Utilising peer-to-peer networking for data transfer over the browser

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November 17, 2015

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Chapter 1

Interim Planning & Investigation Report

1.1 Project Scope

Aims and Objectives

The ultimate objective of my project is to investigate the plausibility of data transfer over web browsers (in particular, with file transfer and media streaming) without the need for a centralised client-server architecture, instead opting for a peer-to-peer network architecture. In order to do so, I plan to:

- Research peer-to-peer networking architecture and topologies
- Research WebRTC
- Research signalling protocols
- Research media streaming compression & protocols
- Research client-side JavaScript frameworks
- Develop a session signalling server in Java with the WebSockets protocol
- Develop a WebRTC Application to transfer and stream uploaded files.
- Implement a structured peer to peer network between peers transferring/streaming a file using the web application.

Stakeholders

The stakeholders involved in my project will be myself, my supervisor, Stelios Kapetanakis and the user.

Methods of Communication

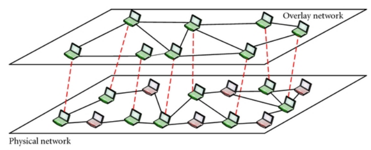
Stelios and I have set up a regular meeting once a week on Friday at 4pm to catch up. On top of this, we communicate regularly via email and Stelios has access to a project git repository on GitHub and a workflow board set up on my web server to track the progress of my project.

1.2 Research

Comparing Network Architectures

Peer-to-peer networking is the distribution of resources and processing between the nodes of a network. These networks tend to take the form of an overlay network which is a topology describing a virtual network that sits on top of a physical network (e.g the internet) consisting of a subset of the nodes connected to the physical network.

Figure 1.1: An Unstructured Peer-To-Peer Overlay Network [1]



Although an overlay network does not need to manage the burden the physical network is responsible for, in order to discover and route new nodes, it needs to have some way of managing the subset of nodes using it. There are several different ways of defining how it does this:

- Unstructured peer-to-peer: Peer connections in the overlay are established randomly and do not adhere to a network topology. New peers copy the connections another peer has formed and develops it's own over time.[2]. These networks are easier to build than structured networks as routing is random and they also tend to fair better in periods when the rate of peers leaving and joining (churn rate) is high due to their non-deterministic nature. However, searching in these networks tends to be less efficient as they rely on flooding the network to find nodes that have the data they are searching for.

- Structured peer-to-peer: Peers in a network are organised in a specified network topology and generally use a distributed hash table (DHT) to link together. The DHT consists of many peers maintaining a partial hash table referencing the unique keys of other peers in the network, allowing it to route to them. This way, a peer can communicate with another by hopping messages through peers in their hash table. Generally, each peer's hash table consists of nodes getting exponentially further away from it in order to improve the efficiency of this process. [2].

- Hybrid peer-to-peer: A combination of peer-to-peer and client-server models, these networks use centralized servers in some way. This model tends to work better than both unstructured and structured as dependent on how it is implemented, features that function better in decentralized networks can be left to the peers in network whilst the server can handle the features it is better at. [3]

Additionally, there is also the client-server model. In a basic sense, this is when the machines processing data (servers) are distinct from the computers requesting this processing (client), although in actuality, the boundaries between them vary dependent on how it is implemented. Whilst the shift of processing on to the service supplier means that the user of the application does not need a powerful machine to run it, it also means that the service supplier has the responsibility of maintaining and paying for these servers. Furthermore, although modern server architectures are designed in a distributed structure granting them to be more robust (as distribution allows for redundancy and load balancing), if these servers undergo too much load or in extreme cases, if the server farm completely crashes, the user would not be able to use the application as intended.

Using a peer to peer architecture avoids the issues associated with the client-server model as processing is distributed between the nodes making up the network, resulting in it being cheaper to maintain as there is less reliance on servers and more robust as the network scales as load increases. However, there are a number of considerations to be aware of in peer to peer networking, the largest of which being security as there is no centralized authority to manage access control to resources. Thus, a malicious client could potentially launch a number of attacks versus other nodes in the network such as Denial Of Service (DoS) where a malicious group of nodes floods a network with a massive amount of fake data, potentially crashing nodes within it or

Man in the Middle (MitM) attacks where a node is able to intercept data flowing between two other nodes and spy on or poison this data[4]. Whilst it would be hard to completely avoid risks like this as it is an inherent flaw in peer-to-peer architecture, introducing the basic concept of trust into a peer-to-peer network can stop malicious peers from entering it in the first place. This will be implemented in my application by allowing users to enable authentication (via password) for the uploaded file potentially preventing malicious attackers from being able to download or stream it.

My application will most closely resemble a hybrid peer-to-peer network as even though the actual channel for transferring data between peers (WebRTC Data Channel) will not go through a server, it will use a signalling server to route peers together. To form a network of peers that go beyond the one-to-many peer connection established by WebRTC, the signalling server in conjunction with the client-side application will have to manage how these peers connect to each other. A way of doing this is to connect new peers to the second newest peer and so on, forming a linear chain of peers that can reroute if the neighbouring peer disconnected.

Figure 1.2: Linear network

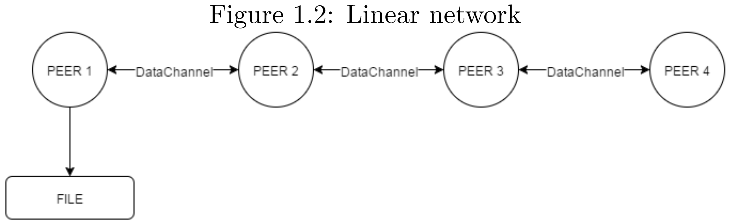
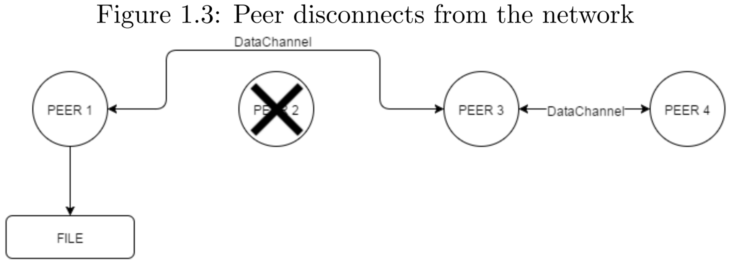
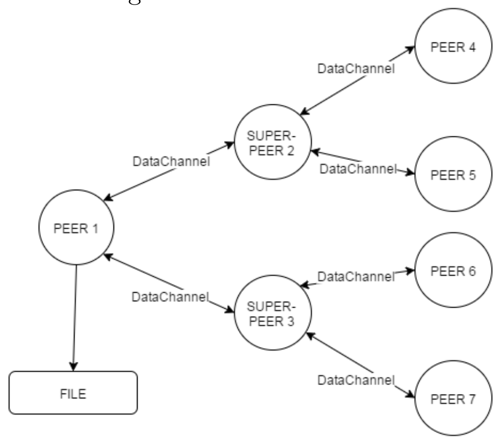


Figure 1.3: Peer disconnects from the network



However, this would prove inefficient if a peer in the chain malfunctioned or restricted bandwidth, potentially bottlenecking the rest of the peers behind it. As an alternative, peers could be routed based on a tree network topology [5] consisting of supernodes, "high capability" nodes that relay the transferred data to subnodes. This way load can be balanced across many nodes by distributing new nodes to another supernode or by electing further supernodes if it increases too much or if one disconnects. By exploiting heterogeneity between peers of the network, this topology can also be used to improve performance within the network by electing supernodes based on criteria such as location and, in our case, how much of the data has already been transferred or streamed to them. By doing so, performance within a network can potentially be improved as subnodes can be connected to supernodes based on this criteria, e.g if a subnode is located in the same place as a supernode then use it.[6].

Figure 1.4: Tree Network



Current Solutions to Data Transfer

Currently, solutions such as DropBox and Google Drive focus on cloud storage as a service whilst providing the ability to transfer data as a secondary function of this service. Although this is an extremely valuable and convenient idea enabling consumers to back-up their data, not all want a third party service that stores the data they want to transfer as this practice does raise ethical issues, namely with the data's security, privacy and ownership once it has been uploaded. However as a consumer, this can be hard to avoid when the online storage and transfer of data are so closely intertwined as these services have a huge market share.

Once you have uploaded files to one of these services, there is a trust placed on the company to store the data securely. However you could argue that this trust is misplaced, in 2010, the "Cloud Security Alliance" released a regularly updated list of the top threats faced by cloud computing services submitting there are numerous security issues faced within the cloud computing industry with many of the issues on this list occurring due to malicious intentions. For example the 6th item on the list, "Malicious Insiders" describes a situation in which current or former employees abuse their authorizations within system to gain access to sensitive information [7]. This suggests that even though companies can protect their client's data to an extent, there are still issues the industry face that consumers may want to avoid.

Whilst the uploaded data can be encrypted in a way that means only clients of the service can decrypt it (through end-to-end encryption), many people feel insecure leaving traces of their private information on a remote server belonging to a company that is not necessarily always acting in their interest. In 2013, this concern was legitimized by Edward Snowden when he disclosed information about government surveillance programs such as PRISM that coerced firms such as Google, Microsoft and Yahoo to provide private consumer data from their services to the government.[8] More recently, this idea has been reinforced by legislation such as the "Investigatory Powers Bill" being introduced in the UK that could prohibit companies from using end-to-end encryption techniques allowing authorities to request decrypted client data [9]. Whilst we can assume they have done this with non-malicious intentions, by weakening the encryption practices of these companies, they will potentially weaken the defence against malicious attackers.

As an alternative to using cloud storage solutions for sharing files, there is also specific data transfer sites such as WeTransfer that allows you to send files up to 2gb via their site. This works by sending a link through email to the person you want to send the file to. Whilst it does store the uploaded files, they are only kept for 7 days in order to prevent unnecessary storage costs [10]. Although this is better for data privacy, WeTransfer use third party providers such as Amazon Web Services (AWS) to store this data using AWS S3 Storage [11] meaning there is still the potential concern of data privacy and security highlighted previously.

Peer-to-peer networks also been popular for file sharing since the late 1990s due to the rise of applications such as Napster which focused on peer to peer music sharing. Napster worked by using a central server to index files that each peer made available on their machine. Each peer would then be able to search the index for copies of songs and download them from each other. However, this service was eventually shut down as the company ran into legal problems with copyright infringement. Since then, protocols such as

BitTorrent have improved on the idea of peer to peer sharing. The BitTorrent protocol works by peers creating ".torrent" descriptor files that describe the file's metadata, this is then shared however it is seen fit. Each peer wanting to download this file then picks up this ".torrent" file, opens it with a BitTorrent client and joins a "swarm" of peers, becoming one of the many "leechers" downloading this file. At the same time, this peer becomes one of the many "seeders" uploading this file as they download it so that other leechers can download it from them. The initial peer discovery is based on "trackers", servers hosting lists of seeders and leechers for the file. One of the issues with BitTorrent is that in order to share a file, you must go through the process of downloading a client, creating a ".torrent" file, adding it to a trackers list and sharing the ".torrent" with your peers and this can be seen as a arduous task for a basic consumer looking to share their files. Another problem is that if a tracker is compromised, there is potential for malicious attacks using the information stored on there.

As an alternative to these current solutions, the application I plan to develop has the aim of separating the online transfer of data from it's storage by connecting the peers involved in the transfer directly with each other. This circumvents the problems with cloud storage as the data being transferred does not pass through any servers as well as the problems with current peer to peer file sharing as it does not require a desktop client or torrent files. To allow my application to share files online, WebRTC will be used.

WebRTC

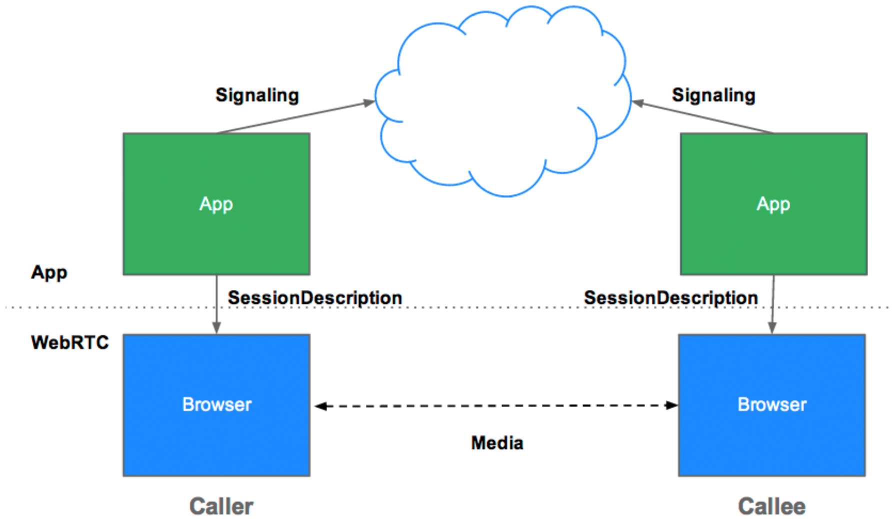
WebRTC (Real Time Communication) is an emerging web technology that enables browsers to communicate real time via a peer-to-peer connection, avoiding the need for a centralized server to transfer data between clients. This was first released by Google as an open source project in May 2011 [13] and was later drafted as an API definition by W3C remaining as a work in progress. [14]. WebRTC has yet to be fully implemented in every web browser but Chrome, Firefox and a WebRTC specific browser called Bowser do support it. Firefox (Nightly), in particular seems to be leading the way in this so the application will specifically be developed towards this browser[15]. The 3 main WebRTC APIs supported at this time are:

- RTCDataChannel: "The RTCDataChannel interface represents a bi-directional data channel between two peers of a connection." [16]
- RTCPeerConnection: "The RTCPeerConnection interface represents a WebRTC connection between the local computer and a remote peer. It is used to handle efficient streaming of data between the two peers." [16]
- getUserMedia: "Prompts the user for permission to use one video and/or one audio input device such as a camera or screensharing and/or a microphone. If the user provides permission, then the successCallback is invoked with the resulting MediaStream object as its argument. If the user denies permission or media is not available, then the errorCallback is called with PermissionDeniedError or NotFoundError respectively. Note that it is possible for neither completion callback to be called, as the user is not required to make a choice."[16]

In order to achieve it's aim, the application will utilize the RTCPeerConnection and RTCDataChannel APIs. The former to establish a peer connection between two clients and the latter to create a data channel over this peer connection to transfer data.

As mentioned in the Javascript Session Establishment Protocol (JSEP) [17], although WebRTC and the browser is used to transfer the data between two peers, it purposely does not handle signalling. This is a concept that came from telecommunications and utilised in VoIP and is the process of organising the communication between two clients, handling the exchange of metadata that creates and manages a session. The rationale behind WebRTC being signalling protocol-agnostic is that different applications will require particular protocols in order to, for example, fit into previously existing architecture. In the case of my application, to handle signalling, Session Initiation Protocol (SIP) over WebSockets will be used.

Figure 1.5: WebRTC Architecture as defined by JSEP [17]



WebSockets is a protocol implemented by browsers and servers to provide bi-directional communication between them[18]. Once established, a session with a client communicating with the server is left open for the server to send messages to the client and vice versa, making it a good candidate for signalling with a WebRTC application which needs peers to be able to reliably send messages back and forth through the server. Over this WebSockets session, SIP messages will be sent. SIP is a communication protocol that does not specify how signals are transported but how these signals are defined. The transaction model defined by SIP is similar to HTTP with each SIP request being matched by a SIP response. An example of a SIP over WebSockets transaction:[19]

Initial handshake with WebSockets signalling server over HTTP
Alice -> proxy.example.com (TLS)

```
GET / HTTP/1.1
Host: proxy.example.com
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Key: dGhlIHNhbXBsZSBub25jZQ==
Origin: https://www.example.com
Sec-WebSocket-Protocol: sip
Sec-WebSocket-Version: 13
```

Switching to WebSockets protocol
proxy.example.com -> Alice (TLS)

```
HTTP/1.1 101 Switching Protocols
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Accept: s3pPLMBiTxaQ9kYGzzhZRbK+xOo=
Sec-WebSocket-Protocol: sip
```

SIP REGISTER request letting the server know of Alice's "location"
Alice -> proxy.example.com (TLS)

```
REGISTER sip:proxy.example.com SIP/2.0
Via: SIP/2.0/WSS df7jal23ls0d.invalid;branch=z9hG4bKasudf
From: sip:alice@example.com;tag=65bnmj.34asd
To: sip:alice@example.com
Call-ID: aiuy7k9njasd
CSeq: 1 REGISTER
Max-Forwards: 70
Supported: path, outbound, gruu
```

```
Contact: <sip:alice@df7jal23ls0d.invalid;transport=ws>
;reg-id=1
;+sip.instance="<urn:uuid:f81-7dec-14a06cf1>"
```

OK response
proxy.example.com -> Alice (TLS)

```
SIP/2.0 200 OK
Via: SIP/2.0/WSS df7jal23ls0d.invalid;branch=z9hG4bKasudf
From: sip:alice@example.com;tag=65bnmj.34asd
To: sip:alice@example.com;tag=12isjljn8
Call-ID: aiuy7k9njasd
CSeq: 1 REGISTER
Supported: outbound, gruu
Contact: <sip:alice@df7jal23ls0d.invalid;transport=ws>
;reg-id=1
;+sip.instance="<urn:uuid:f81-7dec-14a06cf1>"
;pub-gruu="sip:alice@example.com;gr=urn:uuid:f81-7dec-14a06cf1"
;temp-gruu="sip:87ash54=3dd.98a@example.com;gr"
;expires=3600
```

Once two peers have registered, one of them can send an invite to another through the server in the form of an INVITE request to form a signalling channel between them which WebRTC uses to establish a peer connection and data channel. To create this peer connection, it uses interactive connectivity establishment (ICE) to find a list of the possible IP's and ports of each peer which are then sent through the server. Once this is done, the data channel can be formed and packets can be sent peer-to-peer. These packets are managed and secured by Secure Real Time Transport Protocol (SCTP) for media and Stream Control Transmission Protocol(SCTP) for non-media and encrypted by Datagram Transport Layer Security (DTLS) [20].

1.3 Specification

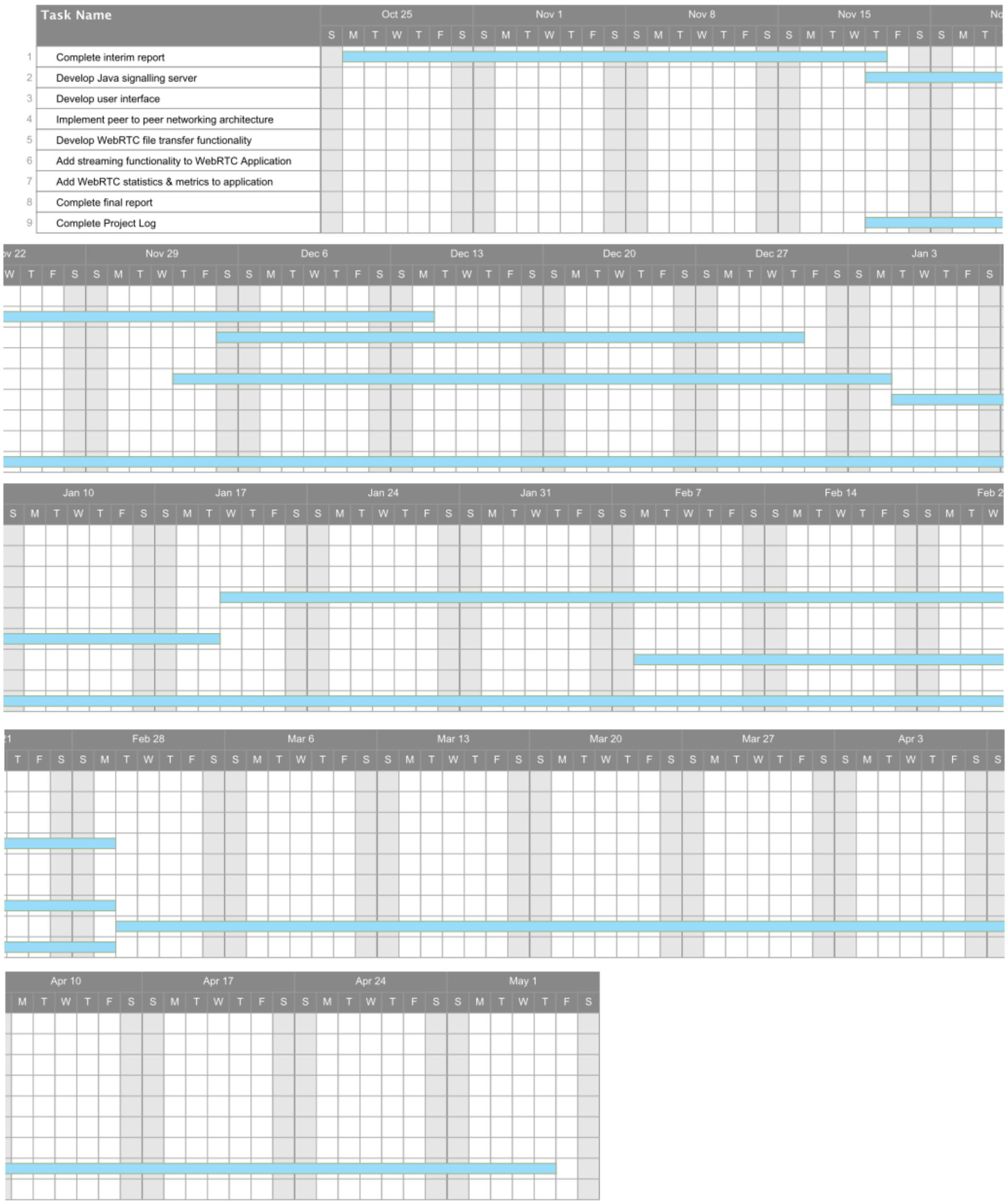
Deliverables

The first intermediate product will be the signalling server written in Java. This will handle the exchange of client meta data in order to establish the connection between two peers using the web application. I plan to overlap the development of this with the development of the data transfer functionality and user interface of my second deliverable, the web application as manually testing the signalling server will be a lot easier with a partially developed application to test it with.

The first end deliverable will be the client side web application the user interacts with in order to select a file as well as handling sending the meta data to the signalling server and managing the peer-to-peer data transfer and media streaming. This is broken down into several intermediate products, the data transfer functionality, the media streaming functionality, the peer-to-peer network and the user interface. I plan to produce the data transfer functionality first along side the user interface to allow for manual testing. After I have implemented data transfer, I will work on media streaming and forming the peer-to-peer network topology.

The second end deliverable will be the final report containing documentation and analysis using the metrics from my application, comparing how it and technologies behind it perform in comparison to others, focusing in particular on how peer-to-peer over the browser (WebRTC) compares to other methods of data transfer and media streaming.

Figure 1.6: Schedule of Activities



Risk Analysis

Risk	Probability (1-5)	Impact (1-5)	Mitigation	Contingency
Illness/Injury	4	3	Reserve time for illness Be hygienic Eat healthy Exercise	Allow time for recovery Take medicine to aid recovery
Inaccurate estimations	3	3	Be liberal with estimations Reserve time for deliverables behind schedule	Adjust scope of project
Data loss	1	5	Use a version control system Keep local backups	Recover data from Git
Uncommunicative stakeholder	1	3	Ensure regular meetings with stakeholder	
Stakeholder turnover	1	4	N/A (out of my control)	Get new stakeholders
Project scope too large	3	4	Research enough to be certain in project scope Be liberal with estimations	Adjust scope of project
Technologies too immature/insufficient for project	2	4	Research technologies beforehand	Find alternative technologies Adjust scope of project

Quality Analysis

The main measure of success will be the web application's performance in it's ability to transfer & stream data between two peers. To track this, I will implement metrics using the WebRTC ”getStats” statistics API, which allows for monitoring of the bandwidth usage, packets lost and network delay within a data channel between two peers. I will then gather these statistics in two different cases, one where there is no formal network structure (to find a baseline) and then when the many-to-many network has been implemented to compare if the structured peer-to-peer network does improve performance of the application. This network will also have it's own monitoring to ensure that peers are being correctly organised. Further to this, I will also compare the speeds of file transfer with other services such as DropBox through their API, however this may prove unrealistic as these services will be running on more performant resources. To certify that the user-experience is acceptable, the application will also be user-tested. The signalling server will be load tested in isolation to make certain it can handle multiple requests to ensure it does not bottleneck the application.

1.4 Methodology

I chose to use an alternative methodology to the waterfall model because it lacks the ability to adapt to changes in a project deadline. Due to the way waterfall is structured into different phases that must be completed sequentially, often when changes such as new requirements occur, all these phases must be repeated in order to account for this. Iterative methodologies take an approach that can adapt to these changing requirements because they utilise short development cycles and focus on developing small modules of a product at one time, making it easier to revise a product if necessary. This is particular useful in my project as it is relatively experimental and the requirements of it may change regularly.

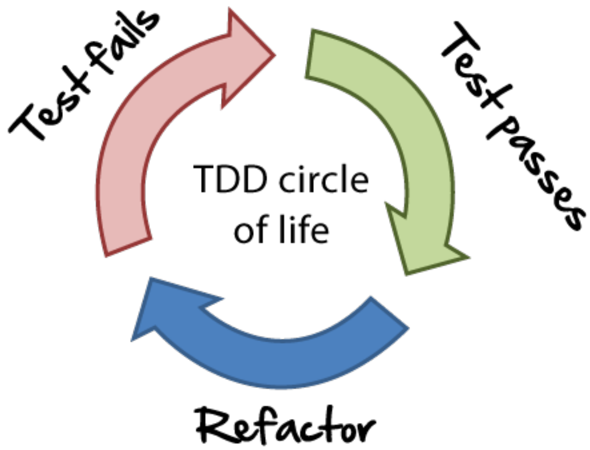
Thus, as a way of tracking the progression of my project, I plan to use an iterative and evolutionary methodology. This is used within software development as a way of incrementally developing applications through small cycles. Whilst it will be similar to scrum, it will not have the stricter framework surrounding it that requires a product owner and scrum master. This methodology will be relatively simple and based around a backlog of tasks from which a developer pulls from in a limited amount, normally 1 or 2 tasks at a time which will are then pushed through the development work flow.

In my case, the work flow will be relatively simple:

1. To Do
2. In Progress
3. Code Review
4. Manual Testing
5. Done

During the "In Progress" step of the work flow, I will use a test driven development (TDD) process in which tests are written first and then code is wrote to make the test work. However, I will be fairly lenient with this, only using this process on parts of the code that require stringent testing as writing unnecessary tests will take up development time.

Figure 1.7: Test-Driven Development (TDD) Cycle [21]



During the "Code Review" step, I plan to self-evaluate the task I have completed. On top of this, I will run static code analysis tools (such as FindBugs/PMD for Java) if the task is a coding task and use the code review section StackExchange to get second opinions. If it passes the code review step and it is possible to do so, I will black-box test the task from a user's perspective to see that it actually works as intended. Once every task forming a feature is completed, I will manually test the feature as a whole to see that each task has integrated together as planned.

To visualise this workflow, I will use the open source web application "Kanboard" which I have hosted on an AWS EC2 Instance. This will allow me to keep track of progress throughout the duration of the project. To manage the actual changes made to the project files, I have utilised the version control system Git with a private GitHub repository containing my project.

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This ethics form is designed to help you quickly and easily identify how you should approach any ethical issues raised by your project or dissertation. It should be completed for ALL research projects and dissertations prior to the commencement of the project. Please do not approach any participants involved in the research until this have been completed and discussed with your supervisor or member of the CEM ethics committee (if appropriate).

This form must be completed by the project student or researcher responsible for the project. Once completed, you should discuss it with your supervisor to ensure that you take the right follow-up actions.

If you answer 'No' to all questions in this form and this is confirmed with your supervisor (if appropriate) then no further action is required. Please note that in signing this form you accept that it is still your responsibility for your project or dissertation module to follow the **University's Guidance on Good Practice in Research Ethics and Governance**, available on StudentCentral. Any significant change in the question, design or conduct of your project or dissertation that would alter your answers on this form must be notified to your supervisor who will advise you on whether you need further action.

If you have answered 'yes' to *any* of the questions in Section B of the Student Checklist your supervisor will need to make a judgment as to whether or not the research includes more than a minimum level of risk. If this is the case then your supervisor will need to email this form to the CEM ethics committee (CEMethics@brighton.ac.uk) for discussion prior to the commencement of research. This does not mean that you will not be able to do the research, but it will need to be considered by the School Research Ethics and Governance Committee.

Ethics forms, example consent forms/participant information sheets and supporting guidance are available on the ***Research Ethics for Projects – CEM*** area of StudentCentral.

Signed copies of this completed ethics form must be submitted with your project or dissertation. Note: the project or dissertation will not be marked if the completed checklist is not included.

PROJECT DETAILS

1. Name of researcher: Dominic Rathbone

2. Name of supervisor: Stelios Kapetanakis

3. Title of project: Utilising peer-to-peer networking for data transfer over the browser

4. Outline of the research (up to 100 words):

My research aims to investigate the possibility of a peer-to-peer network being used as an alternative to to traditional solutions for transfering data over a web browser, normally done by client-server models. This will be investigated by creating a web application that implements WebRTC, a relatively new technology enabling two browser clients (peers) to communicate directly without the need for a server.

5. Location of research: Brighton, United Kingdom.

8. Email address: domr115@googlemail.com

9. Contact address:

32 Gladstone Place

Brighton, East Sussex

BN2 3QD

10. Telephone number: 07951711341

Please tick the appropriate box and answer the questions where appropriate.	Yes	No
1. Does the study involve **participants who might be considered vulnerable** due to age or to a social, psychological or medical condition? (*e.g. children, people with learning disabilities or mental health problems, but participants who may be considered vulnerable are not confined to these groups).* If yes then provide details of any such participants. See the University's 'Guidance on Good Practice in Research Ethics and Governance' for more details. ……… ……… Note: proposals involving vulnerable participants are often likely to require ethical approval from the Faculty of Science & Engineering Research Ethics and Governance Committee (FREGC).		✔
2. Will **photographic or video recordings** of research participants be collected as part of the research? If yes then please outline consent and data protection procedures *(e.g. interviews cannot be overheard, details will not be accessible to others)*, for the use of participants' images. Example consent and information forms can be found on StudentCentral and see guidance on data collection at the end of this document. ……… ……… If your data will not be confidential and anonymous then outline the justification for this decision here and procedures for mitigating against potential harm. ……… ………		✔
3. Does the study require the **co-operation of an individual to gain access** to the participants? (*e.g. a teacher at a school or a manager of sheltered housing)* If yes then describe the procedures that will be put in place to ensure safe and ethical direct involvement of human participants. Where necessary and as appropriate, include comments on obtaining informed consent, reducing harm, providing feedback, and accessing participants through an individual providing information such as a teacher/lecturer, manager, employer etc. Example consent and information forms can be found on StudentCentral. ……… ………		✔
4. Will the participants be asked to discuss what might be perceived as **sensitive topics** (*e.g. sexual behaviour, drug use, religious belief, detailed financial matters) or* could participants experience psychological stress, anxiety or other negative consequences (beyond what would be expected to be encountered in normal life)? If yes then describe the procedures that will be put in place to ensure safe and ethical direct involvement of human participants. Where necessary and as appropriate, include comments on obtaining informed consent, reducing harm, providing feedback. Example consent and information forms can be found on StudentCentral. ……… ………		✔
5. Will individual participants be involved in **repetitive/prolonged testing or vigorous physical activity, experience pain of any kind, or be exposed to dangerous situations, environments or materials** as part of the research? If yes then describe the procedures that will be put in place to ensure safe and ethical direct involvement of human participants. Where necessary and as appropriate, include comments on obtaining informed consent, reducing harm, providing feedback. Example consent and information forms can be found on StudentCentral. ……… ………		✔
6. Will members of the public be **indirectly involved** in the research without their knowledge at the time? (*e.g. covert observation of people in non-public places, the use of methods that will affect privacy)*.		✔

Please tick the appropriate box and answer the questions where appropriate.		Yes	No
	If yes then provide brief details here *(e.g. how they will be involved and, where known, the age, gender, ethnicity and location of those who will be indirectly involved).* ……… ……… ` Provide details of any negative impacts members of the public will be likely to face and that would not be considered minimal impacts (e.g. invasion of privacy, harm to property, being subject to what an individual perceives to be inappropriate behaviour). Describe the risks and if appropriate explain why you believe they are only minimal. ……… ……… Describe any procedures that will be put in place to ensure safe and ethical indirect involvement of members of the public (*e.g. providing information and feedback if requested by the public*). Examples of participation information forms can be found on StudentCentral. ……… ……… Describe how you will ensure data collection is confidential and anonymous (*e.g. people will not be able to be identified by photographs or notes taken by observers*), how data will be stored and who will have access to the data. If the data will not be confidential or anonymous, outline the justification for this decision here and procedures for mitigating against potential harm. ……… ………		
7.	Does this research include **secondary data** that may carry personal or sensitive organisational information? *(Secondary data refers to any data you plan to use that you did not collect yourself, e.g. datasets held by organisations, patient records, confidential minutes of meetings, personal diary entrie).* If yes then provide details regarding any secondary data to be used that may carry sensitive personal or organisational information. ……… ……… If secondary data CEMs containing sensitive personal or organisational information are to be used, outline how such use will be ethically managed *(e.g. details such as anonymising data CEMs, ensuring protection of source agency, gaining consent of data owners, and how the data will be stored)*. See guidance on data collection at the end of this document. ……… ………		✔
8.	Is this research likely to have significant **negative impacts on the environment**? (*For example, the release of dangerous substances or damaging intrusions into protected habitats.)* If yes then provide details of these impacts here (for example the release of dangerous substances or damaging intrusions into protected habitats) and ……………………………………………………………………………………………… ……………………………………………………………………………………………… Describe how you will mitigate against significant environmental harm and manage risks. ……………………………………………………………………………………………… ………………………………………………………………………………………………		✔
9.	Will any participants receive **financial reimbursement** for their time? (*excluding reasonable expenses to cover travel and other costs*). If yes then provide details and a short justification (e.g. amounts and form of reimbursement). ………		✔

Please tick the appropriate box and answer the questions where appropriate.	Yes	No
………		
10. Are there any **other ethical concerns** associated with the research that are not covered in the questions above? If yes then give details here. ……… ………		✔

All Undergraduate and Masters level projects or dissertations in the School of CEM must adhere to the following procedures on data storage and confidentiality.

All data should be encrypted and stored securely. Documentation should be kept in a locked cabinet or desk, and electronic data should preferably be kept on a removable disk or data stick which can be locked away, or if this is not possible on a password protected computer. Confidential and sensitive data should not be emailed unless it is encrypted or password protected since emails are centrally archived.

For Undergraduate/Masters projects, normally only the student and supervisor will have access to the data (see the University's 'Guidance on Good Practice in Research Ethics and Governance for further details).Once a mark for the project or dissertation has been published, all data must be removed from personal computers, and original questionnaires and consent forms should be destroyed unless the research is likely to be published or data re-used. If this is the case a justification for this should be included where appropriate in this form and in the relevant consent and participant information forms.

Student: Please sign below to confirm that you have completed the Ethics form and will adhere to these procedures on data storage and confidentiality.

Signed (**Student**):

Date: 16/11/2015

Supervisor: I confirm that the research ***does/does not*** (delete as applicable) include more than a **minimum level of risk**.

Signed (**Supervisor**): ……………………………………………………….

Date: ……………………………………………………….

Note: If the **supervisor judges** that there is more than the **minimum level of risk** then your supervisor will need to email this form to the CEM ethics committee (CEMethics@brighton.ac.uk) for discussion prior to the commencement of research.