MeshKit

Building & Sustaining Community Mesh Networks

Alyx Baldwin

Parsons The New School for Design

Design + Technology Department
New York, NY 10011
baldj046@newschool.edu

Abstract. A social networking toolkit for building self-sustaining, ad-hoc and static wireless mesh communities, through intrinsic social gaming and a peer to peer economy.

1. Introduction

As wireless communication becomes more ubiquitous and mobile, the rigid, centralized nature of telecommunication and Internet service infrastructures needs to be reassessed. Companies are charging exorbitant amounts for voice, data and SMS, while throttling service and applying bandwidth caps.[1][2] Accessibility to communication through centralized sources can be restricted or severed completely by censorship, major catastrophes, or political uprisings. Many rural areas are still lacking in basic communicative frameworks.

With the ubiquity of Wifi-enabled devices, and their ability to communicate directly amongst themselves, without a centralized infrastructure, an alternative means of communication can be implemented. Wide spread static and ad-hoc wireless mesh networks open up the possibility for decentralized communication between laptops, desktops, mobile devices and routers. In a full, proactive mesh network, every node (connected device) is linked to each other, while forwarding packets (communicating) without discretion. This leads to a mesh's ability to self-heal linked nodes, making it very hard to disrupt communication.[3] It is also cost effective to end users, as Internet and other resources can be equally distributed across the mesh, without costs or maintenance incurred for external routing infrastructures. Ad-Hoc mesh networks provide connectivity amongst users anywhere, even in traditionally connection-less zones like subways or remote villages.

MeshKit provides software tools, built on top of an open source mesh protocol, to assist in forming convenient, reliable mesh networks for specific purposes. These include: building mesh communities, art & science collaborations, reaching rural areas, flash mobs & protests, encrypted dead drops, broadcasting and emergency mode. Strong community, trust and interdependence to sustain the mesh are addressed through a social gaming framework and peer to peer economy that grows organically with user experience and rate of use.

2. Communication Problems

2.1 Prices and Capping

Many telecommunication (telecoms) and Internet Service Providers (ISPs) around the world charge exorbitant fees for access to Voice, SMS and Data. In terms of packaged mobile access, the United States and Canada charge almost twice the amount of other countries such as Denmark, Finland and South Korea. [1]

The cost against users for the accessibility of voice, SMS and data from telecommunication and Internet service providers is detrimental to the end users, especially those in African countries that only account for seven percent of the world's online presence. The Internet can be a valuable means for development, but is doing very little

when access for the regular user is out of reach. [4]

Additionally, this data may have bandwidth caps or throttling in place to impede the free flow of information. In the US, Comcast has implemented a throttling tool that slows down heavy traffic usage, [5] while Bell Canada has been implementing network-wide throttling during peak hours, without telling their Internet service resellers. [6] AT&T recently announced that it will begin to cap all of its DSL users at 150GB a month, which is a step backward from a future of stream-on-demand services such as Netflix. [2]

These data rates are consequences of a lack of government policy in regulating price gouging and the monopolization of telecom and ISP access in New Zealand, Costa Rica and many African countries. [4] Currently, there's a debate over a Net Neutrality standard, which, if dismissed, might lead to a multi-tier, bandwidth-rationed Internet. Some websites and services would be given preferential bandwidth over the non-preferred ones, based entirely on the ISPs discretion. The general consensus amongst the tech customer base is that it is anti-consumer and anti-competitive, while going against the fundamental ideology of an equally distributed Internet. [7]

2.2 Censorship

Some governments around the world take a totalitarian approach to restricting the publication or access to certain online information. The "Great Firewall of China" is the most notorious and sophisticated online government censorship and surveillance project, but dozens of other countries, such as Burma, Vietnam and Cuba also take aggressive steps in restricting access. Sometimes this active enforcement leads to arresting and detaining violating citizens. [8]

Censored citizens and their governments have been recently battling on a more technically savvy level. As these governments develop better tools to decrypt and survey emails and other online traffic, users are adding more encryption into their work-flow, through Tor, VPN and proxy services.[9] As long as these citizens are using a government regulated pipeline to the Internet or phone service, there will always be a constant threat of prosecution.

A proposed "Internet Kill Switch" in the United States has been causing some censorship concerns. It was introduced through the "Cybersecurity and Internet Freedom Act of 2011" bill, and would allow the Department of Homeland Security to shut down parts of the privately owned Internet in case of a "cyber-emergency." The lack of a defined "cyber-emergency" opens up the definition to loose interpretation and could become a loophole for censorship. [10]

2.3 Political Uprisings and Protests

On the 18th of February, 2011, three days after the start of the rebel uprising in Libya, the Libyan dictator Muammar Gaddafi began shutting down all telecommunication and Internet services as a means to prevent the rapid organization of revolutionaries in the country. Until April 2nd, rebels in East Libya had been using semaphore, an analog flag-waving communication tool, to remain networked. With the help of a Libyan-American telecommunication executive, millions of dollars in funding and support from neighboring countries, a team of engineers infiltrated the country and wired a pirate signal into the existing cellular structure. The network is still experiencing instability, but is providing a vital networking backbone for the rebel movement. Details of the technology used is still hazy, but it is clear that the whole network is being routed through a single hub. Although this effort is incredible in itself, the existence of an ad-hoc mesh network would have relieved the reliance on a single communication entry and exit point, by connecting every user on a self-sustaining and repairable voice and data network.[11][12]

During the Egyptian revolution, mobile and Internet services were disabled. Internet service providers outside the country began offering communication through landline-based dial-up service. Google developed a voice to tweet service that enabled Egyptians to call a number that automatically transcribed their voice into a Twitter feed.[13] The reliance on networking services from outside the country in both the Libyan and Egyptian revolutions leads to

an architecture that doesn't keep pace with the ground-level activity, but instead relies on over-arching solutions to the major problem. Incorporating an ad-hoc mesh that grows alongside a grassroots movement allows the structure to ebb and flow with the rapidly changing social and physical landscapes.

2.4 Major Disasters

During major disasters such as earthquakes and hurricanes, the centralized nature of communication infrastructures fail due to the collapse of radio antennas, networking buildings and power sources. The days after a crisis are the most critical, in order to locate survivors and assess damages. These require very strong communication layers, but they are at their weakest at that time.[14]

Ushahidi is an open-source, visual data collection software that has been used in disasters such as in Haiti, Chile and most recently in Japan. It provides a simple to use and interpret visual topology of needed information after a disaster, such as infrastructure damage, emergencies, health and natural hazards. [15] As effective as this utility is, it requires Internet access and power which would probably not be present immediately after a disaster.

2.5 Rural Areas

Internet and telecommunication accessibility in rural areas is important for economic and social development. The most prevalent reason for the lack of infrastructure now is the unwillingness by ISPs to expand their networks due to the minimal return on investment. [16] An Internet provider would never make back the costs of wiring, hardware and labor involved in expanding into such far reaching areas.

Village Telco is an open-source initiative to provide community telecommunication access in remote areas with mesh networking of regular phones through plugin devices called "Mesh Potatoes." It is still in beta testing, so the effectiveness of this method has yet to be proven. The additional required hardware, combined with each unit costing $80, might prove to be difficult in reaching a critical mass of users to make the meshed network useful. [43]

2.6 Current Mesh Networks

Most wireless mesh networks today are confined to very specific areas of research and practice. They fall into three main categories: academia, proprietary commercial and fringe hacking. These areas tend to focus on a specific goal, iterating within themselves, but never attempting to expand beyond their familiar or practical boundaries. There are a huge variety of wireless protocols in development, most are being tested and refined within the university setting. They focus on the technical challenges of implementing and scaling mesh networks, without considering conceptual and ulterior motives to the framework.

Organizations that utilize ad-hoc mesh networking for very specific goals, such as in Nintendo's 3DS gaming handheld for linking multiple players together[17] or the One Laptop Per Child project for networking children without a consistent Internet connection in rural areas,[18] focus on a means to an end, without considering reaching out to other devices around them. These implementations utilize mesh technology for a set of parameters to perfect, but there's no motivation, outside of their one goal, to develop further.

Fringe network hacking enthusiasts are interested in mesh networks as an act of subversion. A general term for any encrypted, anonymous network is a "darknet" that these groups try to promote on Reddit[19], the Anonops Internet Relay Chat network[20], 808chan[21], and others. They have an incredible sense of motivation to try and implement these ideas, but without a strict production schedule and conceptual oversight, these groups tend to fall apart or become stagnant after a few months. The most promising fringe group is the Netsukuku project[22], but they are still far away from a stable release.

These three groups are motivated by a variety of benefits to ubiquitous and consistent mesh networks. The ad-

hoc nature of a mobile mesh, with the ability to re-route information from broken nodes, is perfect for any disaster scenario. The consistent problem is in a common-person implementation - not many people, during an actual crisis, would know how or care to install a mesh network. If the mesh network interface is already installed and running on their phone, laptop or router, as MeshKit would encourage users to do, this wouldn't be a problem.

The social nature of mesh has spawned thousands of community implementations around the world. Some are centered around universities, while others exist within villages, communes or cities. [23] Since there's no mesh standard yet, these communities all use different protocols - essentially, they all speak different languages, and there's no translator around to link them together. These communities all benefit from cost effectiveness by using a mesh: they don't need to purchase central wireless routers that link all devices to each other and they can share a single Internet connection amongst themselves.

There are technical problems with mesh networks as well. As of now, centralized communication structures provide a higher level of Quality of Service for users as well as access to higher bandwidth. Since users on a mesh are sharing the bandwidth load of everyone else on the network, resources such as power and computing need to be factored into the community structure.. There is also a problem with social cooperation in mesh communities. A mesh needs other active members to keep the network running, but there is a lack of user incentive in this area. [24]

3. MeshKit Solutions

MeshKit proposes a software-based, universal platform for aiding in the construction and sustainability of ad-hoc, static and hybrid wireless mesh networks through recycled & DIY technology, while incorporating elements of social gaming and a peer to peer economy to create a community of reciprocity, trust and interdependence.

Starting a new mesh network through MeshKit provides a list of different communication problems the mesh will solve. Selecting a problem will introduce a solution, with a list of goals needed to successfully solve the problem. MeshKit also lets users find and join other mesh communities.

MeshKit solves pricing and capping issues by introducing a long-term, hybrid mesh community framework, like a decentralized Telecom and ISP, that slowly grows into metropolitan wide networks. Internet gateways on the mesh network would provide access to resources outside the community. Bridges between communities could be joined through Do-It-Yourself (DIY) directional antennas at first, such as a Can-tenna (made from a tin can) or Wok-tenna (made from parabolic cooking-ware)[25], but would eventually be replaced by more stable hardware.

Censorship is tackled through the decentralized nature of mesh networks. MeshKit users can start special broadcast-only networks that let other connected users receive specific information being sent out or encrypted dead drop networks that lets users anonymously deposit files onto the network. Broadcasting can be used to blanket an area with an uninterrupted message, while dead drops could be used by whistle-blowers to leak sensitive or censored information.

Political Uprisings and Protests are addressed by MeshKit through the ability of mobile devices to run in wireless ad-hoc mesh mode. This is also useful for other collaborative applications, such as art and science projects that spawn in areas without other wireless connections. The ability for mesh networks to automatically repair broken nodes is useful both for ad-hoc networks as well as hybrid solutions in major disasters. A special emergency mesh network mode in MeshKit broadcasts an open and non-discriminating connection with any neighbor nodes. This is comparable to survivors calling for help under rubble, except others can pass these "help" messages along the mesh network chain until it reaches a rescue team.

Rural areas are bridged to the Internet with MeshKit using mesh repeaters and directional antennas, while taking into account a mesh network's ability to send communication over multiple hops. [25] The same hybrid mesh

community framework to provide an decentralized Telecom would be applied to remote villages or other rural communities.

4. Cross Layer Cooperation

When considering a short or long-term mesh community, cooperation between users is required – otherwise a mesh network will not function.[3] An interdependent and sustainable atmosphere needs to be created that dissuades "free-leechers." Cooperation between the physical, network, application and social layers is represented through intrinsic and extrinsic economic incentives, in a subversion of a reciprocal "fairness" market economy. This means that each community member should be contributing as much as they consume, as represented through a virtual currency.[24]

The easiest way to meter production and consumption in MeshKit is through an extrinsic currency, called "Coins" on the physical and network layers. Community members contribute with packet forwarding (passing on information), energy and battery cost, and CPU cycles (strain on computer processing). With these hard number measurements, usage statistics can be boiled down to a definite cost and contribution to network activity, and converted into Coins. If a mesh protocol such as the Johns Hopkins University SMesh were implemented, which allows users without MeshKit installed to access the network through the mesh spoofing as an Access Point [26], then a community could charge these outsiders an actual monetary amount for Internet or other resource access. In theory, this would be a Distributed Internet Service and Telecommunications Provider. If an outside user didn't want to pay with money, they could install MeshKit and "pay" with MeshKit Coins.

The inherent nature of a mesh network creates problems for a purely extrinsic economy. Since meshes rely on multiple hops, or jumps between nodes, before a packet finds its destination, users on the edges of a network will have a disproportional amount of packet forwarding, power consumption and CPU cycles.[24] Introducing additional options to contribute, such as providing Internet and GSM (openBTS) gateways, VPN tunnels or bridges to other mesh communities helps balance the economy.

It is also advantageous to introduce other, less defined, points of user contribution through the application and social layers of the network, since the "ability to exchange resources increases efficiency of the system."[24] There are fundamental technical and social resources needed for a mesh community to survive, which are treated as a separate, rivalrous currency by MeshKit. These are represented as Resource Gems, through: knowledge & teaching, hardware construction & repair, software development & installation, maintaining Internet & GSM gateways and social & community presence (Fig. 1). Different projects within a mesh community reward relevant Resource Gems upon their successful completion. By implementing this qualitative, intrinsic Gem currency along with the quantitative, extrinsic Coin economy, an elastic exchange economy is formed.

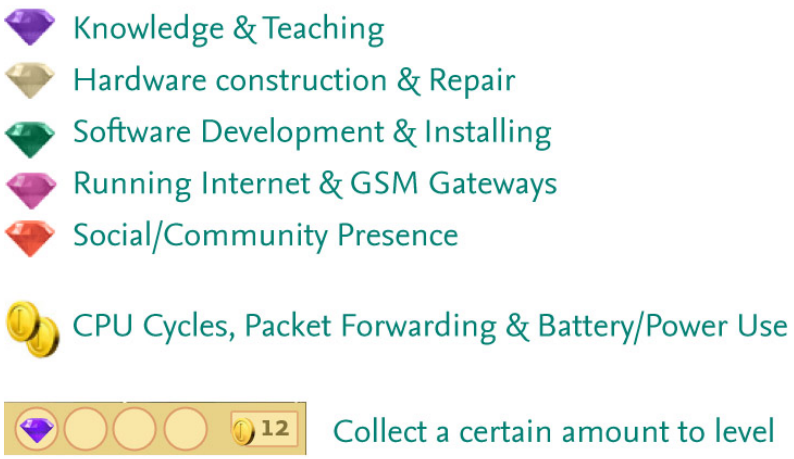

Fig. 1. Gem and Coin Values. Collecting a certain number of Gems in a category levels the user.

5. Starting a Mesh Network

Any user can start a new static, ad-hoc or hybrid mesh network. Depending on the Gem Resources and number of users needed for that particular mesh network to thrive, a custom "hello" is emitted to notify others in the area of the network's existence and goals. Like the Proem system for profile exchanges in mobile collaborations, if a "willing" user replies, they are initiated into the network. [27]

Custom mesh settings are tailored to optimize packet routing, depending on the primary use of the network. Levels of trust and invitation only settings are covered in the following section on Building Trust. Mesh community types and locations are broadcast to outsiders through the SSID name of the wireless network, war-chalking, or through a Google Maps overlay.

User Scenario: A protester at a rally wants to create an open ad-hoc mesh with others in proximity, to share images and video while creating a discussion about next steps. She opens MeshKit on her Android phone and starts a new protest mesh. Other phones with MeshKit installed push (notify) their owner that a new network is starting - they can choose to join or disregard it. A few dozen phones and laptops interconnect and become a wireless ad-hoc mesh, sharing thoughts and passing around images.

5.1 Project Levels

After starting a new mesh network with the intention of creating a long-term, sustainable community, the prospect of actually realizing this project might seem daunting at first. It's best not to overwhelm users with an array of goals, but provide just enough immediate incentive to let the community grow organically - starting out small and slowly empowering users over time [28].

For example, when a new community network is formed amongst a small group of users, this would be considered the Level 1 stage of development – immediate goals would be limited, but the users could install a few wireless routers in the surrounding area to work towards Level 2, a village or department size. Level 3 would require bridges, such as directional antennas, between different scattered "villages" to form a neighborhood or campus size community. Level 4 would require stronger and more stable directional or omnidirectional antennas to reinforce the size and capacity of the network. Finally, a level 5 community would require Metropolitan Area Network hardware to create a city-wide quality of service support structure.

5.2 Building Trust

Interdependent communities require a certain level of trust between users. When engaging in social interactions, users are relying on each other's contributions to maintain stability, so an overarching notion of safety amongst others in the network is very important. [29] The local area surrounding a mesh network naturally lends itself to an increased trust over the undefined territory of the Internet, as acquaintances can carry over to real-world relationships.[24]

When it comes to fleeting, ad-hoc communities, the level of trust between users drops significantly – there is simply not enough time to establish long-term relationships between community members.[45] Therefore, a universally accepted reputation meter is needed to immediately assess reliability and safety of a new network member. This can be achieved through measuring a user's Resource Gem and Coin currency worth - these two indicators directly convey their skill levels and level of commitment to mesh communities.

Identity verification is also important to establish trust in mesh networks. A distributed Web of Trust, or a checks and balances system, is needed to reinforce the validity of a user's Resource Gem and Coin currency value. This would be achieved through a decentralized hash value (cryptographic) exchange of trusted nodes on the network. The same type of system is used by BitCoin, a peer to peer real-world economy, to confirm transactions, prevent redundant spending and prevent manipulation. Further authentication can be formed through MAC address (unique code on every network interface) registration. [30][31]

A similar distributed trust system based on reputation was demonstrated to improve trust in wearable devices through the DIOGENES system. When users interacted in real-life proximity, a database of reputation information for all members in the network were exchanged – this included unique identifiers for each user and an average rating of the communities opinion toward each user.[44]

With the ability to establish trust between nodes, users can specify completely open (not requiring any trust), trusted open, invitation or Resource Gem/Coin level network requirements to filter desired nodes. In a trusted open network, the network would test for trust, confirm trust, place nodes on probation for bad behavior, or, after repeated probation, the MAC address is banned from the network. These varying degrees of acceptability attract users to behave favourably to the goals of the community.[24]

6. Social Game Mechanics

Sustaining mesh networks on a social layer for community cooperation is about fostering interdependence, trust and communication. Games are projections of reality, so when considering the types of game mechanics to apply to MeshKit, it is important to weigh the psychological effect that aggression-based versus community-based games invoke. As the world grows more interdependent and the failure of a system such as currency effects countries elsewhere, reiterating xenophobia and a lack of empathy towards opposing teams in games is working against social progression.[32] Social Gaming Mechanics are applied to MeshKit to move past primitive survival skills, advancing instead towards teaching more complex social survival traits.

During the user testing of "Pirates!," a game designed to test social interaction between players on wireless, mobile devices, most testers were not interested in player-to-player combat. Instead, they preferred to solve missions, while expressing a desire to engage in other player-to-player exchanges, such as trading items or teaming up to accomplish goals. [33] The users in this test, while physically engaging with other players with augmented mobile devices, preferred more social-based over aggression-based interaction mechanics. Accomplishing mesh-based goals through team forming and trading of rivalrous goods are fundamental mechanics incorporated into MeshKit.

6.1 Roles and Groups

Each project within a MeshKit community considers grouping and assigned roles as important steps to retain users and streamline task completion. [34] Through observation of swarm intelligence in social insect colonies, it has been shown that division of labor, recruitment and reinforcement to carry out specific tasks leads to self-organization of community structures. Furthermore, flexibility in roles is beneficial to the community over time – users can change their assigned tasks or leave a project at any time. [35] In the following user scenario, these mechanics are projected into the MeshKit environment:

Fredrika, a 25-year-old, freelance designer from Brooklyn, NY, likes to work on her laptop in Fort Greene park, where a local mesh community offers Internet access. After a certain amount of free Internet, MeshKit asks her to pay for more access either with real money or by contributing her hardware resources to the community. She decides to download MeshKit and start contributing by forwarding packets on her laptop.

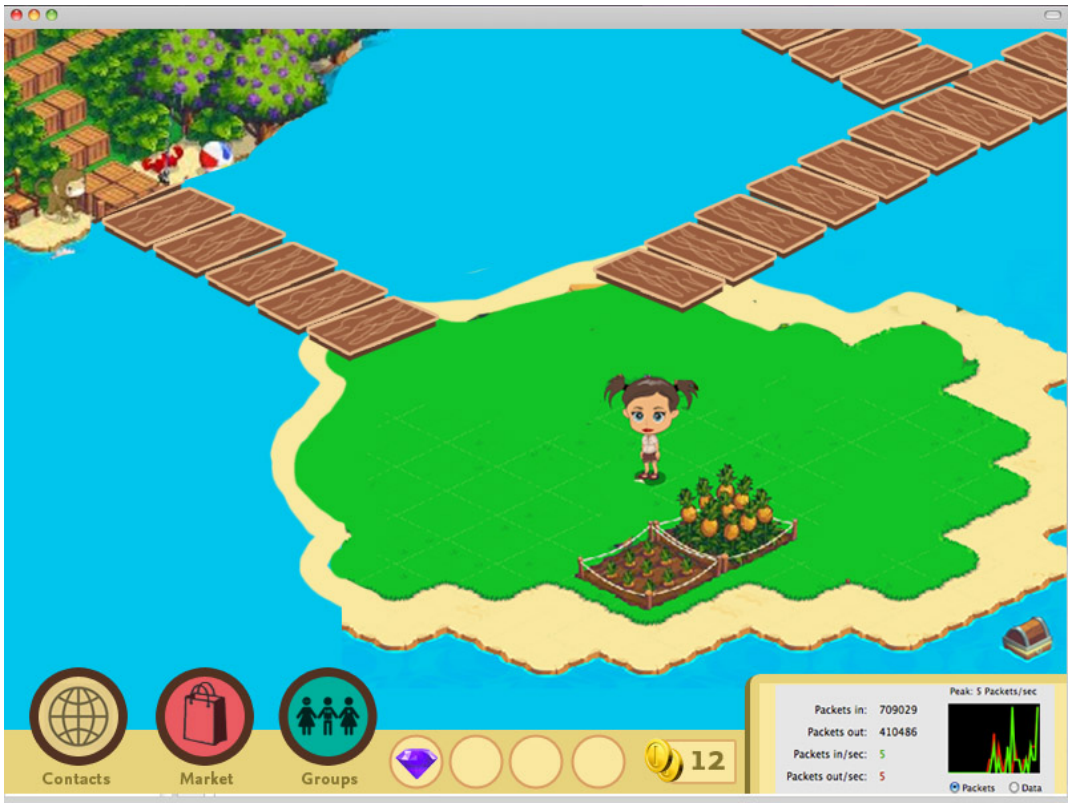

Fig. 2. Starting on a new island that represents their node in the mesh, bridges show linked nodes (islands). Prototype assets are re-mixed from Zynga's Treasure Isle game. [37]

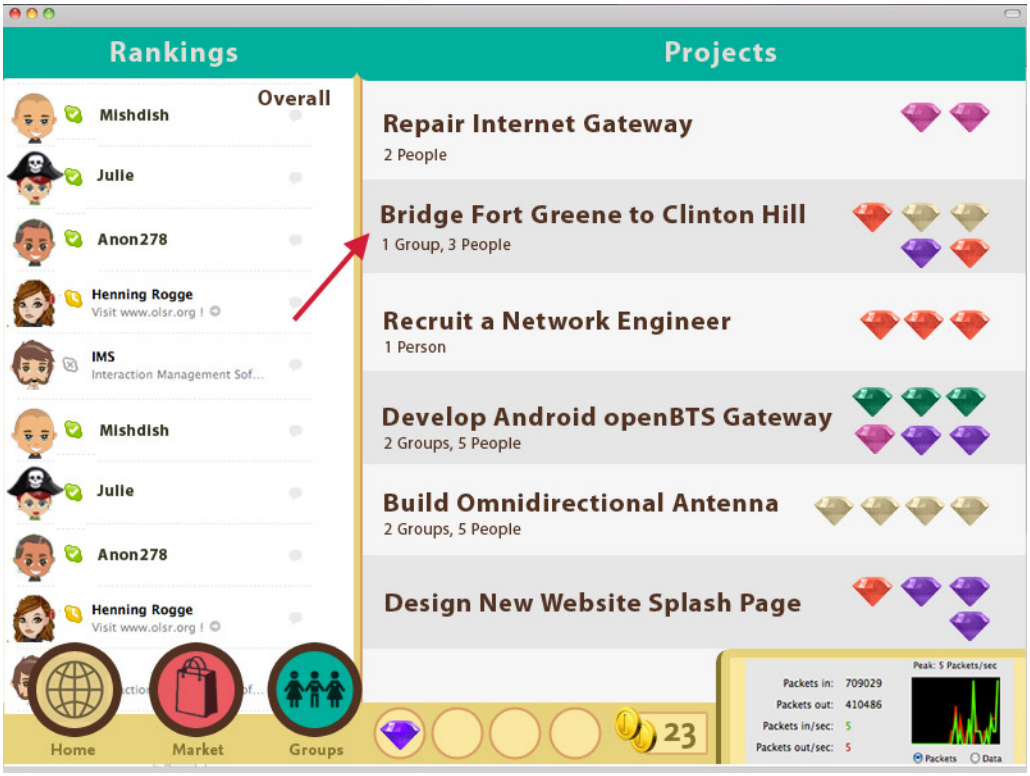

Fig. 3. A list of current projects on the mesh, social rankings. Gem colors represent the skill categories for each

project.

Upon joining the community (Fig. 2), she finds out there's a project to expand the mesh to her neighborhood in Clinton Hill. The group is looking to recruit members that live in the area to setup directional antennas to bridge Fort Greene and Clinton Hill. The group's members all have specialized skills that are needed to build and maintain the bridge - these are represented by the project's Resource Gems (Fig. 3). Once the bridge is completed using two Wok-tennas, group members are rewarded with Coins and appropriate Resource Gems. In this case the Gems are: Hardware, Knowledge, Community and Software. The more Gems a user collects, the more representative they are of their real-world skills.

6.2 Expressive Space

Will Wright, the designer of SimCity and The Sims, emphasizes the need for designers to "give players a large possibility space,"[36] by creating open systems for maximum personal customization, which leads to a community of "player created content," in the way of customizing an avatar's appearance in a role-playing game, designing crop patterns in Farmville, or laying out entire cities in SimCity. This leads to content sharing networks and chat systems focused around artifacts players create.

In MeshKit, each user's node is represented as an island, links between nodes are bridges and the ocean around the islands are the mesh's wireless dead-zones. Users can explore their island, or any other connected by a bridge, to provide a tangible visual representation of the mesh network. This interface was chosen to provide a specific area for each user to express themselves - on their own island - while accommodating the constantly fluctuating topology of the network that occurs with ad-hoc and hybrid mesh networks. Inspiration was also pulled from the popular online social game, Treasure Isle, and Pirates!, the wireless mobile game – both have players exploring islands and finding items shrouded in clues.[37][33]

An early paper prototype of MeshKit used a combination of Settlers of Catan and Uno game pieces to represent the meshed community as hexagonal-shaped island, while wireless dead zones were signified with hexagonal oceans. Dice roll probability chips were placed randomly on each ocean tile, which effected the chance of an event occurring. Players in the test had to protect their community from a sea monster by sharing resources represented by matching Uno cards. Results from this test conveyed the need for individual player islands, less artificial danger and real-world prototyping – these are addressed in the following section.

6.3 Peer to Peer Economy

A user's economy has a direct effect on the appearance of their island. The more Coins they have, the larger their island grows, providing more space for expression and personalization. The number and types of Resource Gems they have are represented by the color of the island. In this way, when any user views a zoomed out map of the entire mesh topology, they would immediately know which users contribute the most (size of island) and in which area (color of island). Additionally, users are ranked on a Gem Resource and Coin value leader-board, so others can easily see who would be the best fit for a particular project.

Online social environments need collecting mechanics, so users can show off what they have to others in the community, what they've accomplished and what they're working toward. [38] In MeshKit combinatorial items are random drops that, when collected as a set, form greater whole parts – in the same way Lego pieces can form complex sums but can also be arranged freely by the user. For instance, pieces of a house might wash up on the shore of a users island – it is one part away from a whole house, or a complete set. Another user in the mesh has the last piece of that house, having traded for it a while back with another party. This user could gift the missing piece to the first user so that their collection is complete and place the house on their island. This type of implicit transaction is important for a balanced reciprocal, social economy, where the future return of a gift is expected at a later date. Combined with negative reciprocal exchange, or bartering system, these form deep bonds between

community members through the conversations that arise. [38][34]

Due to the Lego-esque quality of the collectible assets, users can build out from the pre-conceived item sets and create their own custom structures. These can be freely traded or bought with Coins through the in-game market. Bartering and reciprocal economies have been observed through data exchange in real-world peer to peer networks - such as Bit Torrent - which follow the same rules of reputation found in gaming social mechanics. [39]

In a user test focusing on resource exchange across mesh networks, three groups of three people in different rooms represented different mesh communities, scattered across the floors of a building. Each community generated a different set of resources – they needed resources from the other communities to complete a goal. One tester left the room, one stayed behind to engage trading and complete a task, and the other could choose to stay or go. Testers that ventured out of the mesh communities experienced random dangers, which resulted in a loss of a resource. The testers ended up exhibiting emergent behavior and forming an ad-hoc bartering market within the safe area of a mesh community. Although this was not the desired results, it did show users' adaptability to the dangerous situation by forming a micro-economy within a trusted area – a mesh network.

6.4 Rituals

When a user collects a certain number of Resource Gems in a category, they level up. This is a clear indication of their advancing skill and role transition to a higher social ranking. Rituals are very important in establishing long term bonds between community members – this can be done through raising awareness of a member's leveling, while encouraging gifting of special items by others. This is the same way birthdays and holidays work: giving, receiving and reciprocating at a later date. [34]

To further reinforce rituals, MeshKit is synced to the local date and time of a user's device to convey a 24-hour light cycle and seasons of the year. This could procure more social interaction between mesh users, as discussions about weather, sleep, wakefulness and meals would be topical.

7. Technology

The 802.11s Mesh standard is still being drafted, so there is no universal mesh protocol used today. Therefore, MeshKit is designed to be easily swappable with a variety mesh protocols, such as B.A.T.M.A.N., SMesh and Babel. The current implementation is built on top of Optimized Link State Routing (OLSR), the most widely used and developed open source, ad-hoc mesh protocol – it is most notably used by the Freifunk free radio network initiative in Germany.[40] OLSR can be run on a Unix, Linux, OSX and Windows laptops and desktops, Android and iPhone, tablet devices, and wireless routers.[41] This backwards compatibility allows for the recycling and re-appropriation of outdated hardware technology into new applications.

During a user test, where seven testers had a limited amount of time (30 minutes) to learn how to install the OLSR software and join the mesh network, only one user was able to successfully connect. Each user had a MacBook Pro and were given instructions on how root their OSX system, add & edit a network location, create a manual TCP/IP connection with a provided static IP address, open Terminal, make-install the OLSR protocol, edit the OLSR configuration file to include their WiFi device, and finally run the OLSR daemon. Even though testers tried to help each other through the process, they ran into many system-specific difficulties that slowed down the process. These test results emphasize the need for a user-friendly, automated installation and configuration process for running MeshKit.

The communication infrastructure (Fig. 4) is inspired by a Skype-style single or group voice and text chat system, with the added ability of peer to peer file sharing. If OLSR detects an Internet gateway on the mesh network, it will automatically forward appropriate traffic through the gateway. Considering Open Base Transceiver Station

(openBTS) opens up the possibility to incorporate normal GSM cellphones onto the network, by turning an Android phone into a miniature phone tower receiver.[42] Using similar routing logic to the Internet gateway combined with Voice Over IP, an OpenBTS gateway would let regular phones (such as the Nokia 1100) to connect to the mesh.

To ensure compatibility across all devices, MeshKit will be built in HTML5, which can be ported to mobile devices through the open source Phonegap project or run in any supported web browser.

Fig. 4. Mesh community with communication and contacts interface.

8. Conclusion

Problems with the current communication infrastructure can be solved by the implementation of mesh networks. Using MeshKit would create specific scenarios to solve each of the communication problems. There are difficulties involved on both a social and technical level when establishing ad-hoc and static mesh networks. These need to be addressed through cross-layer cooperation and building trust fostered in an interdependent social gaming atmosphere.

9. Next Steps

Summer 2011: Continue developing back-end Unix/Linux implementation of mesh protocol on routers, laptops and Android phones, while starting to automate processes so others can easily install and contribute to the mesh. Begin conceptual development of game-like social atmosphere front-end, while developing assets for use in HTML5 environment. Meet with mesh network developers in Germany to discuss technical difficulties.

Fall 2011: Begin user-testing of working prototypes in various physical and social environments. Will observe both ad-hoc and static, short term and long term mesh communities to monitor behaviors and general sentiment towards other contributors.

Winter 2011: User testing of fully incorporated front-end elements, monitor resource gifting and trading elements. Continue to polish back-end, while fully implementing front-end User Interface and social gaming assets.

Spring 2012: Final prototyping of front and back-end product, enlisting volunteers for Quality Assurance testing and final product delivery on OSX, Linux, Android with support for Windows and iPhone.

References

[1] Li, C., Moses-Ninan, B., New America Foundation
"An International Comparison of Cell Phone Plans and Prices"
http://newamerica.net/publications/policy/an_international_comparison_of_cell_phone_plans_and_prices
October 14, 2010

[2] Roettgers, J., Gigaom
"AT&T's New Bandwidth Cap is Bad News for Netflix"
http://gigaom.com/video/att-bandwidth-cap-netflix/
March 14, 2011

[3] Cooper, Mark
From WiFi to Wikis and Open Source:
The Political Economy of Collaborative Production in the Digital Information Age

[4] Gruenwald, J., National Journal
"ICANN CEO Blasts African Telecom Companies"
http://techdailydose.nationaljournal.com/2010/03/icann-ceo-blasts-african-telec.php
March 8, 2010

[5] Buchanan, M., Gizmodo
"Comcast's New Network Plan Will Slow Down Heavy Users for Up to 20 Minutes"
gizmodo.com/5039766/comcasts-new-network-management-will-slow-down-heavy-users-for-up-to-20-minutes
August 20, 2008

[6] Bode, K., DSL Reports
"Bell Canada Throttles Wholesalers, Doesn't Bother To Tell Them"
http://www.dslreports.com/shownews/Bell-Canada-Throttles-Wholesalers-Doesnt-Bother-To-Tell-Them-92915
March 24, 2008

[7] Anderson, N., Ars Technica
"Did the FCC Just Bless a Capped Two Tier Internet?"
http://arstechnica.com/tech-policy/news/2010/12/did-the-fcc-just-bless-a-capped-two-tier-internet.ars
December 2010

[8] Reporters Without Borders for Press Freedom
"List of the 13 Internet enemies"
http://en.rsf.org/list-of-the-13-internet-enemies-07-11-2006,19603

November 7, 2006

[9] Reporters Without Borders for Press Freedom
"Web 2.0 versus Control 2.0"
http://en.rsf.org/web-2-0-versus-control-2-0-18-03-2010,36697
March 18, 2010

[10] Orlin, Jon, Tech Crunch
"In Search of the Internet Kill Switch"
http://techcrunch.com/2011/03/06/in-search-of-the-internet-kill-switch/
March 6, 2011

[11] Ray, Bill, The Register
"Libyan network hijacked for rebel cause"
http://www.theregister.co.uk/2011/04/13/rebel_libya/
April 13, 2011

[12] McDermid, Riley, Mobile Beat
"Libya shuts down internet access as unrest intensifies"
http://venturebeat.com/2011/02/18/libya-shuts-down-internet/
February 18, 2011

[13] Arthur, Charles, Guardian.co.uk
"Google and Twitter launch service enabling Egyptians to tweet by phone"
http://www.guardian.co.uk/technology/2011/feb/01/google-twitter-egypt
February 1, 2011

[14] Broadband Mobile Communications Research Lab, Asian Institute of Technology, Bangkok, Thailand
Concept Paper on Emergency Communications during Natural Disasters: Infrastructure and Technology
http://tsunami.ait.ac.th/Documents/disaster_communication_assistance_concept_paper.pdf

[15] Ushahidi
http://www.ushahidi.com/

[16] Reguart, A., Cano, J., Calafate, C., Manzoni, P.
Providing Internet Access in Rural Areas: A Practical Case Based on Wireless Networks
Polytechnic University of Valencia, Valencia, Spain

[17] Jani, David, Itproportal
Nintendo 3DS to Introduce Ad Hoc Network
http://www.itproportal.com/2011/01/19/3ds-european-launch-detailed-live-presentation-amsterdam/?utm_source=dlvr.it&utm_medium=twitter&utm_campaign=itproportal

[18] One Laptop Per Child: Mesh Network Details
http://wiki.laptop.org/go/Mesh_Network_Details

[19] Reddit: Darknet Plan
http://www.reddit.com/r/darknetplan

[20] Anonops IRC Channel
http://search.mibbit.com/channels/AnonOps

[21] 808Chan: Darknet
http://boards.808chan.org/net/

[22] Netsukuku
http://netsukuku.freaknet.org/

[23] Flickenger, Rob, O'Reilly, 2002
Building Wireless Community Networks

[24] Antoniadis, P., Le Grand, B. Université Pierre et Marie Curie, France
Satsiou, A., Tassiulas, L. University of Thessaly & Informatics and Telematics Institute, Greece
Aguiar, R., Barraca, J., Sargento, S., Instituto de Telecomunicações, Universidade de Aveiro, Portugal
Community Building over Neighborhood Wireless Mesh Networks
IEEE Technology and Society, March 2008

[25] Johnson, D., Matthee, K., Sokoya, D., Mboweni, L., Makan, A., Kotze, H.
Building a Rural Wireless Mesh Network
Meraka Institute, 2007

[26] SMesh
Distributed Network and Systems Lab, Johns Hopkins University
http://www.smesh.org/

[27] Korteum, G., Segall, Z., Thaddeus, G., Thompson, C.
Close Encounters: Supporting Mobile Collaboration through Interchange of User Profiles
University of Oregon, Department of Computer Science, Eugene, OR

[28] Kim, Amy Jo
Community Building on the Web, Peachpit Press, 2000

[29] Salen, K., Zimmerman, E.
Rules of Play: Game Design Fundamentals, The MIT Press, Cambridge, London, 2004

[30] BitCoin: P2P Virtual Currency
http://www.bitcoin.org/

[31] Demertzis, F., Xenakis, C.
Soma: Self-Organised Mesh Authentication
University of Piraeus, Department of Digital Systems, Piraeus, Greece

[32][46] Koster, Raph
A Theory of Fun for Game Design, Paraglyph Press, Scottsdale, 2005

[33] Björk, S., Falk, J., Hansson, R., Ljungstrand, P.
Pirates!: Using the Physical World as a Game Board
PLAY research studio, Interactive Institute, Göteborg, Sweden

[34] Koster, Raph
"Social Mechanics: The Engines Behind Everything Multiplayer"
http://www.raphkoster.com/wp-content/uploads/2011/02/Koster_Social_Social-mechanics_GDC2011.pdf
March 2011

[35] Bonabeau, E., Dorigo, M., Theraulaz, G.
Swarm Intelligence: From Natural to Artificial Systems, Oxford University Press, New York, Oxford, 1999

[36] Wright, Will, Computer History Museum
"Lessons from Game Design"
http://www.youtube.com/watch?v=CdgQyq3hEPo
November 20, 2003

[37] Treasure Isle, Zynga
http://www.zynga.com/games/treasure-isle.php

[38] Kim, Amy Jo, Google Tech Talk
"Putting the Fun in Functional: Applying Game Mechanics to Functional Software"
http://www.youtube.com/watch?v=ihUt-163gZI&feature=player_detailpage#t=480s
January 30, 2009

[39] Chuang, John
"Economics of Peer-to-Peer Systems"
http://p2pecon.berkeley.edu/ppt/p2pecon-sinica.pdf
University of California at Berkeley, School of Information Management and Systems, August 3, 2004

[40] OLSR Experiment
http://berlin.freifunk.net/

[41] OLSRD: An Adhoc Wireless Mesh Routing Daemon
http://www.olsr.org/

[42] "You Could Be Your Own Wireless Carrier"
http://www.cell-phone-plans.net/blog/cell-phones/you-could-be-your-own-wireless-carrier/

[43] Village Telco
http://www.villagetelco.org/about/

[44] Scheinder, J., Korteum, G., Jager, J., Fickas, S., Segall, Z.
Disseminating Trust Information in Wearable Communities
University of Oregon, Department of Computer and Information Science, Eugene, OR