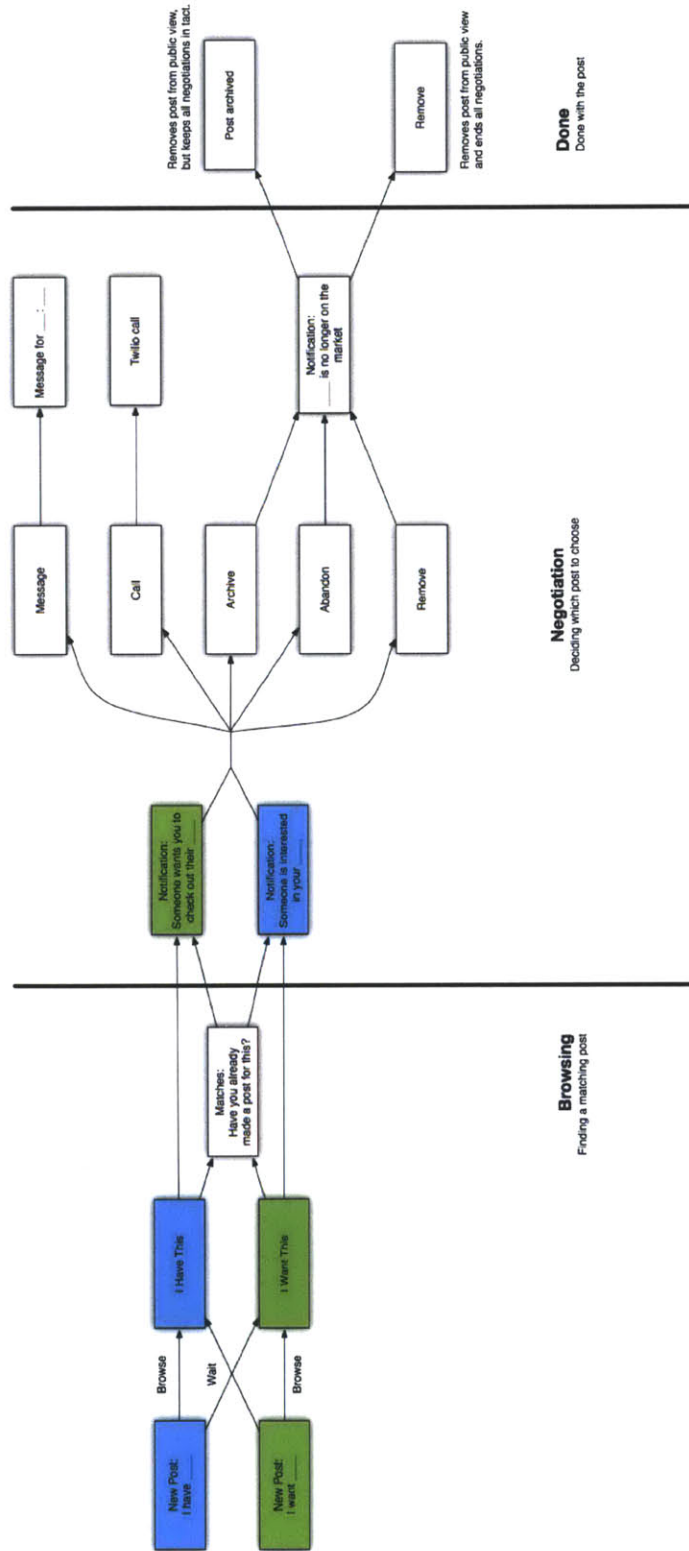


Figure 18: Evolved Peddl user experience

Implementation

To test the broadcast marketplace concept we built and deployed mobile and web applications under the moniker of Peddl. The mobile application runs on the iPhone and was implemented using the iOS 5 SDK. Post location is determined using the onboard GPS chip. Real-time notifications are delivered using Apple's Push Notification Service. The web application was implemented using HTML and the Backbone.js library. Location from the browser is obtained using the HTML Geolocation API. The backend was built on the NodeJS asynchronous I/O JavaScript library. Data is persisted in MongoDB and indexed using the Solr search server, allowing for textual and geospatial queries of posts. Natural language processing to determine matches and related posts uses the NodeJS natural module. The backend is hosted on Rackspace cloud infrastructure.

iOS application

Architecture

The iOS application was implemented using the iOS 5 SDK and Xcode 4.2. The mobile app communicates with the backend server using HTTP requests across either 802.11 wireless or the cellular network. Exact location of the poster is determined using the location services API [33], which in turn used a combination of data from the cellular provider, nearby wireless networks and the internal GPS chip to fix a location (A-GPS). Data interchange between the mobile application and the backend was achieved using JavaScript Object Notation (JSON) encoding [34] of underlying data. The user interface of the iOS application was coded using the Cocoa Touch framework.

Interface

We designed the user experience of the iOS application to adhere as closely as possible to Apple's Human Interface Guidelines [35] ensuring a familiar and intuitive experience for users of the platform. Users are able to select from five main functions on the tab bar: My Posts, I Want, Nearby, I Have and Account.

My Posts

The My Posts tab (*Figure 19*) allows users to view list of posts they've made, along with the number of responses and status of each post. Tapping on any post shows a list of associated negotiations and tapping on a negotiation shows the corresponding message thread along with a location map and photos.

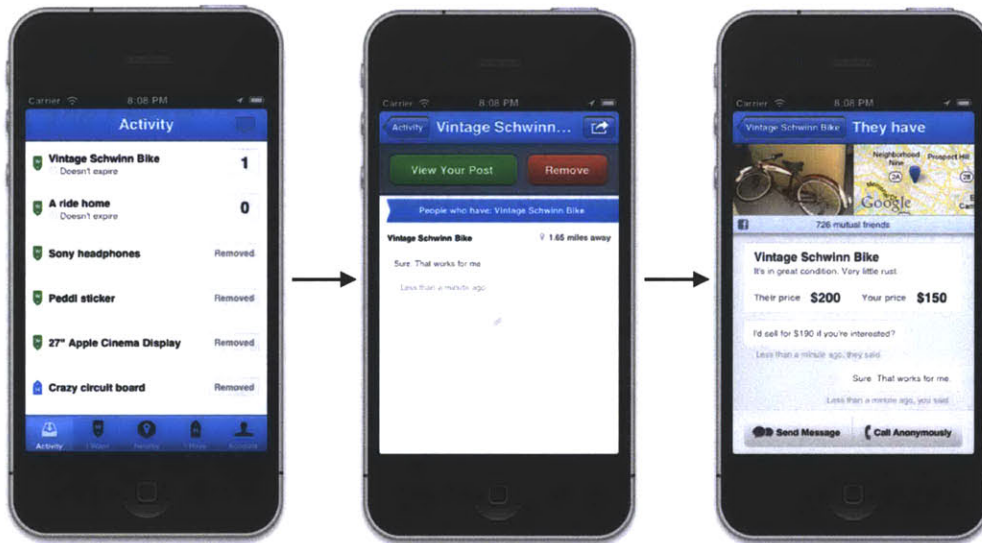


Figure 19: My Posts tab (iOS)

I Want and I Have

The I Want and I Have tab items are used to create new posts. Tapping on either will bring up the new post process that asks the user for the post's title, description, price, photo, expiry and location (*Figure 20*). After confirming the details of a new post, tapping 'Post on Peddl' will send the post to the Peddl backend.

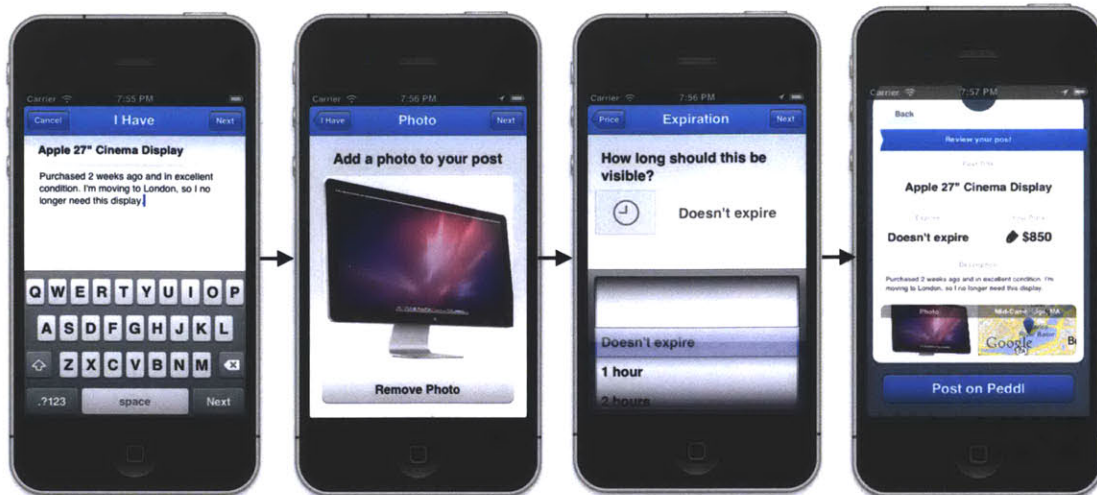


Figure 20: I Want/I Have posting process (iOS)

Nearby

The Nearby tab is used to browse the posts around the user (Figure 21). By default, posts are shown as a list ordered by distance from the user. Posts can be sorted by distance, creation time or price, or filtered by want or have type. Tapping on a post will show associated attributes as well as an 'I Want/Have This' button allowing a user to respond to the post. On the top right of the Nearby tab is a Map button which flips over the list view and displays all posts plotted on a map.



Figure 21: Nearby tab (iOS)

Account

The account tab allows the user to update their name, email address, phone number, password and notification preferences.

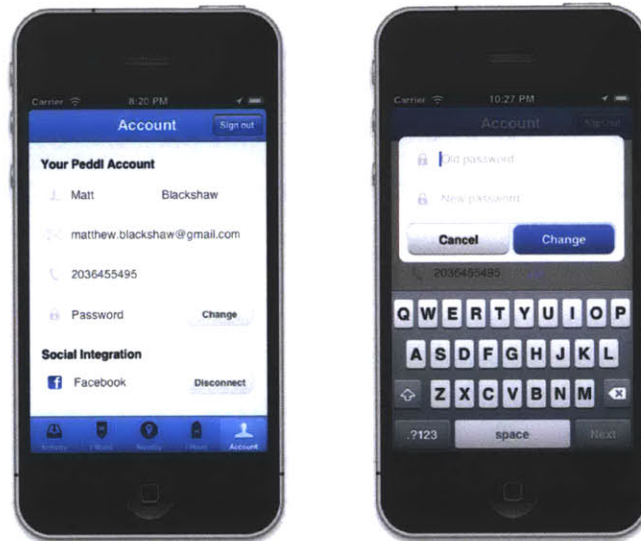


Figure 22: Account tab screen (iOS)

Web application

Architecture

The web application is coded using jQuery [36], Backbone [37] and W3C Geolocation API [38]. Like the mobile application, data is exchanged with the backend using JSON encoding. Unlike traditional web services all rendering and presentation of data is completed client-side using Backbone supported views. In other words, all necessary files to run the Peddl web application are loaded when a user visits our site and requests for application data are made to the backend using asynchronous JavaScript and XML (AJAX), meaning no page refreshes are required. To ensure fast loading time of the web application, RequireJS [39] is used to asynchronously load application code as needed.

Interface

We designed the interface of the web application to resemble that of Google Maps – a familiar experience for most users. The application has two main modes, Browse and My Posts. Users are able to edit their account details by selecting settings from their Account drop down on the top right of the screen.

Browse

Browse mode displays a set of posts both on a left list view and plotted on a right map view. Selecting a post cell on the list view or a marker on the map displays a post overlay with associated attributes and an 'I Want/Have This' button. A search bar lines the top of the screen allowing full text search of nearby posts. Similar to our iOS application, posts can be sorted by distance, price or time, or filtered by type.

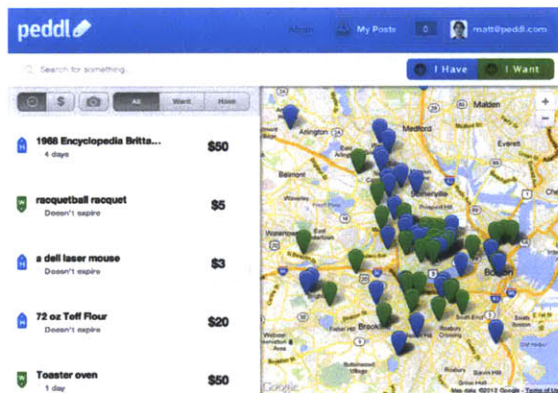


Figure 23: Browse mode (web)

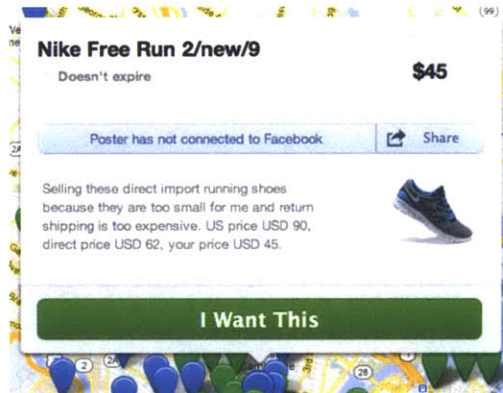


Figure 24: Post detail (web)

My Posts

My Posts mode allows users to engage in negotiations with people that respond to their posts. Similar to Browse mode, the screen is split between the list and plotted map view of a user's posts, except the list view is displayed to the right of the map. We chose to place the list of user posts on the right side to reduce confusion between the modalities. Selecting a post cell or map marker replaces the list and map view with the associated

negotiations. Clicking on a negotiation cell brings up an overlay on the map which allows the user to message or call the other party.

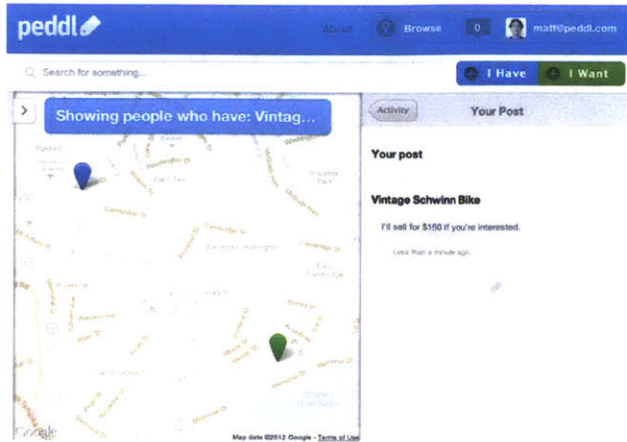


Figure 25: My Post mode (web)

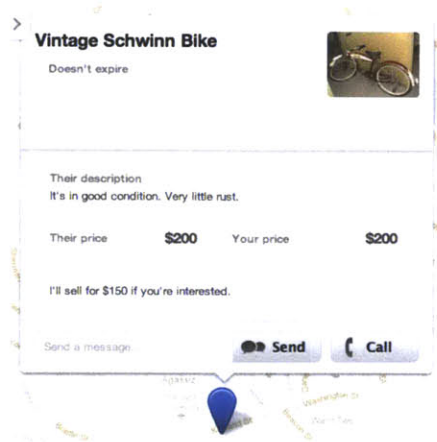


Figure 26: Negotiation detail (web)

Backend

This section walks through the major components that power the RESTful APIs and push notifications for the iOS and web applications. The architecture of these components is shown in *Figure 27*.

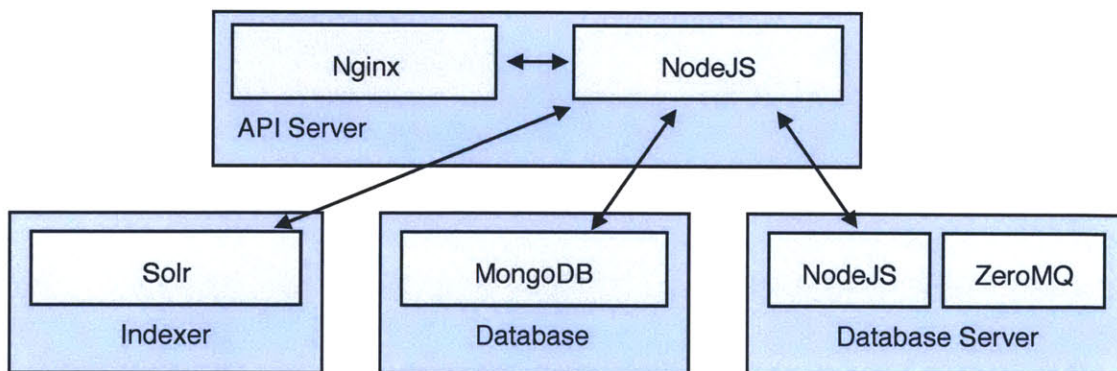


Figure 27: Peddl backend architecture

NodeJS and Nginx

The purpose of this component is to serve up static HTML, JavaScript and image assets and offer an HTTP API that can be used to request post and negotiation data from the database. The core logic of the backend was coded using NodeJS [40], a combination of the V8 JavaScript engine [41] and non-blocking event facilities common to many Unix kernels. This combination enables easy programming of highly scalable APIs and efficient real-time message passing between disconnected components of a system. NodeJS enabled simple programming and scaling of the communication system we designed for Peddl. We use the ExpressJS framework [42] for easy implementation of a RESTful HTTP API.

MongoDB and Solr

User and post data is persisted using MongoDB [43], a NoSQL database, and the Mongoose object document model module [44]. Textual and geospatial search is provided using Solr, an HTTP frontend to the Lucene search library created by the Apache Software Foundation [45]. Lucene provides efficient faceted, n-gram and geospatial search for Peddl enabling efficient navigation of information.

ZeroMQ

Messages are passed between processes using the ZeroMQ networking library [46]. ZeroMQ offers a low-level, robust, socket interface easing the intricacies of inter-process communication. Peddl uses ZeroMQ to pass JSON objects between Socket.IO, the Apple Push Notification Service (APNS) and the Postmark service allowing for real-time delivery of negotiation messages.

Socket.IO, Apple Push Notification Service and Postmark

The purpose of these components are to notify users of new activity on Peddl. Socket.IO [47] allows server-side processes to push information to web applications through WebSockets [48] or long-polling XML HTTP requests. The Apple Push Notification Service [49] keeps a constant TCP connection with iOS devices allowing applications to instantly deliver messages to iOS clients. The Peddl backend hands off messages through this TCP connection, allowing users of the iOS application to be notified of new activity. Finally, Postmark [50] was used to deliver email notifications to users of the web application.

Preventing notification overload

To prevent a flood of notifications, we used following rules to help ensure users do not receive a notification multiple times:

```
Upon reception of a new notification {
    If the user is currently signed in and actively using the
    web application {
        Deliver the notification using Socket.IO to the
        browser
    }
    Otherwise if the user has an APNS token {
        Deliver the notification using APNS to an iOS device
    }
    Otherwise {
        Add the notification to the digest queue
    }
}
```

In a separate process we run an email daemon which collects notifications that have occurred within a defined period and digests them into a single email. The logic for this daemon is as follows:

```
For each user X who has unread notifications {
  For each negotiation Y of user X {
    If there is an unread notification for negotiation Y
    older than 2 minutes for which no email has been sent
    {
      Send digest email for all unread notifications
      of negotiation Y and mark as sent
    }
  }
}
```

Twilio

Twilio [51] enables the anonymous calling features of Peddl. When an application makes a call request to the Peddl backend, it is forwarded to the Twilio API. The request asks Twilio to place two outbound calls, one to each user of the negotiation, and direct the voice data of each call to the other allowing the users to converse. We place strict rate limits on call requests to ensure that users don't receive unnecessary calls.

Facebook

Integration with Facebook [52] allows users to see the friends they have in common with other posters. This feature depends on users permitting Peddl access to their list of Facebook friends using an OAuth [53] permission dialog. Once Peddl had been granted access, Facebook provides Peddl with a token allowing data to be requested from Facebook on behalf of the user. If connected, whenever a user views a post, it queries the Peddl backend for mutual friends, and if both Peddl users are connected to Facebook, the request is passed to Facebook. To reduce unnecessary requests and abide by Facebook's rate limits, mutual friend queries are cached in the MongoDB database.

Rackspace

Peddl is hosted on the Rackspace [54] virtual machine infrastructure allowing for high scalability. A total of 7 virtual machine instances and 1 load balancer were used to keep Peddl running smoothly.

- 1 x MongoDB instance (4 processor cores and 8GB of RAM)
- 1 x Solr instance (4 processor cores and 8GB of RAM)
- 1 x Notification server instance (4 processor cores and 1GB of RAM)
- 2 x API server instance (4 processor cores and 1GB of RAM)

The load balancer directed traffic to the 2 API server instances with the least load. This ensured roughly equal traffic to each of the API servers. Additionally, the load balancing ensured that if any one API server failed, the service could gracefully hand off incoming requests to unaffected instances.

Evaluation

To test and evaluate the broadcast marketplace concept, Peddl was launched at MIT and in the surrounding community on February 3rd, 2012 and data was collected until April 8th, 2012. While sign up and posting weren't limited to the Cambridge and Boston area, we focused outreach on these locales to spur a critical mass and generate significant data. In this chapter, we analyze our trial data using Peddl as a vehicle to study the relative merits of population, proximity, and how the idea can spread and evolve. Based on adoption and usage patterns we postulate toward reasons for the viability of the broadcast marketplace concept.

Measuring success

Due to the network effect inherent to any marketplace a complete comparative evaluation of a broadcast marketplace is premature. Additionally, the truly comparative test of weighing Peddl against markets such as Craigslist and eBay is not possible as they offer limited or no historical data for transactions. Instead, we used this trial as a test to determine if the concept is viable and can be made to work. If warranted, future work will include a comparative evaluation, but for the purposes of this thesis it is out of scope.

Therefore, we evaluated success by looking at the following measures:

1. Was the system able to function technically?
2. Did target locales use the system successfully?
3. Was significant data generated in target locales?
4. Based on usage data, can we quantify the value of additional geographic, social and temporal proximity?
5. Based on usage data, can we quantify the impact of additional transparency in terms of creating additional activity or consummated transactions?

In the next section we will discuss the data observed over two months of deployment using these measures as discussion points.

Launch

In order to be successful, we needed generate enough usage such that people would gain utility from participating in the marketplace. This required a critical mass of want and have posts in similar categories so matches could be made and transactions consummated. As such, we timed launch at the end of MIT's independent study period and before the start of the spring semester to capitalize on the demand that students have for textbooks, moving and dorm furniture. To raise awareness about our marketplace and its potential utility we reached out to local newspapers and blogs (MIT Tech, Cambridge Chronicle, BostInno, Thrillist, Technology Review) and asked if they were willing to cover Peddl. The response was positive and at launch we had a number of articles lined up. We also reached out to the Media Lab community and asking them to post some of the more bespoke and interesting items created in the lab that they were willing to sell in an effort to generate interesting content.

On February 3rd, 2012 we officially launched Peddl to the MIT community. Through Google Analytics and our own web-based monitor we were able to track usage in real-time. Within the first week we had 1,213 unique visitors and, 224 registered users and 187 posts totaling \$34,675 in value. Technically the system functioned, handling the load gracefully and allowing users to connect and communicate without issue. While we didn't concentrate on growth in other cities, many blogs and publications picked up on our service and usage quickly grew in San Francisco, New York, Seattle, Chicago and Los Angeles.

As a result, we passed our first and second measures of success.

Usage

Between February 3rd and April 8th we observed:

- 5,839 unique visitors to peddl.com
- 19,342 page views of peddl.com
- 805 registered users
- 726 total posts
- 377 posts for things people want to buy
- 349 posts for things people want to sell
- \$234,913 in total post value
- 145 negotiations
- \$2,346 in consummated transactions
- 22 successfully completed transactions

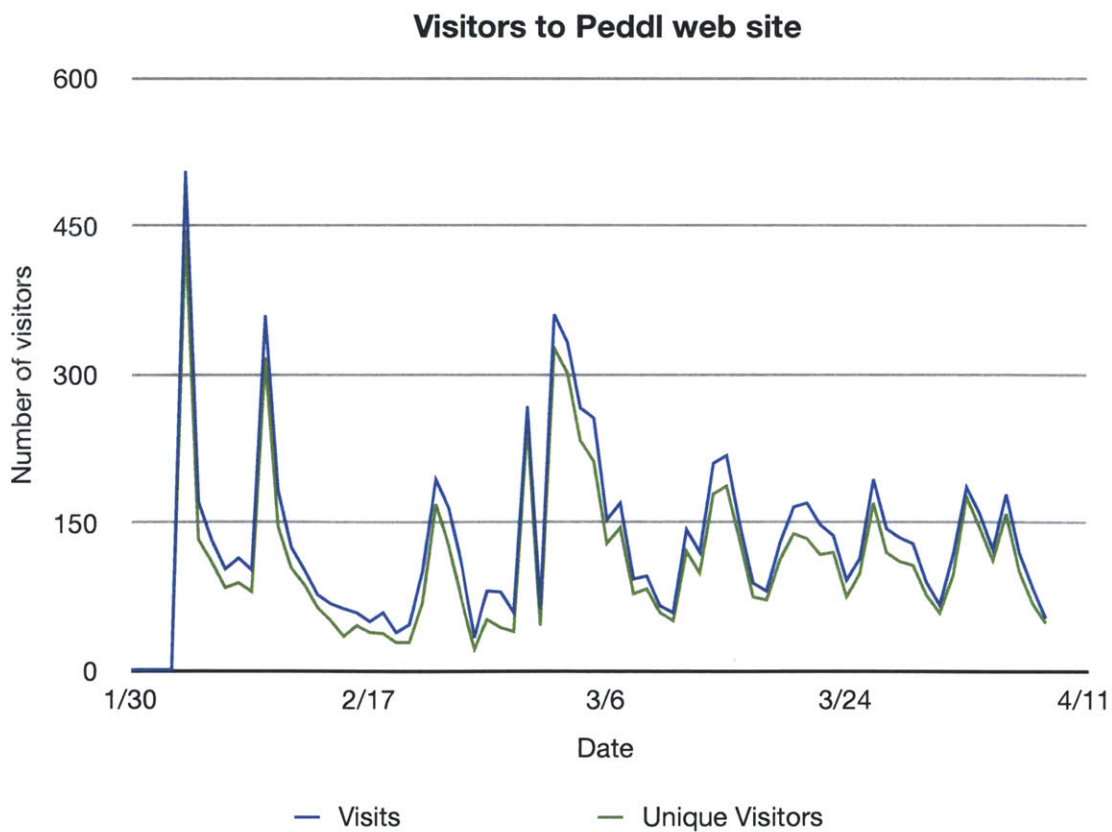


Figure 28: Visitors to Peddl web site

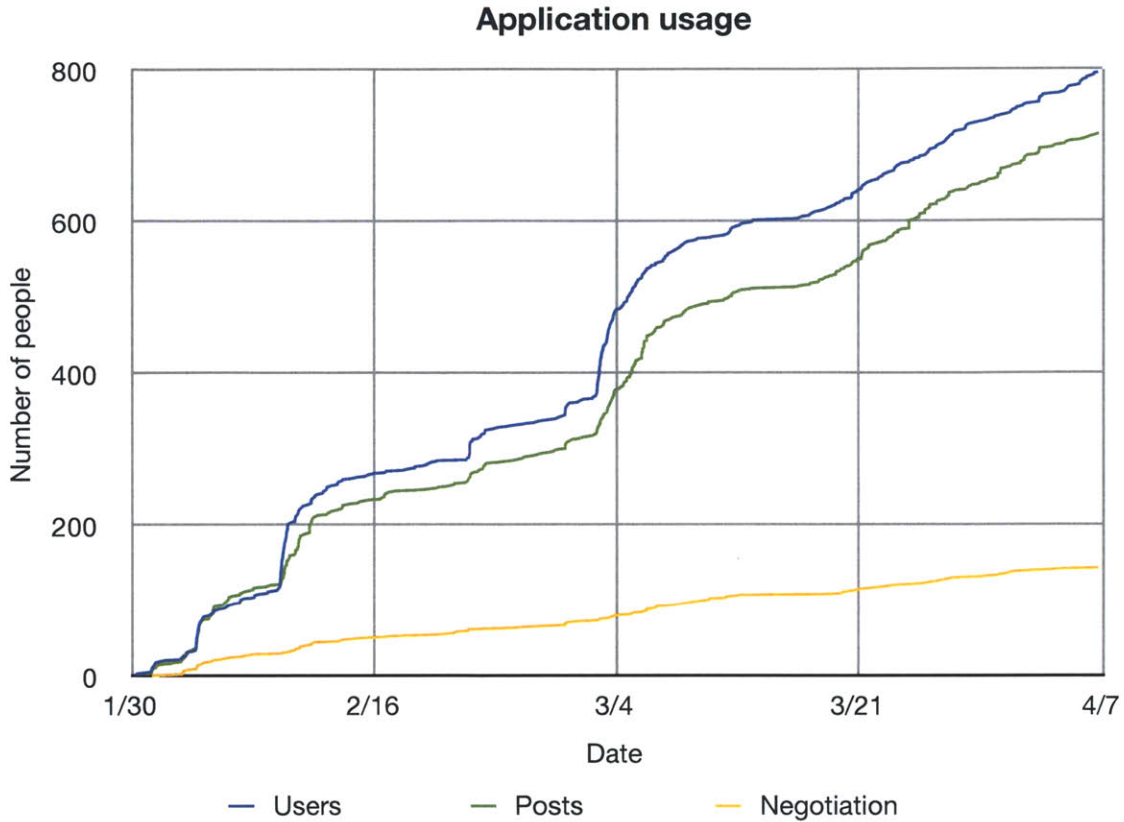


Figure 29: Peddl application usage

Mobile vs. Web Application

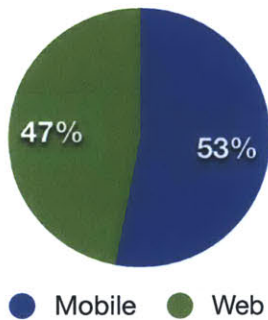


Figure 30: Mobile versus web application usage

Post Type

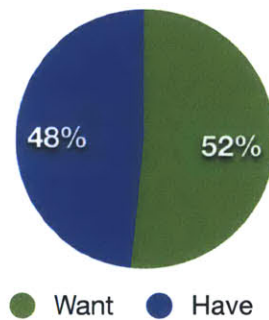


Figure 31: Post type

Completed Negotiations

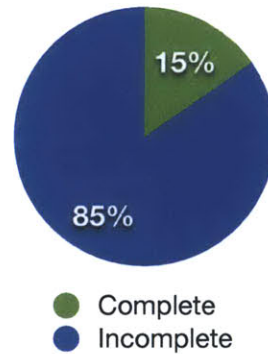


Figure 32: Proportion of completed negotiations

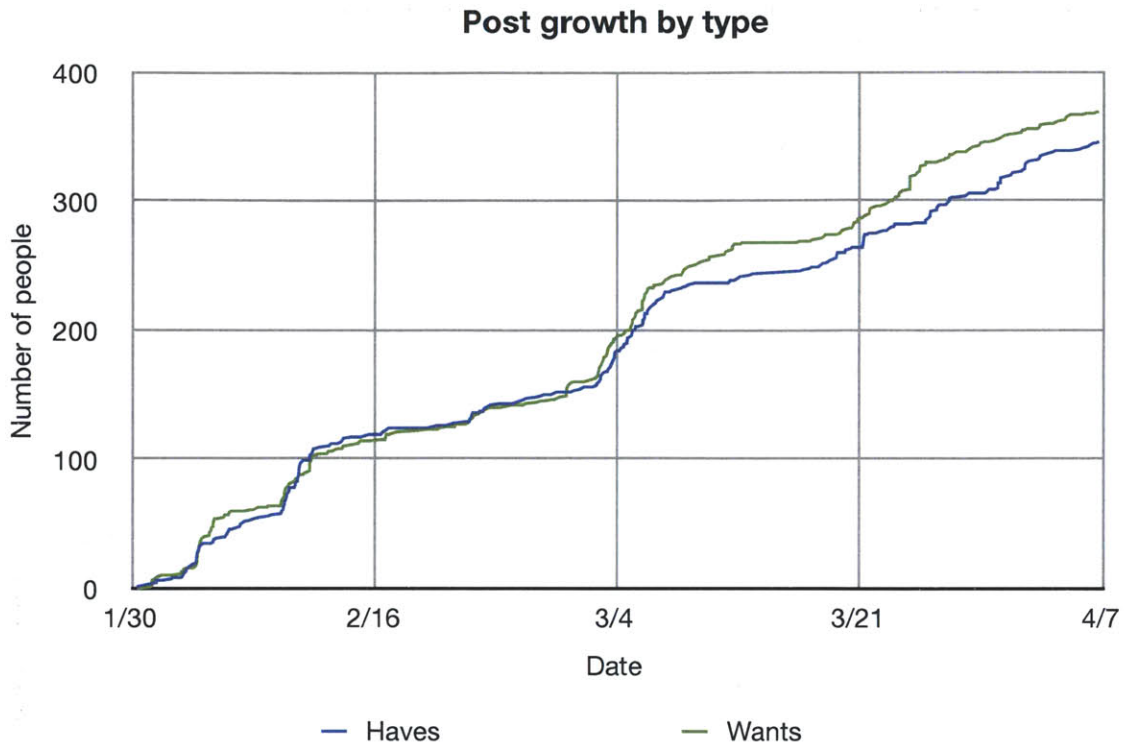


Figure 33: Post growth by type

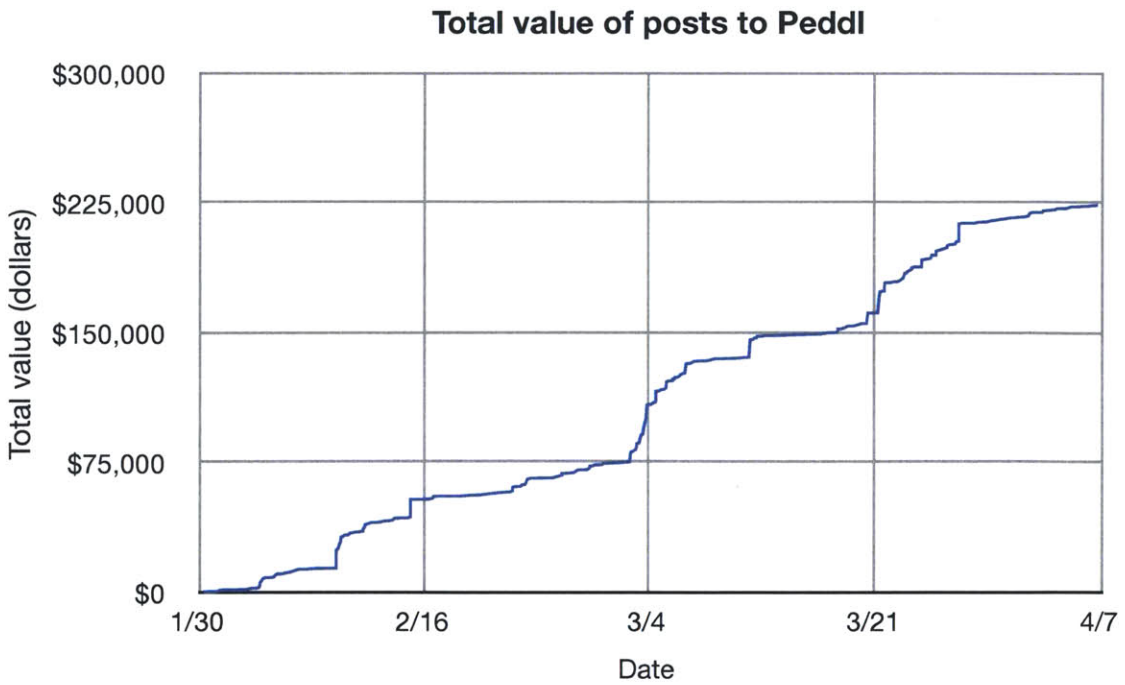


Figure 34: Total value of posts to Peddl

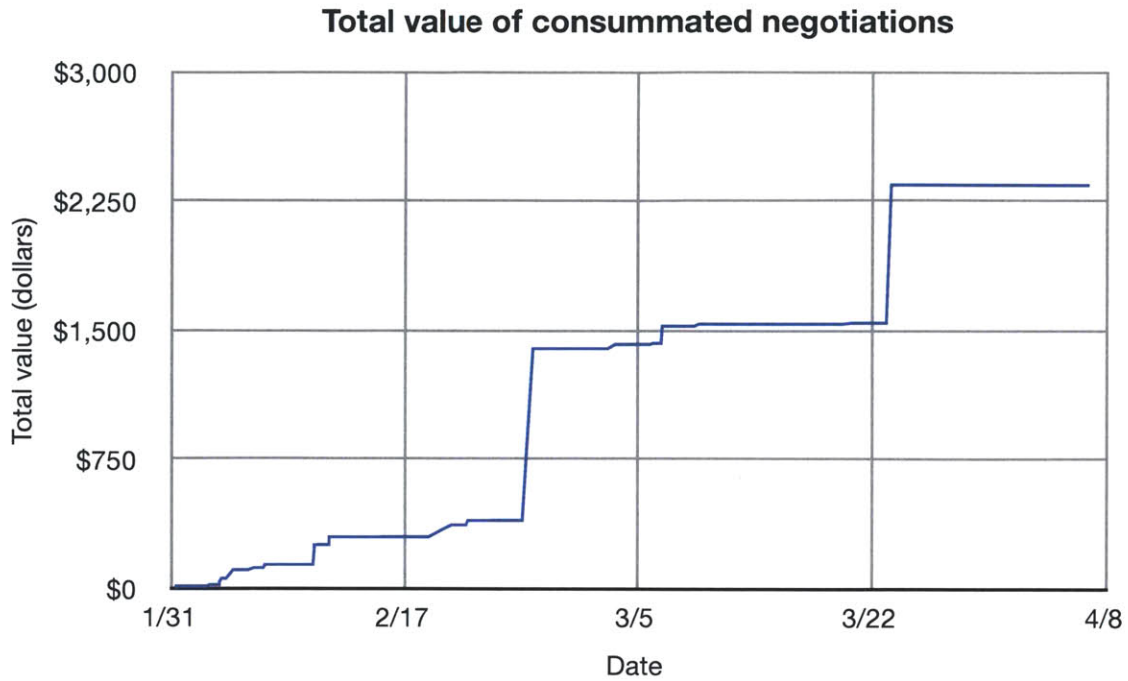


Figure 35: Total value of consummated negotiations

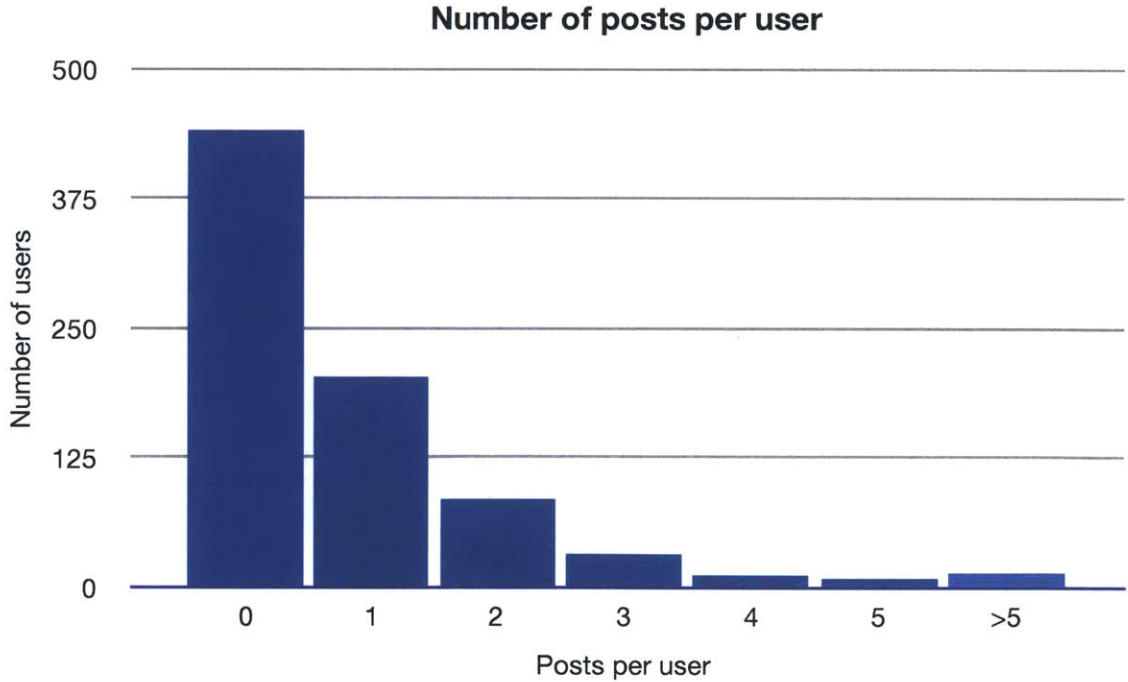


Figure 36: Number of posts per user

Correlations

To understand if the additional geographic and social context we attached to posts was of any utility to our users, we looked for correlations between the price spread, the distance between posts and the number of mutual friends. Because the broadcast marketplace is a form of bid-ask marketplace, we used the spread between bid and ask prices as a measure of the value a user places on context around post. While price spread is affected by all contextual parameters (quality of good, age, location, trust), we considered it acceptable for the purposes of this analysis. Because the magnitude of the spread is a function of the post price (higher price generally creates a larger absolute spread), we normalized the spread by dividing it by the mid price between bid and ask.

Geographic proximity and price

To quantify the value our users place on geographic proximity of posts, we tested for correlations between the distance between posts and the normalized price spread (*Figure 37*). Completed negotiations are shown as blue dots, while incomplete are shown as red dots. While we hypothesized a positive relationship between distance and price, we were not able to establish a significant correlation ($R^2 = 0.174$, $P\text{-value} = 0.115$). We believe this is due to the relatively small size of our dataset (145 negotiations). This is a metric we will continue to monitor as our data set grows. Due to the current size of our data set we do not yet have a conclusion for our fourth measure of success.

Social proximity and price

To measure the value of social proximity to our users, we looked for correlations between the number of mutual friends and the normalized price spread (*Figure 38*). Because this test relied on both parties being connected to Facebook our data set was reduced from 145 total negotiations to 36. Due to limited data, we were not able to establish a correlation ($R^2 = 0.051$, $P\text{-value} = 0.185$). We will continue to look for this relationship as

our data set grows. Due to the current size of our data set we do not yet have a conclusion for our fourth measure of success.

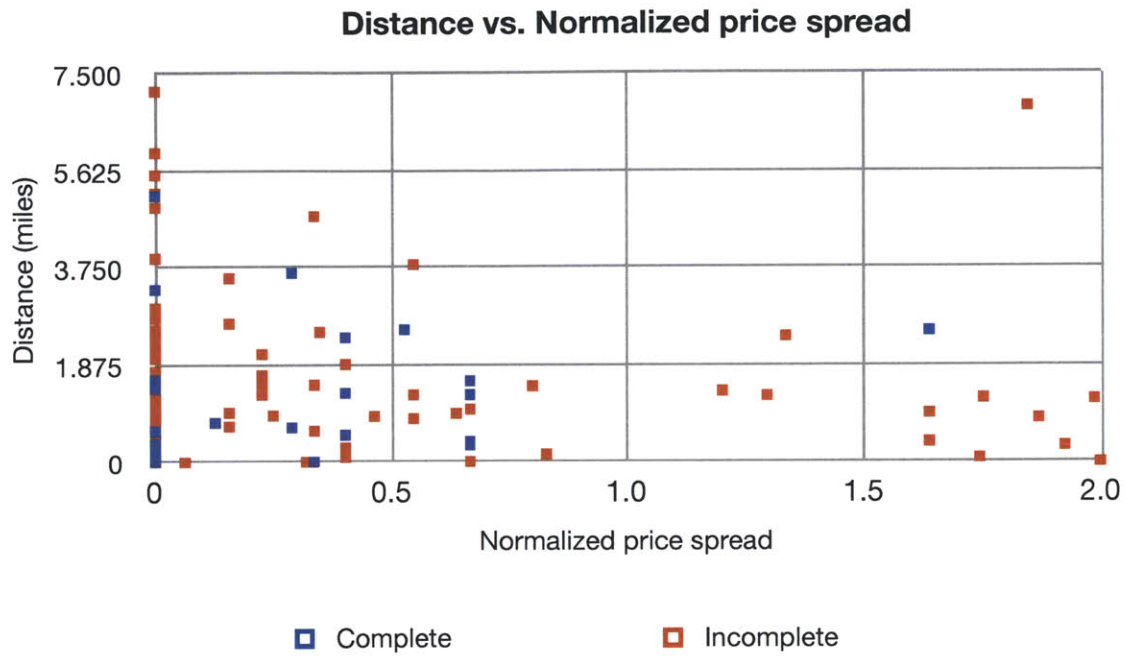


Figure 37: Distance versus normalized price spread

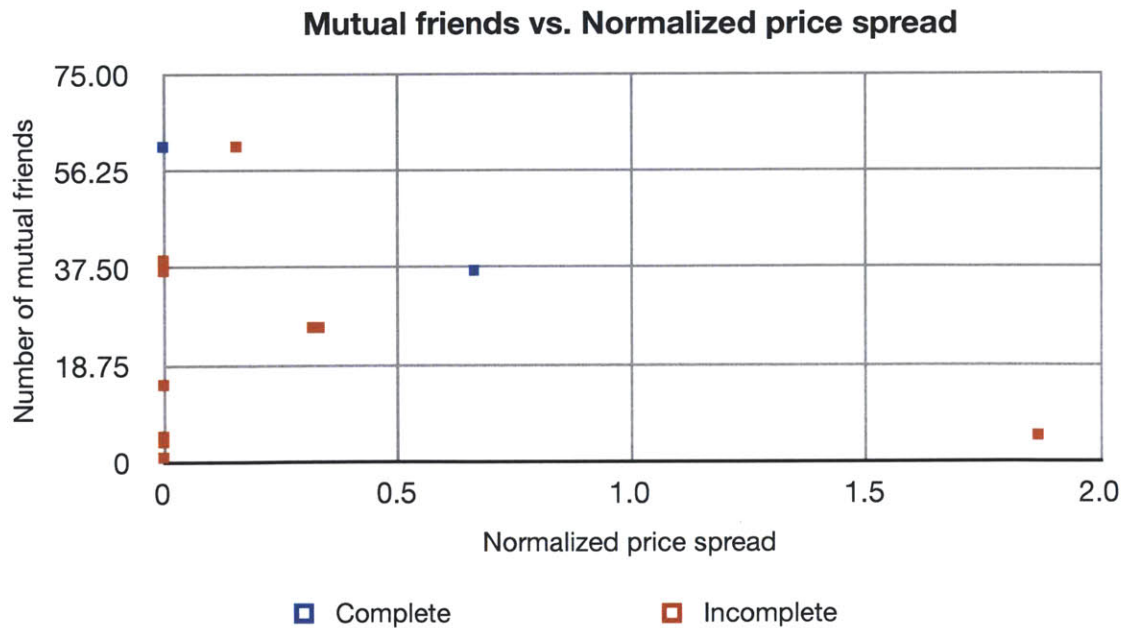


Figure 38: Mutual friends versus normalized price spread

Impact of additional transparency

We initially hypothesized that by making both posts and offers public we would see an increased number of posts and consequently activity in the marketplace. To test this hypothesis we looked for the number of posts formed due to second degree connections in the marketplace. That is, posts that exist only because they're responses to a post which was in turn a response to another post. Due to lack of transparency these sorts of connections are unable to form in existing marketplaces. *Figure 39* shows the graph of all posts (nodes) and negotiations (edges) in Peddl. If we focus solely on the posts of second degree (those which are at least of distance 2 from a post that was not a response), then we can visualize the additional posts and activity created through the transparency achieved in the broadcast marketplace (*Figure 41*). From this view we can quantify that additional transparency of supply and demand created 15 additional negotiations, an increase of 11.5%.

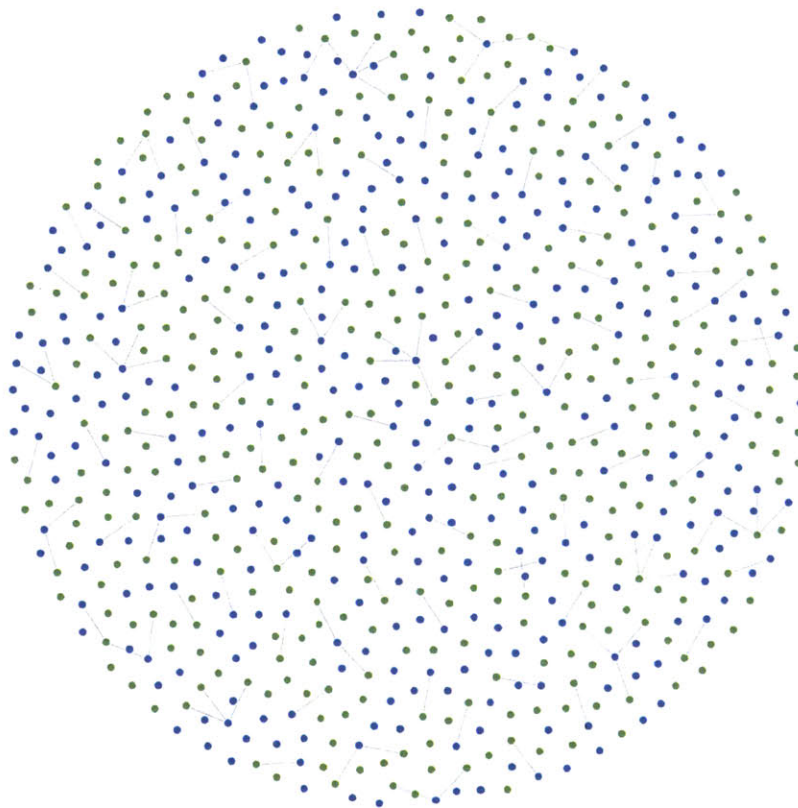


Figure 39: Graph view of Peddl

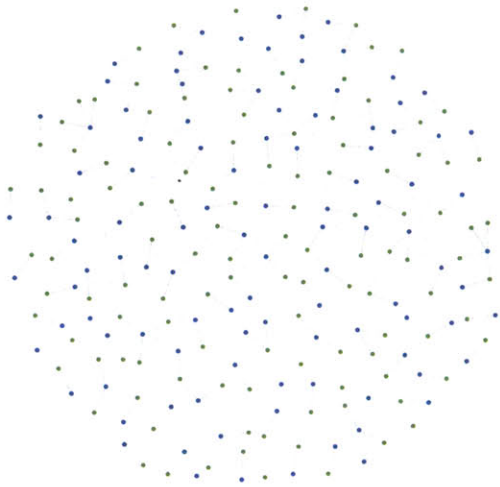


Figure 40: Graph view of Peddl with negotiations highlighted



Figure 41: Graph view of Peddl negotiations with posts of distance greater than 2 highlighted

Viability of the Broadcast Marketplace

Over the course of our trial we made several key observations that indicate viability of the broadcast marketplace concept.

Based on the fact that existing marketplaces were dominantly seller-powered [22], we hypothesized that the majority of initial posts, or root nodes in the graph, would be for things people have. Throughout the trial, we observed an almost direct split between want and have posts as shown in *Figure 31*. We initially thought this could be due to an abundance of initial have posts and consequent want post responses, but further analysis showed this split existed among initial posts. We believe that this difference from entrenched marketplaces exists due to the equal weight our system places on supply and demand. Craigslist exposes 'Gigs' and 'Items wanted' as only 2 of 11 possible post types in their user interface meaning it is of little prominence compared to supply-side post types. By contrast Peddl exposes the concepts of 'I Want' and 'I Have' with equal prominence throughout the interface. While this causality is anecdotal, it lends credence to the idea

that users are willing to express both supply and demand to the marketplace and thus viability to our concept.

Additionally, the observed number of second degree posts also adds viability to the broadcast marketplace. Through making every intention public, our users generated an additional 15 negotiations or an 11.5% increase.

Future work

While the data we collected over the course of our trial indicated at the viability of the broadcast marketplace, further studies and data collection is needed to formally prove that the design is more efficient. However, based on our usage observations we can foresee future work on Peddl which will improve the user experience and encourage adoption. This work falls into three categories: 1) categorical understanding of entities, 2) an open API, and 3) formalizing informal marketplaces.

Categorical understanding of entities

While Peddl currently understands matches through the processing of the title and description of posts, a better solution may be a system with categorical understanding of real-world entities. We imagine a collection of categories (books, DVDs, tablet computers, mobile phones, etc), each populated by freely available online data from Amazon and Freebase.

When making posts users could enter the first few characters of the item they're selling and Peddl could offer up suggestions of entities already present in our system. If a match is found we could generate a listing complete with title, author, cover art and other metadata. Additionally, users can make posts from pictures of barcodes on the back of books, albums, movies or other products which our system could similarly resolve to underlying data. Finally, if users were to indicate the category of their post when entered into the system, then we could better suggest matches without relying on natural language processing of post title and description.

Open API

Throughout the trial we had a number of requests for an API to allow others to build applications which need tasks performed or to surface the ability of a community to perform tasks. We plan to augment Peddl with an API that allows posts to be made using the same inputs permitted in our iOS and web applications. Additionally, we are planning to explore the possibility of 'I Want' and 'I Have' buttons on sites, allowing visitors to indicate supply or demand of a good or service. We could incentivize use of such buttons through an affiliate program allowing the site owner to earn revenue from any transactions that originate from the use of these buttons.

Formalizing informal marketplaces

Many marketplaces exist in communities today through internal sites and mailing lists. Peddl seeks to formalize these markets through the surfacing of mutual friends, allowing users to understand the networks to which posters belong. Because this social data is obtained from connection to Facebook we're also able to collect the communities (school, workplace or geographic locale) to which a user belongs. Mutual networks could then be surfaced as tags on posts or used as filters allowing users to precisely know the community in which a post originated, further formalizing these informal marketplaces.

Conclusion

The broadcast marketplace is a first attempt at a balanced marketplace where additional social, geographic and temporal context increases the information available to participants, aiding liquidity. This thesis contributes the design and implementation of a broadcast marketplace, Peddl, and evaluates the viability of the concept over a two month trial – we collected data on 5,839 unique visitors and 805 registered users, who made 726 posts totaling \$234,913 in value. From this data we show that the additional transparency of supply and demand afforded by the broadcast marketplace results in increased activity, demonstrating the viability and potential of the idea. Long-term usage and further study is needed to evaluate the full potential and formulate a formal proof of efficiency for the system.

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