MANET application for Windows Phone

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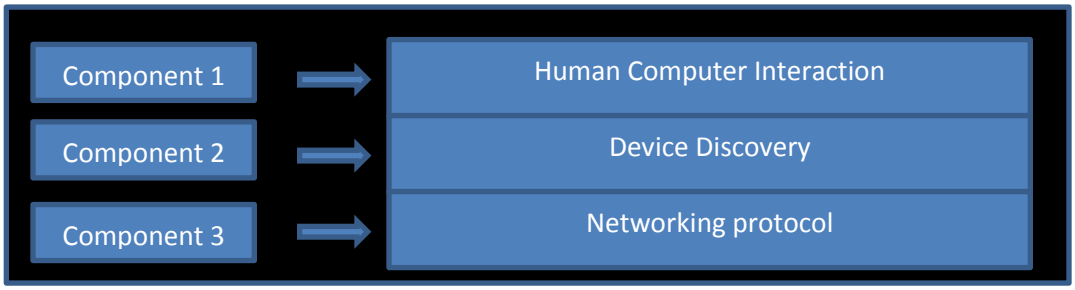
Project Description

Recent developments in mobile technologies have created many networking opportunities. This project attempts to utilize these developments in mobile technology by creating MANETs with Windows Phone 7 (WP7) mobile devices. More specifically, it looks at three components that make up a successful MANET; effective and intuitive user interaction, efficient and secure device discovery, and reliable network routing protocols.



Problem Statement

Mobile human computer interaction is an area of computing that is becoming one of the most popular and sought after areas of development. With the recent emergence and success of smartphones, the use of mobile internet has dramatically increased. This makes the next generation of useful and meaningful applications, as well as interaction models, a huge topic amongst consumers and industry [2]. The importance of mobile HCI is apparent across a large number of areas within the industry. This importance has resulted in major mobile companies investing a large amount of resources into this research. Another important area, which ties in with mobile HCI, is mobile interaction design. In particular, this involves the designing of interfaces to display the most relevant information to the user given a limited screen size.

The five main problems with Mobile HCI's that will be addressed is shown below [1]:

Designing for mobility

The world today comprises of people who are always on the move. As file sharing becomes increasingly popular, users will want to transfer files across a network as fast as possible; this may occur when the users are not in proximity of one another as the users may be travelling.

Designing for a widespread population

The target users come from different backgrounds and some people may not be exposed to certain technologies. Designing a system that will cater for a variety of users will be important.

Designing for limited input/output facilities

There are limited input/outputs facilities that mobile phones may have. We will have to consider factors such as screen size, sound, keyboards etc. We will look into the limitations that these facilities provide and ways to overcome these limitations.

Designing mobile systems for levels unfamiliar to most desktop users

When designing our mobile system we need to consider the consistency between mobile phones and desktops. This consistency allows users to make the transition from a desktop to a mobile phone interface.

Device discovery

Device discovery is crucial to the functioning of this system, as a network cannot be created when devices do not know who their neighbors are; or if they even exist. Due to the nature of mobile devices, a number of unique issues are associated with device discovery in mobile ad-hoc networks (MANETs).These are issues of power management, security and usability.

Power management - How can battery life be extended without decreasing the potential for connectivity?

Devices will constantly be moving in and out of range of various MANETs. As a result, they need to be scanning for available MANETs with some regularity, or they consequently risk missing potential networking opportunities. As with most MANETs, our system will form connections via Wi-Fi radio. Wi-Fi radio requires an extraordinary amount of power when scanning for networks, or transferring small amounts of data [9]. Consequently, Wi-Fi devices generally make use of power saving modes (PSMs) that switch off the radio periodically. However, this relies on a consistent connection to a single access point. There are various other radios and sensors on mobile devices that run more efficiently. These can be used, and exploited, to both discover and predict the existence of MANETs. A protocol that allows for regular scans without draining too much battery power needs to be found.

Security - How can the user's privacy and security be maintained at acceptable levels, in an environment where device communication is essential?

Any form of computer networking has privacy and security issue related to it. The nature of device discovery creates opportunities for attacks relating to data interception and data modification. Devices communicate with each other to establish connections, and malicious users can easily masquerade as regular users. For example, they may act as a man in the middle; routing and reading the information that the two users, oblivious to his presence, are sending. Methods and protocols which ensure that devices can trust each other need to be established. Furthermore,

systems that increase the efficiency of device discovery may make use of user's behaviour patterns. Ways of protecting this data need to be considered.

Usability - How do users and their devices connect to a specific device within a device ecology, or cloudlet?

After device detection has been completed, the user needs to decide which other device to interact with. This proves to be challenging as large number of devices in the same locale as the user, correspond to overwhelming number of options presented to them. In known systems,, users need to select it from a list the name of the device, or the SSID of the network, in order to connect to the network. This time consuming process is also subject to mistaken identity when that list is large. Consider the case when two users, Alice and Bob, wish to connect their devices via Bluetooth. Alice has yet to change the name on her phone from the default "Phone1." Consider now that another person has the same device, as Alice, has yet to change the device name from "Phone1", and is within the detection range of Bob's phone. Bob will be presented with two devices named "Phone1" and must now guess which one is his friend. The purpose of this section of the project is to find and implement, or develop a quick and intuitive way of indicating which device to interact with.

Network routing protocols

Mobile phones have become more capable in establishing reliable and coherent wireless connections as well as being able to handle more computationally complex tasks. Setting up an Ad Hoc network between mobile phones becomes possible if the correct routing protocols are chosen.

Although these cloudlets (MANETs) will primarily be centered on file transfer, mobile phones offering services will also be considered. Many routing protocols for data transfer between mobile devices have been discussed in the past. These can both establish and maintain a cloudlet network. However, mobile phones have the following restrictions that make such a cloudlet difficult to create:

1. Energy consumption restrictions
2. Bandwidth limitations
3. Scalability issues

Mobile devices are dependent on battery power, and thus it is important to minimize their energy consumption. In order to maximize the usage of a mobile battery, the entire network's energy consumption should be minimized by a carefully choosing an optimum routing protocol.
Since mobile phones all share the same frequency channel, this limits the bandwidth that is available to mobile networks. This puts constraints on flooding or broadcasting in the network to effectively implement a routing protocol. Furthermore, mobile Ad Hoc networks change rapidly and unpredictably since the locations of the devices are constantly changing. The bandwidth limitations affect how the cloudlet responds to these rapid changes in the network to maintain a solid Ad Hoc network.

Due to the potential size of cloudlets that will be formed, it is necessary to consider scalability issues that may arise once the Ad Hoc networks gets large. This involves selecting or creating a routing protocol that scales well whilst maintaining correctness among route finding procedures. The three factors above pose problems when investigating or choosing a routing protocol for mobile devices.

Procedures and Methods

Users play a vital role when addressing HCI problems. Solutions need to be produced that correspond to the users' needs and expectations. Using the Windows Phone operating system and their tiled interface will provide interesting alternatives in solving the issue of mobility. File transfer is simple when users are in close proximity of one another; however issues arise when the users are outside this proximity.
Designing a system that allows users to transfer files to one another regardless of their location will be the focus of solving the issue of mobility. This process involves:

1. Analyzing existing systems that allow file transfer automatically and manually
2. Designing a prototype that caters for file transfer while users are not in the proximity of one another.
3. Assess whether files are correctly transferred from one client to another
4. Gaining feedback from users on which file transfer method they prefer

A simple and easy to use interface will be designed in that will take into account users from different backgrounds. Different interface designs for file transfer will be evaluated to cater for the widespread population. A number of interface prototypes for choosing files will be designed, and evaluated. The following steps will be taken to evaluate the interface prototypes:

1. Deploying the interface for users of different backgrounds to use.
2. Evaluating the users interaction with the system
3. Deducing factors that cater for users from different backgrounds

Screen size will play a vital role when trying to display information to the user. One area of concern involves a user attempting to send a file to another user. The user may have a number of tiles representing other users. Devising an efficient way of selecting the correct user will be the central focus when working with the limited screen size since not all the tiles can be displayed on the screen at once. Different interface design techniques in this area will be evaluated. When designing prototypes, the aim will be to design a system that shows ways of displaying the most relevant information to the user to maximize our screen usage. Feedback from users will result in an understanding on which method users prefer.

Designing a system for levels unfamiliar to desktop users, it is required to be consistent with desktops. The biggest challenge is to cater for people who aren't familiar to the tiling interface of a Windows Phone device. Analyzing various desktop platforms and successful mobile interfaces to see the consistency in their design will provide interesting alternatives to the problem. and look.

These consistencies will be applied to the systems that are designed. Special attention will be paid towards Windows 8 as this desktop platform will have the greatest influence on our system.

Network routing protocols

Many routing protocols for both peer-to-peer networks and mobile Ad Hoc networks exist. Most of these protocols establish an Ad Hoc network correctly without considering battery limitations, scalability issues and bandwidth limitations. Finding a routing protocol that takes all three factors into consideration will be the focus of the following procedures:

1. Implement a known protocol that establishes an Ad Hoc network.
2. Assess the efficiency in terms of battery consumption and bandwidth usage
3. Assess the efficiency of the protocol while adding more devices to the network

These steps will provide information on the three factors and generates data for future comparisons. Poor energy consumption and bandwidth usage will be expected for larger networks. These three steps will then be iterated with different protocols until:

1. A thorough understanding of what part of the protocol is responsible for the most energy consumption.
2. An efficient way of utilizing the bandwidth is found.
3. The order of the routing protocol is determined

Information gathered from different protocols will separate the specific aims of different protocols. Integrating these aims towards a protocol that is suitable for mobile Ad Hoc networks will cater for the battery limitations, bandwidth limitations and scalability issues. The final protocol that is implemented will be tested under the following criteria:

1. Battery consumption throughout the network
2. Bandwidth usage
3. Correctness of route discovery and coherence of data transfer
4. Effects on the network as network gets large

Device discovery

Solutions to the discovery problem will be found in the literature. The conference proceedings of Ubicomp [10] and Pervasive [11] have been suggested as good resources, as they deal with methods and systems relating Ubiquitous and Pervasive computing.
The hardware specifications and Operating System of the device for which the solution shall be developing will filter out the possibilities that are not supported by WP7. The process of creating device discovery is as follows.

1. Select existing systems that best suit the goals of mobile device discovery
2. Implement these systems on the mobile phone
3. evaluate the implementation on the properties

Device discovery must be evaluated on the three properties mentioned above; namely power management, usability and security.

Power management

Ideally, the literature relevant to the implemented solution will have presented battery usage data, and possibly comparisons between their system and regular Wi-Fi scanning. Even if this is available, it is unlikely to have been measured on the same device that we shall be using, thus a way in which to measure the power that is drawn from the battery will need to be used. This will be a done while utilizing the device discovery system. Measurements can be made by using either a multi-meter, or by measuring the lifetime of the battery. The cellphone environment will need to be controlled so that processes unrelated to the system do not confound the results. The power consumption will be tested over a number of possible real-world conditions:

- Multiple connections available (example UCT networks and MANET)
- Network connection always available
- Network connection sometimes available
- No available network connection

Results will be obtained in the following manner.

1. Find or set benchmark for regular Wi-Fi scanning/ device-discovery on WP7 device in all conditions
    a. record data over many consecutive tests
2. Test new system under same conditions
. record data over many consecutive tests
3. Compare against benchmark
4. Perform statistical analysis

Security

The evaluation of the security of our system cannot be attained with tests. Rather, during the implementation process we will attempt to follow the best practices as recommended by appropriate security standards. Then, once we have completed the implementation, we will evaluate the extent to which the system adheres to that security standard and possibly other, security standards.

Usability

We cannot at this stage set out a plan for evaluating the usability of a solution since choosing the best evaluation technique requires a thorough knowledge of what the actual solution is. Solutions that require an action from the user should be observed with different methods than those that run automatically, with the intention of the user being oblivious to its actions. Usability will be evaluated as follows:

1. The solution is implemented on the device.
2. The characteristics of the solution are considered, and the most appropriate methods for evaluating the usability will be tested.
3. User tests carried out.
4. Results are evaluated.

Ethical Professional and Legal Issues

Like any file sharing application one of the legal implications our system will face is copyright infringements. As recent history has shown P2P systems such as Napster and Kazaa have been shut down or made to change their entire system due to this infringement. One way of getting around the issue when it comes to media files is to only allow free media files to be transferred.

Furthermore, many peer-to-peer networks have been taken down in the past due to copyright issues mostly involving the field of the entertainment industry. These networks involve a centralized network where routing takes place. The proposed routing protocols will be part of decentralized technology where there is no central server that redirects routing requests. These methods do not violate copyright infringement acts or any ethical issues. Furthermore, due to the limitations of mobile phones, the data distributed will be small in size. These limitations make it difficult for users to tap into the issues regarding copyright infringement. The focus of cloudlet networks will be to offer services within the network.

As we shall be performing user testing, ethical clearance will need to be obtained from the ethics board. In order to be cleared, a consent form will be drawn up and provide users with information.

Related Work

Issues arise when a user searches for a person's tile. This can be solved using the scrolling method. The idea of having your finger at the bottom or top of the screen when searching through tiles and then moving your finger back to the center to slow down the scrolling was influenced by S. Jones et al. [3] In their literature they evaluated integrated zooming and scrolling on small screens, where they applied their method at an efficient way to view pictures.

A number of hierarchical systems, which minimize the amount of time a mobile Wi-Fi radio spends scanning for networks, exist. Namely, Turducken [5], Blue-Fi [3], Pering et. al [6]'s system, Senseless [7]. Turducken and Persing's system make use of sensing devices not ordinarily found on mobile phones. Thus, Blue-Fi and Senseless are very applicable.

Blue-Fi keeps records of the Bluetooth devices and cellular network towers that it frequently comes into contact with. It also stores any Wi-Fi networks that it has connected to while in range of the Bluetooth devices and cellular network towers. By storing these data, mobile phone with Blue-Fi can predict when it comes into range of a Wi-Fi, network and only switch on the Wi-Fi scanning function when a network is likely to exist [3].

Senseless uses energy efficient sensors, such as the accelerometer, to predict when more power hungry sensors, such as GPS, are required. GPS is unlikely to be needed when the user is sitting and watching Television, but might be used when the user is walking, or driving, around. Senseless does not specifically involve network and device discovery, it does encompass the idea of what this component is all about. Using low power functions to tell the high power functions when they should activate [7].

Routing protocols that make the use of DHT have been implemented in the past. The paper "How to Implement DHTs in Mobile Ad Hoc networks" [13], discusses both a layered and integrated approach to the problem. Each approach have their trade-offs between complexity and efficiency. "Peer-to-peer File sharing over Mobile Ad Hoc Networks" [12], discuss various ways DHTs can be implemented and their pitfalls. Since both P2P and mobile networks are becoming more popular, improving the efficiency and integrating it into mobile phones becomes the focus of designing routing protocols. Furthermore, hardware improvements have been made through use of MEMS technology [14]. The correctness and coherence of data transfer between mobile phones have also been discussed in [15].

Anticipated Outcomes

A mobile Ad Hoc system that focuses on allowing users to transfer files and offering services will be developed for Windows mobile. The system will make use of the windows phone 7 tiling interface. Within this interface users will be able to select the files they want to transfer by holding their finger over a file. A tiling interface would then appear showing various tiles which represent people. The sender of the file will be able to drag and drop the file into these tiles. A scrolling interface will be implemented to overcome the small screen size. The tiles will be ordered in alphabetical order by name; the user may then hold their finger towards the bottom of the screen, which will allow the user to go scroll through the tiles in an efficient manner. Iterative methods will be used to provide a solution that caters for a widespread population and is consistent with desktop interfaces.

Using this interface, users first use device discovery methods to connect to the Ad Hoc network. . We expect that the system will automatically detect MANETs in a way that uses less power than standard Wi-Fi device detection. We also expect to that our system will provide users with a simpler, more energy efficient and a more usable means of connecting to other WP7 devices, and transferring data between them. This will alleviate the need to use complicated and laborious connection protocols such as Bluetooth [4, 8].

Lastly, an efficient routing protocol needs to be implemented for stable and coherent file transfer that minimizes battery usage. This protocol will to take into consideration scalability problems that arise when the network size increases. A protocol will be implemented that also considers the limited bandwidth used by mobile devices.

There are a number of success factors to base our project upon which include:

- The ability to send a file successfully from one recipient to the other.
- A user friendly system that caters for a widespread population
- The ability for the devices to automatically pick up another device.
- The ability to detect all available MANETs without sacrificing too much battery life
- Implementation of an efficient routing protocol that minimizes power consumption
- Implementation of a protocol that scales well as the network gets large
- Correctness of file transfer given the mobility of mobile devices

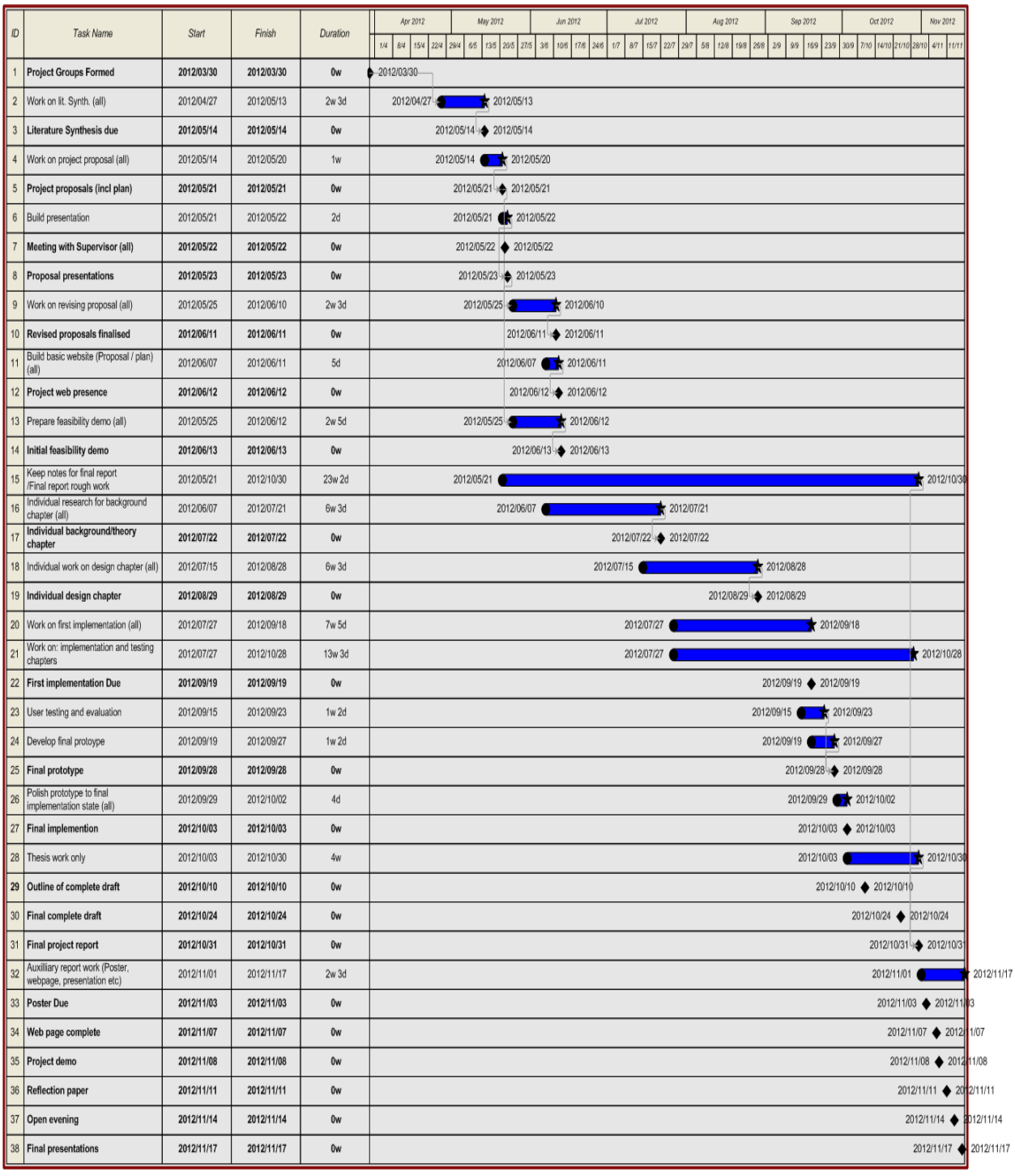
Project Plan

Risks

Risk	Description	Probability	Severity	Mitigation
Group member failures.	Failure for group members to efficiently contribute towards the project.	Low	Low	Keep each other motivated and remind each other of deadlines.
Ethical clearance denied	Clearance denied when looking at user testing.	Low	High	Apply as early as possible for ethical clearance before testing begins.
Unable to reach milestones	Failure of any group members to produce deliverables on time	Low	High	Have weekly meetings with the supervisor and help each other if one member needs help.
Device limitations	Windows phone device may limit us in implementation of our system	Medium	Medium	Make sure we research what the limitations of Windows phone is before we start final implementation
Poor scope estimation	Unable to implement all features of the project	Medium	High	Discuss the thoroughly with the supervisor and plan accordingly

Timeline/Gantt

Our Gantt chart displays a rough breakdown of when the milestones occur, and the time periods within which we should be working towards those milestones. As our project period reaches its conclusion, the milestones tend to occur at smaller intervals. At this point we group the various tasks into “auxiliary report work.” This includes the tasks left after the final report has been handed in.



ID	Task Name	Start	Finish	Duration
1	**Project Groups Formed**	**2012/03/30**	**2012/03/30**	**0w**
2	Work on lit. Synth. (all)	2012/04/27	2012/05/13	2w 3d
3	**Literature Synthesis due**	**2012/05/14**	**2012/05/14**	**0w**
4	Work on project proposal (all)	2012/05/14	2012/05/20	1w
5	**Project proposals (incl plan)**	**2012/05/21**	**2012/05/21**	**0w**
6	Build presentation	2012/05/21	2012/05/22	2d
7	**Meeting with Supervisor (all)**	**2012/05/22**	**2012/05/22**	**0w**
8	**Proposal presentations**	**2012/05/23**	**2012/05/23**	**0w**
9	Work on revising proposal (all)	2012/05/25	2012/06/10	2w 3d
10	**Revised proposals finalised**	**2012/06/11**	**2012/06/11**	**0w**
11	Build basic website (Proposal / plan) (all)	2012/06/07	2012/06/11	5d
12	**Project web presence**	**2012/06/12**	**2012/06/12**	**0w**
13	Prepare feasibility demo (all)	2012/05/25	2012/06/12	2w 5d
14	**Initial feasibility demo**	**2012/06/13**	**2012/06/13**	**0w**
15	Keep notes for final report /Final report rough work	2012/05/21	2012/10/30	23w 2d
16	Individual research for background chapter (all)	2012/06/07	2012/07/21	6w 3d
17	**Individual background/theory chapter**	**2012/07/22**	**2012/07/22**	**0w**
18	Individual work on design chapter (all)	2012/07/15	2012/08/28	6w 3d
19	**Individual design chapter**	**2012/08/29**	**2012/08/29**	**0w**
20	Work on first implementation (all)	2012/07/27	2012/09/18	7w 5d
21	Work on: implementation and testing chapters	2012/07/27	2012/10/28	13w 3d
22	**First implementation Due**	**2012/09/19**	**2012/09/19**	**0w**
23	User testing and evaluation	2012/09/15	2012/09/23	1w 2d
24	Develop final protoype	2012/09/19	2012/09/27	1w 2d
25	**Final prototype**	**2012/09/28**	**2012/09/28**	**0w**
26	Polish prototype to final implementation state (all)	2012/09/29	2012/10/02	4d
27	**Final implemention**	**2012/10/03**	**2012/10/03**	**0w**
28	Thesis work only	2012/10/03	2012/10/30	4w
29	**Outline of complete draft**	**2012/10/10**	**2012/10/10**	**0w**
30	**Final complete draft**	**2012/10/24**	**2012/10/24**	**0w**
31	**Final project report**	**2012/10/31**	**2012/10/31**	**0w**
32	Auxilliary report work (Poster, webpage, presentation etc)	2012/11/01	2012/11/17	2w 3d
33	**Poster Due**	**2012/11/03**	**2012/11/03**	**0w**
34	**Web page complete**	**2012/11/07**	**2012/11/07**	**0w**
35	**Project demo**	**2012/11/08**	**2012/11/08**	**0w**
36	**Reflection paper**	**2012/11/11**	**2012/11/11**	**0w**
37	**Open evening**	**2012/11/14**	**2012/11/14**	**0w**
38	**Final presentations**	**2012/11/17**	**2012/11/17**	**0w**

Resources (Equipment, software, people, literature)

Windows Phone 7 compatible mobile phones
Windows development environment
Development documentation for the above
A sample of users representative of the widespread population for which this system is aimed.
Sources of relevant literature

Milestones and Deliverables

	Due Date
Project group formed and preferences indicated	30 March
Literature survey due	14 May
Project proposals including project plan	21 May
Presentation of project proposals	24 May
Revised proposals finalized	11 June
Project web presence	12 June
Initial feasibility demonstration	13 June
Individual background/theory chapter	29 July
Individual design chapter	29 August
First Implementation	19 September
Final prototype/Experiment/Performance Test + Write-up	28 September
Coding, testing complete. chapters on implementation and testing complete	3 October
Outline of complete report	10 October
Final complete draft report	24 October
Final Project Report	31 October
Poster due	3 November
Web page	7 November
Project demonstration	8 November
Reflection paper	11 November
Open Evening	14 November
Final project presentations	17 November

Work allocation

HCI	***Device Discovery***	***Network routing protocol***
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References

[1] Dunlop, M.D. and Brewster, S.A. The challenges of mobile devices for human computer interaction (editorial for special edition). *Personal and Ubiquitous Computing.* 6, 4(2002), 235-236.

[2] Jones, S. et al. An evaluation of integrated zooming and scrolling on small screens. *International Journal of Human-Computer Studies*. 63, 3 2005, 271-303

[3] Ananthanarayanan, G. and Stoica, I. Blue-Fi: enhancing Wi-Fi performance using Bluetooth signals, in *Proceedings of the 7th international conference on Mobile systems, applications, and services (MobiSys '09)* (New York, New York, USA, 2009), 249.

[4] Hall, E.S. et al. RF Rendez-Blue: Reducing Power and Inquiry Costs in Bluetooth-Enabled Mobile Systems, in *Proceedings of the 11th International Conference on Computer Communications and Networks. IEEE.* (2002), 640-645.

[5] Sorber, J. et al. Turducken: hierarchical power management for mobile devices, in *Proceedings of the 3rd international conference on Mobile systems, applications, and services*. (2005), 261-274.

[6] Pering, T. et al. Exploiting radio hierarchies for power-efficient wireless device discovery and connection setup, in *18th International Conference on VLSI Design held jointly with 4th International Conference on Embedded Systems Design* (2005), 774-779.

[7] Abdesslem, F.B. and Phillips, A. Less is more: energy-efficient mobile sensing with senseless, in *Proceedings of the 1st ACM workshop on Networking, systems, and applications for mobile handhelds (MobiHeld '09)* (Barcelona, 2009), 61-62.

[8] Scott, D. et.al. Using Visual Tags to Bypass Bluetooth Device Discovery. *Mobile Computing and Communications Review.* 9, 1 (2005), 41-53.

[9] Agarwal, Y. et al. Wireless Wakeups Revisited : Energy Management for VoIP over Wi-Fi Smartphones, in *Proceedings of the 5th international conference on Mobile systems, applications, and services international conference*. (2007).

[10] Author unknown. 2012. Ubicomp 2012. http://www.ubicomp.org/ubicomp2012/

[11] Author unknown. 2012. Pervasive 2012. http://pervasiveconference.org/2012/

[12] Ding, G., Bhargava, B., & Lafayette, W. (n.d.). Peer-to-peer File-sharing over Mobile Ad hoc Networks 1 Department of Computer Sciences, 1-5

[13] Pucha, H., Das, S. M., Hu, Y. C., Lafayette, W., Hash, D., & Dhts, T. (2004). How to Implement DHTs in Mobile Ad Hoc Networks ?, (1), 2-3

[14] Rodoplu, V., & Meng, T. H. (1999). Minimum Energy Mobile Wireless Networks, *17*(8), 1333-1344

[15] Johnson, D. B., & Maltz, D. A. (n.d.). Dynamic Source Routing in Ad Hoc Wireless Networks
[16] NIELSEN, J. 1994. Ten Usability Heuristics. Heuristics for User Interface Design.
http://www.useit.com/papers/heuristic/heuristic_list.html