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DEVELOPMENT OF AN OPEN SOURCE WEB-BASED INFRASTRUCTURE
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Abstract

Background: The term 'Open Source' is commonly associated with software due to its proven success, encompassing a user's ability to review and modify the underlying source code, to disseminate modified or unmodified versions to others, and to use it without facing the prospect of legal repercussions (Siedlok, 2001). In the context of product design, namely medical device design, the concept remains relatively novel with no prior research being reported. A study of applying the open source concept to medical device design by developing a web based infrastructure for its facilitation is reported here.

Results: The stakeholder requirements are captured using a semi-structured questionnaire and validated through cross referencing responses to questions with other responses from stakeholders of the same or similar occupation. The most prominent responses are selected as the key stakeholder requirements and utilised in conjunction with the functional system requirements outlined in the System Requirements Specification (SyRS), both sets of requirements provide the foundation for the open source web based infrastructure development.

Conclusion: The comprehensiveness of the requirements indicate that the open source web based infrastructure will support the design of all medical devices that are classified as high risk, medium risk or low risk devices, whilst devices external to this scope remain a future certainty.

Acknowledgements

I would like to take this opportunity to thank those who have helped me during the projects completion; First and foremost I would like to thank my supervisor Professor Rajkumar Roy for providing continual support and guidance during sociable and unsociable hours, without which I would have not completed this project. Second, I would like to thank my friends, family and colleagues for their morale support and contribution towards the stakeholder requirements, reflecting the open source web based infrastructure that was delivered as a result of the project. Lastly I would like to thank Cranfield University for providing me with the opportunity to learn and retain knowledge that will enable me to progress within my chosen career.

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# 1.	CHAPTER ONE: INTRODUCTION

1.1   Introduction

In today's competitive and fast paced global economy, organisations are expected to continuously innovate in order to prosper and remain sustainable. To do this, they need to adopt a dynamic learning style that will supersede their competitors. To facilitate such a requirement, the organisation must realise the potential knowledge that exists within and outside of the organisational boundaries, and identify a method for its workforce and ultimately the organisation to reap the benefits (Otto and Simon, 2008). In recent years it has become increasingly apparent for organisations to reduce the number of tiers that exist in its hierarchy, (Cross, Borgatti and Parker, 2002) state *"a byproduct of these restructuring efforts is that coordination and work increasingly occur through informal networks of relationships rather than through channels tightly prescribed by formal reporting structures or detailed work processes"*.

However, while organisations predominately focus on establishing collaborative relationships that exist outside their physical boundary, limited attention is directed towards assessing and supporting internal informal networks. Furthermore critical informal networks often compete with and are disrupted by aspects of an organisation that control its operation, examples include, formal structure, human resource practices, work processes, leadership style, culture and geographical dispersion. This can occur in scenarios where management place a high dependency on subordinates from diverse backgrounds to collaborate effectively. (Cross, Borgatti and Parker, 2002) reiterate that both practical experience and scholarly research has proven the ideology of grouping individuals with diverse backgrounds and problem solving styles to be ineffective as a collaborative taskforce. *It is one problem to learn or act on knowledge with others who think like you (such as a community of practice). It is an entirely different problem to do this in diverse social contexts, such as cross-functional teams, where people often do not share a common vision, language, and metrics*

of performance or even understanding of the problem itself. (Janis, 1982; Perrow, 1986; Vaughn, 1996)

The informal relationships that exist within an organisation are far more reflective of the organisational culture or 'the way we do things around here' comparative to relationships established in a hierarchical sense. However as an inherent feature, these informal networks remain 'invisible', therefore organisations lack understanding and consensus of how to utilise them for their own benefit, a consequence of de layering organisations, virtual work and globalisation. By isolating these invisible patterns of interaction, it becomes possible to identify and work with important groups (e.g.., new product development, communities of practice or top leadership networks) to facilitate effective collaboration. Despite their absence from the formal organisational structure, these groups are a high priority for organisations that rely heavily upon their ability to collaborate and synthesise disparate expertise, that as a result underpin organisational capabilities and support the current shift towards strategically important innovation (Cross, Borgatti and Parker, 2002). While procedures designed to pervade learning within and across organisational boundaries have been in place for some time, it has only recently become apparent to organisations of the accrued potential performance benefits.

1.2   New Product Development (NPD) Process

In the majority of circumstances an organisation is solely dependent upon its ability to continuously innovate and introduce new products to the market; influences include rapid technological progression and changes in consumer perception, requirements, style and culture. Furthermore, these changes have drastically shortened the product lifecycle, driving organisations to focus on quality, speed and expense of innovation. It has also increased the demand from consumers where new products and processes are a principle within competition, reflecting that of a dynamic and fiercely competitive environment. As a result a market pull models have replaced that of the traditional Research and Design (R&D) approach. The primary aim of 'any' NPD project is transform a concept to

a product or service, or as referred to by (Steenstra, 2009), concept to commercialisation. In literature, the NPD processes are represented as a series of tasks, the number of which varies between authors, ranging from three (idea generation, product development and product commercialisation) (Yang and Yu, 2002) to twelve, frequently divided into marketing and technical tasks (Copper and Kleinsmitdt, 1996). However, the American Productivity and Quality Centre (APQC) have created a generic NPD process model that reflects the combined processes of the best practice organisations.
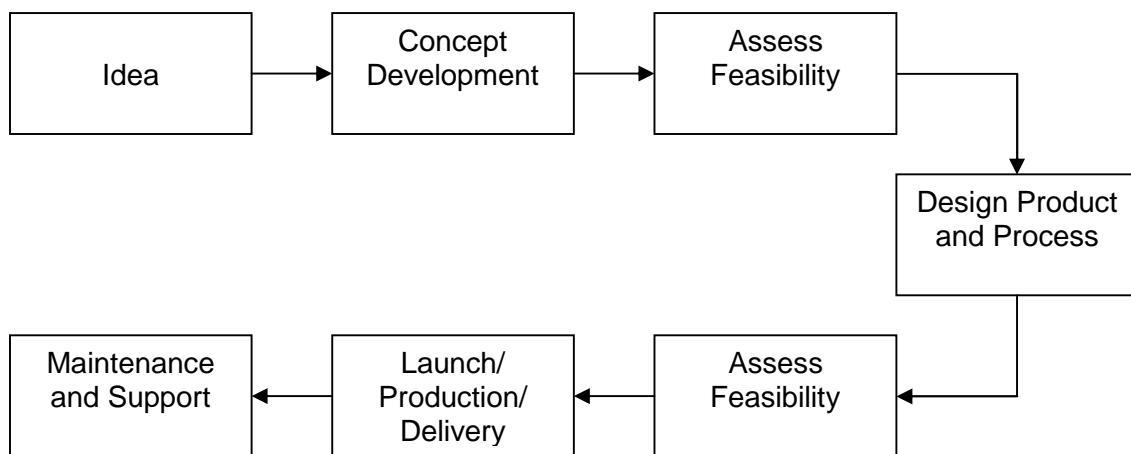
Figure 1-1: Generic NPD process model, adaptation of figure extracted from (Siedlok, 2001)

Furthermore, authors stipulate the importance of 'creativity' possessed by individuals or teams within successful product development (Thamhaim, 1990), particularly focusing upon cross functional NPD teams.

According to (Wheelwright and Clark, 1992) the structure and management of development teams is dependent upon organisational characteristics, e.g. industry, size and experience within NPD. In their research they identify four types of teams, including Functional, Lightweight, Heavyweight and Autonomous. In essence the purpose of each team is to effectively amalgamate knowledge and skills from disparate functions in an attempt to introduce a product that satisfies market requirements. However, each structure does not account for customers and their opinions. (Pitta et al., 1996) espouses the significance of

surpassing organisational boundaries in parallel with customer advocacy. In other words it is essential that organisations realize the potential that exists outside its boundaries and be open to establishing relationships with 'learning' partners, e.g. customers, suppliers, distributors relieving dependency upon internal resources and presuppositions.

The requirement to fulfil customer's expectations has coerced organisations to establish new communicational channels and incorporate customers within the NPD process, whereas the increasing technological complexity of products induced organisations to explore new sources of expertise and innovation within the technological domain, as a result various actors including 'other' organisations were involved within the NPD process.

"Innovation is often a process to which several actors with complementary capabilities contribute. Bringing these actors together is often welfare improving, since none of them has sufficient knowledge or information to produce the innovation on their own" (Siedlok, 2001).

1.3   Free and Open Source Software (F/OSS)

In the majority of cases innovations have been revealed to others in an open manner. However, revealing innovation is not without its benefits to the creator; making it possible for the innovation to developed and implemented in future products, 'raising the bar' or standard previously set, resulting in the creator possessing advantage as innovators or as part of a collective within an organisation. It is for these reasons and a few sociological motives that NPD processes have evolved, a prime example being the foundation and development of Free/Open Source Software (F/OSS). To paraphrase the definition provided by (Siedlok, 2001), the term "Free" or Open Source" encompasses a user's ability to review and modify the underlying source code, to disseminate modified or unmodified versions to others, and to use it without facing the prospect of legal repercussions. The 'free' software movement initiated by Richard Stallman

produced open source software as a byproduct; the Free Software Foundation (FSF) founded by Stallman was a means to converse the trend towards propriety software development, and release of software products; encapsulating the underlying source code. However, although 'Free' and 'Open Source' often appear as two inseparable terms used interchangeably, a distinction lies within their philosophical sense, as postulated by (Stallman, 2007):

"Nearly all open source software is free software; the two terms describe almost the same category of software. But they stand for views based on fundamentally different values. Open source is a development methodology; free software is a social movement".

A similarity among the two terms pertains to licenses associated with the projects undertaken; the free software foundation and open source initiative both employ the use of the General Public License (GPL), however alternative licenses are suggested by both governing bodies, a prime example associated with FSF based development is 'Copyleft'. It is a licensing scheme empowering users with the right to use, modify and redistribute the underlying source code with assurance that intellectual rights of all parties involved within the software development remain protected.

1.4   Applying the F/OSS Model to Alternate Areas

With reference to the open source approach to developing new products it is clear the traditional approach poses no resemblance, the following figure provides a comparison:

| Defining Requirements | Design | Implementation | Integration | Field Testing | Support |
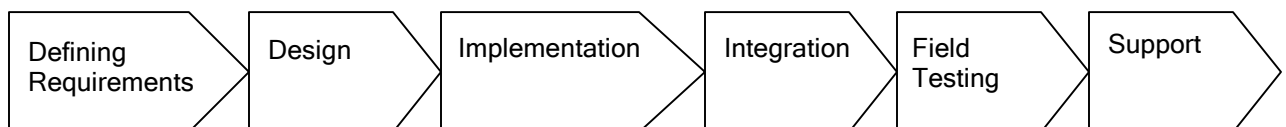
Figure 1-2: Propriety project development process, adaptation of figure extracted from (Lighthouse Case Studies, 1999)

Figure 1-3: Open source project development process, adaptation of figure extracted from (Lighthouse Case Studies, 1999)

The following list summarises the primary differences between both approaches, although not exclusive, many of which have been stated previously:

- OSS products are developed by potentially large numbers of decentralised disparate volunteer's.
- OSS products are developed under no time constraint, developers act on their own accord.
- OSS products are developed from no detailed design.
- Efforts to coordinate reside virtually, using email groups and discussion boards.
- Leadership and control of the project is delegated to the 'benevolent dictator'.

To further previous discussion regarding the applicability of the open source model to alternate areas 'other' that the software industry, (Siedlok, 2001) cites those who exist as OSS community members, justify why open source cannot be applied to alternate industries. The primary reasons include, resources would have to be incorporated into the production process, standardisation problems, being recognised depends on superiority not commitment or skills (Barber in Dafermos, 2001), strict deadlines and salaries apply (Prasad, 2001), and lower level of modularity in alternate industries (Moody in Dafermos, 2001).

However, the adoption of the model is not a completely lost cause, (Siedlok, 2001) states that it may be possible through undermining the basic assumptions

about the organisation and modification of the model. Furthermore (Siedlok, 2001) reviewed the existing open source model and proposed a 'new' model referred to as Open Source Product Development Model (OSPDM) which can be applied to alternate areas, its primary characteristics include; multiple feedback channels, encouraging involvement of external stakeholders, maintain transparency throughout entire process, direct communication and involvement of customers and discussion lists and communities.

(Siedlok, 2001) espoused that an organisation deciding to adopt the OSPDM model may find it obligatory to create or accept an entirely new licensing/patenting system. Furthermore, (Siedlok, 2001) concludes with the role the open source movement will have on its adoption, stating it *"will have to understand its own functioning much better, explore mixed business models and market itself more proactively. The more successful the OS movement the better chances for its main features and mechanisms to be adopted in other industries"*.

1.5   Background

The current climate has issued healthcare providers across the world with increasing economical and socio-cultural pressures in order to remain sustainable, contributing factors include an increase in demand; an increasing percentage of the population are living longer due to advances in medicine and improved welfare. It is apparent that administrative and clinical processes are becoming more complex with a higher demand for advanced technology; driving members of the medical profession, e.g. clinicians, doctors and nurses to become technology specialists (Steenstra, 2009).

In order to deal with complex challenges faced by healthcare providers to remain sustainable the need to maximise efficiency of current structures and develop new products and systems across primary care and hospitals is essential, and can be achieved through the adoption of an innovative culture. The new products and services must also be affordable and accessible to the community,

specifically diagnostic and therapeutic technologies that are only available in hospitals. The need for affordable and accessible medical innovations is applicable not only to developing countries but healthcare economies across the world (Steenstra, 2009).

In relation to the current technological phase open source is predominately associated with software due to its practical application and feasibility, while product design remains subject to controversy, the primary reason being the legal implications concerned with Intellectual Property Rights (IPRs). In order to provide assurance to the parties' concerned strict control and supervision would have to remain an inherent feature throughout the process used to take product from concept to commercialisation (Koninklijke Philips Electronics, 2009). The current IP (Intellectual Property) model for developing medical devices is dependent upon the acquisition and exploitation of Intellectual Property Rights (IPRs); examples include patents, registered design and trademark. The model is endorsed by Universities, large medical Original Equipment Manufacturers (OEMs) and Small Medium Enterprises (SMEs). Unfortunately the model reflects that of closed source development, therefore the generation of ideas for potential innovations and influence on development of new devices is restricted to a sample of stakeholders, excluding patients, clinicians and SMEs.

As a consequence the introduction of new medical technologies experience long development periods, impacting their value when released to the market. Furthermore as a restriction is placed on the involvement of prime stakeholders, the focus for development would be targeted more towards producing technologies that offer a higher Return On Investment (ROI), whilst discarding concepts that could have an impact on quality of life (Steenstra, 2009). However the overall trend suggests that the number of error rates associated with closed source is continually escalating and economically, even large OEMs are releasing they can't afford to recruit a sufficient number of internal developers to suffice the requirements of many large scale projects. It is for this reason that

organisations need to distribute the workload, utilising resources located further a field than corporate boundaries. With reference to open source software development, organisations that have adopted this approach include both formal consortia such as Apache Software Foundation, and informal collective efforts that employ open source licensing (Messerschmitt, 2009).If performed correctly open source 'product design' could revolutionise the way in which products are designed, in effect products created for the people by the people (Koninklijke Philips Electronics, 2009).

1.6 Research Motivation

The open source approach will improve the communication between stakeholders concerned, and encourage ideas with the potential to influence the development of new devices, primarily at the design stage. The research will address the stakeholder and functional requirements for developing an open source web based infrastructure, both are equally important in providing a feasible design and implementation. The novel research to be conducted will finally improve the design of medical devices, providing an infrastructure that will enable the workload to be distributed to a larger taskforce, as a result a positive impact made upon costs, impacting accessibility and availability. The outcome of the proposed research will make process of designing medical devices more transparent and accurate, subjective to diverse contribution and opinions.

1.7 Research Aim and Objectives

The aim of the research project is to capture stakeholder's requirements to be utilised in the development of an open source web-based infrastructure for designing medical devices in order to reduce costs, impacting both availability and accessibility.

The objectives can be summarised as follows:

- To define stakeholders that will contribute to open source medical device design and development.
- To capture the defined stakeholder requirements.
- To develop a detailed specification of a web based infrastructure for the device development.
- To develop a prototype web based infrastructure for the open source design.
- To assess the infrastructure based on in-house design sessions.

1.8   Company Profile

The research involves Innovations Factory as the industrial sponsor, a small organisation founded in 2003 at the University of Warwick, providing consultancy services to small and medium enterprises (SMEs) that develop and manufacture medical products or diversifying into healthcare technologies. Innovations Factory has developed effective partnerships with support providers, including MidTECH, Medilink, West Midlands and CHID as with other organisations (Innovations Factory, 2009).

1.9   Thesis Structure

The thesis will be structured by chapter in a respective order, progressing from an Introduction to a Discussion and Conclusion as illustrated below:
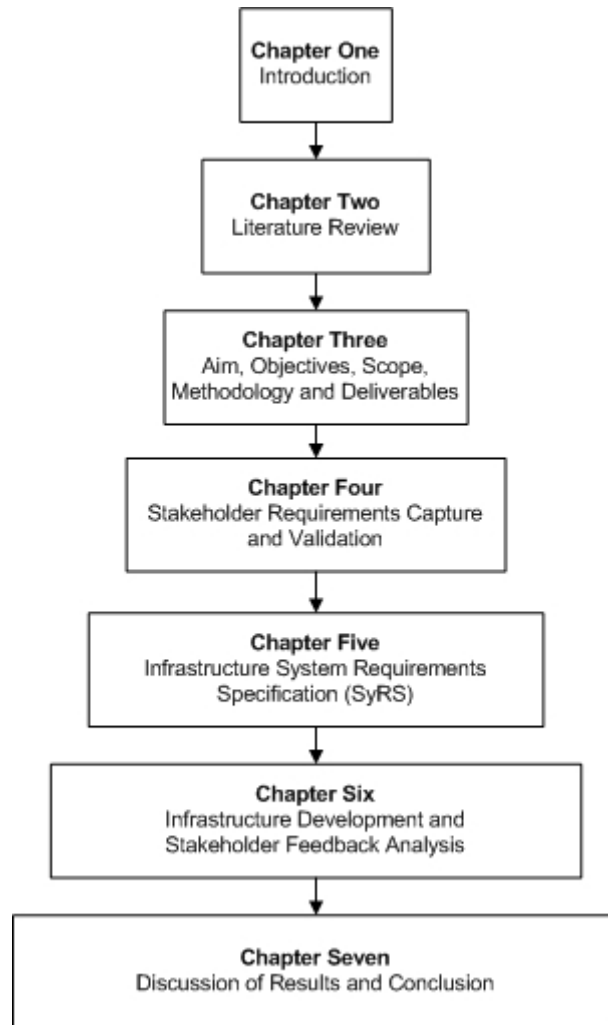
Figure 1-4: Process diagram illustrating thesis structure

1.10   Chapter Summary

This chapter provides an introduction to the research project, initially discussing the importance of innovation for organisations in order to prosper and survive within such a competitive global economy. This can be achieved through isolating invisible patterns of interaction in order to identify and work with important groups (e.g.., new product development, communities of practice or top leadership networks) to facilitate effective collaboration. However (Cross, Borgatti and Parker, 2002) reiterate that both practical experience and scholarly research has proven the ideology of grouping individuals with diverse backgrounds and

problem solving styles to be ineffective as a collaborative taskforce. Furthermore, technological progression and changes in consumer requirements have drastically shortened the product lifecycle, driving organisations to focus on quality, speed and expense of innovation. It is for these reasons and a few sociological motives that NPD processes have evolved, a prime example being the foundation and development of Free/Open Source Software (F/OSS). However, the adoption of the primary features and mechanisms of the open source model to other industries is dependent upon the success of the movement, additionally mixed business models will have to be explored.

# 2.	CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

2.1.1 Purpose

The following section will review the areas Communities of Practice (CoP), Web 2.0 technologies and services and Free/Open Source Software (F/OSS) communities. Firstly, the term communities of practice will be defined and various types set apart, and an understanding of how knowledge exchange is facilitated from disparate individuals separated by distance. Second an understanding of the term Web 2.0 and its adaptations, including Medicine/Health 2.0 and Social Networking, and the most prominent technology enablers for knowledge exchange identified. Third, a prime example of how open source has been applied to the development of software and the factors that contribute towards its adoption and success. The section will finalise with a summary of the research conducted and the identification of knowledge gaps to be addressed. The preceding areas have been covered to address the sociological, e.g. community building and technical, e.g. Web 2.0 technologies aspects of developing an open source web based infrastructure with a prime example pertaining to software development for guidance.

2.2 Communities of Practice Vs Networks of Practice

(Brown and Duguid, 2000) classify a type of network as being either, a Network of Practice (NoP), or a Community of Practice (CoP), unfortunately the meanings remain some what blurred. (Van Baalen et al., 2005) argue the distinction may seem trivial and evident at first glance, but further reflection reveals that it is hard to determine whether the social collective should be classified as being a CoP or NoP. According to (Otto and Simon, 2008), (Van Baalen et al., 2005) propose a NoP as being distributed with little effort to initiate collective action, and as a result limited knowledge produced. In comparison a CoP ensures a sense of 'togetherness', forming stable relationships to support effective collective action. Arguably (Lave and Wenger, 1991) define a NoP as being *"fluid social*

arrangements/relations, enacted among a self-selected group of participants", in contrast a CoP *"where people may meet face to face, to coordinate activities and to communicate with each other"*. Furthermore one may simply have the perspective of CoP's and NoP's being examples of social networks that aid the process of collaboration and knowledge sharing using electronic networks as a means.

The social network can be perceived as an infrastructure with its own governance and patterns of interaction, enabling independent social exchange between two or more parties (Van Baalen et al., 2005). (Wasko and Faraj, 2005) selectively define 'electronic' networks of practice as an independent, open activity system predominately focused upon a shared practice, where network members are willing to engage with one another through computer-mediated communication in providing solutions to problems and contributing to the common practice. However, (Ciborra and Patriot, 1998) argue that employees are reluctant to share their knowledge with colleagues, furthermore to exacerbate the situation; knowledge is not a fluid resource and one that can be easily accessed (Szulanski, 1996), therefore it is essential to grasp an understanding of the cultural, social and technical attributes involved, specifically within the design of Knowledge Management Systems (KMS) in order to encourage participation and contribution from disparate locales (Holsthouse, 1998). In recent literature targeted at organisational practices, two primary perspectives define the basis for KMS design; knowledge as an object and knowledge embedded within people (Wasko and Faraj, 2000). However, one perspective remains understated: knowledge embedded within the community. This perspective portrays knowledge as a 'public good' that is created, maintained and exchanged through social mediation and emergent 'electronic' networks of practice, and as the *"social practice of knowing"* (Schultze, 1999), accentuating the fact that learning, knowing and 'innovating' are prescribed to be tightly bound forms of human activity and inevitably affiliated to practice. If knowledge exists within a community, KMS are more effective in enabling discussion, consensus and

exchange between members of the community; such systems are equipped with collaborative technologies such as listservs, electronic bulletin boards and discussion groups and chat facilities.

In general the enablers of knowledge sharing constitute mechanisms that support question post and response, sharing personal experiences, and discussing and/or debating issues relevant to the community, three examples of 'electronic' networks of practice include (comp.lang c11, comp.objects and comp.database) all of which are open communities committed to producing and exchanging valuable programming knowledge in dynamic technical areas. Furthermore, the American Productivity and Quality Centre identified four types of CoPs and their corresponding requirements, illustrated in the following table:

Table 2-1: Community types and requirements (APQC, 2000)

Community Type	**Unique Requirements**
Help Communities to support each other on everyday problems and share ideas on an ad hoc basis	Connect people and enable spontaneous exchange
Best practice communities that developed, validated and then shared best practices	Process support and enable spontaneous exchange
Knowledge stewarding communities that maintained a body of knowledge for day-to-day use as well as the community around it	Document management; community management; enlisting of experts
Innovation communities that sought breakthrough ideas	Bringing together individuals with multiple perspectives; indentifying new trends

In contrast to physical groups, electronic communities hold no restrictions on accessibility or group size, participation within the community is optional and personal information is provided at the participant's discretion (Kollock and Smith, 1996; Sproull and Faraj, 1995).

2.3   Medicine and Health 2.0 Era

The terms Medicine 2.0 and Health 2.0 are often used interchangeably; (Hughes et al., 2008) conducted a study analysing both terms as defined by a large set of literature, to avoid surmising a generic definition, rankings and contexts of the pages that were analysed formed the basis of the definition:

- Medicine/Health 2.0 enables actors, namely doctors, patients and scientists within healthcare to utilise a specific set of Web 2.0 tools, including blogs, podcasts, tagging, wikis in conjunction with the principles of open source and user generated content to personalise healthcare, collaborate and aid health education.

There are many variations on this definition that have been stipulated by other authors, including (Eysenbach, 2008), all of which pertain to a common theme. In the broader sense Medicine/Health 2.0 also pertains to a novel, improved health system which encourages collaboration, participation, apomediation, and openness, controverting the conventional, hierarchical, closed structures imposed by healthcare and medicine (Eysenbach, 2008).

2.4   Social Networking

In recent years social networking applications have become the epitome of Web 2.0, examples include Facebook, MySpace and LinkedIn, at its core a network of users with the ability to drive content. The infrastructure is sustained through user contributions enabled by a standard set of applications, and explicitly representing human relationships, forming an extended network of relations and facilitating collaboration and collaborative refinement; through analysis the following methods of establishing relationships emerged customary in social networking applications:

- Browsing through and adding friends that exist on a friend's profile, extending the end users network beyond its initial scope.

- An invitation sent to all contacts, utilising the end users email address as the distributive criteria, in response the recipients join as a member and a friend.

- Alternatively the end user can perform a global search to look for a specific person, utilising the search feature provided, as a result matching profiles will be displayed.

(How Stuff Works, 2009a; How Stuff Works, 2009b)

The profile acts as a focal point of social networking applications, providing users with the ability to present themselves digitally whilst acting as a portal to 'known' entities/friends. (Dwyer, Hiltz, and Widmeyer, 2008) states "*If interaction is the goal, then for social networking applications, a profile is the pre-requisite"*. This statement applies to the majority of applications that facilitate interaction; users create a profile for the primary purpose of authenticating and communicating with each other in a digital environment. Once 'friends' have been established a profile provides a representation of a user's personal social network, also referred to as an extended network (Dwyer, Hiltz, and Widmeyer, 2008).

The social networking aspect is relatively novel within medical informatics; furthermore its current application within Medicine/Health 2.0 yields relationships to be established predominately between symptoms, diagnosis and therapy comparative to relationships between humans. However, (Eysenbach, 2008) argues that the web and its associated technologies have changed the attitudes and culture within healthcare, the internet has provided a catalyst for stakeholder empowerment, Web 2.0 technologies provide a new philosophical meaning to stakeholder participation and engagement, exemplified by discussion forums, blogs, wikis, Real Simple Syndication (RSS), podcasts, and tagging and social bookmarking. (Wagner and Bolluju, 2005) espouses the view that the majority of knowledge creation and sharing is accomplished through a process of discussion with questions and answers, collaborative editing or through a process of storytelling, the epitome of which are discussion forums, wikis and blogs.

(Wagner and Bolluju, 2005; Boulos et al., 2006) stipulate that wikis can be utilised as a source for capturing information and knowledge, whilst providing a method of virtual collaboration, for example the dissemination of dialog and information among participants within a group project or facilitating learning through allowing learners to interact with one another, utilising wikis as an open environment for collaboration and becoming part of a CoP. In conjunction discussion forums and blogs capture the attention of participants, encouraging them to share knowledge, reflect and debate, often attracting a dedicated, large but uneven readership. Furthermore, engendering the formation of small virtual groupings interested in building a knowledge base orienting a common topic within a CoP.

Table 2-2: Community types and requirements (APQC, 2000)

	Discussion Forum	**Weblog**	**Wiki**
Speed of Publication	Single click publication possible with many implementations. Results reflected instantaneously on the server		
Ease of Publication	Single click publication possible with many implementations, indexing and formatting large handled by software. Users may have access to a simplified mark-up language		
Knowledge Representatio n and Organisation	Chronological organisation less useful than topical organisation, work around 'sticky' messages	Chronological organisation less useful than topical organisation, work around through indices and access to archives	Topical organisation as well as bi-directional indexing, and chronology of changes
Team Support	Provided in the form of open or closed set of members; some of the members may designated as moderators	Meant for individual publishing, but most tools offer team support as well	Inherently open to public contributions editing, but most tools facilitate restricting wikis to a closed group of

			users
Security	Security measures, such as access rights and administrative permissions, are normally provided		
Version Management	Not provided; messages posted are not expected to be modified (although some forums permit editing after posting)	Not provided; although blog posts may be edited by contributor(s)	Versions and history of changes are provided; facilities are available for rollback
Community of Practice Fit	Help	Innovation	Best practice

The concept of openness and participation predates discussions regarding Web 2.0, with its foundation in open source development communities, as previously mentioned these communities lower barriers to participation to encourage a spur of new ideas and suggestions that are accepted by popular demand (O' Reilly, 2003). With regard to the Web 2.0 concept, the concept of opening up surpasses the open source software idea of providing developers with access to the code to providing users with the ability to produce and expose content for manipulation and combination in what are commonly referred to as 'mash-ups' (Anderson, 2007).

2.5   Introducing a 3D Dimension

In 2003 Linden Lab founded by Philip Rosedale developed a virtual environment accessible via the Internet, known as Second Life (SL). Its intended use was to allow users, referred to as 'residents' within the virtual environment to interact through the use of avatars, its functionality extends to allow residents to explore, meet and socialise, participate in individual and/or group activities, create and trade virtual property and travel to destinations located within the virtual 'world', referred to as the 'grid' (Wikipedia 2009d). The introduction of virtual worlds, those of type Massively Multiuser Online Media (MMOM) (combinedstory et al., 2007)   have provided a catalyst for new developments within technological

collaboration, predominately the Second Life environment where users as avatars are capable of walking, flying, communicating with each other, expressing themselves, conducting business, extending their social network through establishing plutonic relationships, but also collaborative design and build with others.

A technology that is specifically dedicated towards collaborative design using disparate design disciplines is Building Information Modelling (BIM). A BIM can be described as an information model enabling relevant information to be stored in association with a given context; properties include "*shape, material, decomposition structure, functional and physical properties and life cycle information*" (van Nederveen, 2007). Thus, providing a shared model for information interchange and sharing in accordance with associative disciplines, including architectural design and structural engineering. However, an alternate and different technology for the integration and collaboration of disciplines is that of virtual worlds also referred to as a 'Multi-User Virtual Environment' as defined by Linden Lab (van Nederveen, 2007). (combinedstory et al., 2007) cited that Greg Verdino (Digital Marketing Executive and Blogger) claims *"Second Life tends to get classed with MMORPGs (Massively Multiplayer Online Role-Playing Games) like World of Warcraft, but is actually very different because it's not a game"*. With this in mind, is it possible to utilise the tools provided within Second Life to design and build within a multidisciplinary environment? (Van Nederveen, 2007) states 'yes' that it is indeed possible with justification from the three viewpoints, those being design, engineering and collaboration.

From a design perspective with respect towards the visual appearance of architectural compositions, Second Life can be advantageous. The process of developing compositions is both an interesting and valuable one, and as an end result viewable from any angle, however in comparison to that of dedicated 3D modelers, including Revit, Maya or SketchUp it is rather time consuming. From an engineering perspective with respect to realistically simulating environmental

conditions, Second Life is disadvantageous. However, it is possible to incorporate a limited set of characteristics from the weather system but is unlikely that these will reflect that of an advantageous user friendly simulation environment provided by more conventional tools.

From a collaborative perspective Second Life again proves to be advantageous, providing users with an interface that visually displays avatars and their actions, and allows users to chat with each other. In addition Second Life is able to interface with communicative tools, such as messenger services and webcams as documented in Australian research focusing upon collaborative design within virtual environments. To clarify, Second Life provides an array of opportunities for designers and a collaborative taskforce whilst lacking from an engineering viewpoint, primarily due to the 'downgrade' in functionality than that provided of conventional 3D modelers, e.g. no import facility is provided to enable 3D modelers developed in other applications to be imported.

However, regardless of its inability to support detailed 3D models and engineering analyses and simulations it does cater for small collaborative design studies with high dependency on communication and collaborative facilities (van Nederveen, 2007). In contrast to the End User License Agreements (EULA) and Terms of Service (TOS) imposed by website proprietors, Linden Lab ensure the line is not blurred on who owns Intellectual Property Rights (IPRs) to contributor's creative creations in an environment that they otherwise control. During a conference in November 2003 Linden Lab announced that it would grant users IPRs for their creations within and outside of the virtual environment (Herman et al., 2006).

2.6   The Free/Open Source Software (F/OSS) Paradigm

The Internet has expanded exponentially and enabled the propagation of electronic communicative techniques, providing a medium for people to contact each other without former geographical barriers; this form of technological

progression has provided an alternate infrastructure for social activities, a classification of which has been defined previously by (Wasko and Faraj, 2005). The subject area of virtual communities, more commonly known as 'online' communities is extensive, authors that attempted to refine its context include, (Gattiker, 2001; Rheingold, 2000; Ribeiro, 1997; Schoberth et al., 2003; Smith & Kollock, 1994; Wellman & Gulia, 1995).

An extract from the literature conducted by Rheingold provides a definition for what he referred to as "the virtual community", stating that they constitute "social aggregations" created in response to sufficient social interaction. In todays technological phase the types of virtual community or online community as it will be referred to from this point forward have become more distinct with increasing user awareness. The most prominent example related to open source is that of Free/Open Source Software (F/OSS) communities which are widely acknowledged as are other types of online communities, including online gaming. The primary reason for this pertains to the social characteristics that exist as common trends among them (Hildreth et al., 1998; Mckenna & Bargh, 2000; Schoberth et al., 2003; Walther, 1996), both contain web based forums and at their core orient software development and gaming, however there is a clear distinction that differentiates them, whilst most internet communities focus on fantasies, hobbies, gaming or social support, F/OSS communities operate as distributed project teams in a production environment (O'Mahony and Ferraro, 2004, p. 10).

2.7   F/OSS Culture

Open Source Software (OSS) projects are facilitated by contributions from anonymous developers, timely releases, feature selection based upon the developer's motivation and ability, decentralisation and peer review (Raymond, 1999). Standard business procedures, including schedules, project planning, task delegation; defined feature set and date of release are disregarded and frowned upon by OSS developers. This is reinforced through the following statement

"Open source is typically viewed as a cooperative approach to product development, and hence more of a technology model. It is typically not viewed as a business approach". However it has become apparent from the word 'go' that increasingly more companies are being formed and/or establishing joint ventures around the open source concept, adopting it as a business strategy with the intention of generating revenues whilst reducing costs, prime examples being Red Hat and Caledera/SCO.

With reference to the select few definitions provided previously for distinguishing a CoP and NoP, the classification of F/OSS communities is inevitably a complex task, authors (Lanzara & Morner, 2003; Oh & Jeon, 2004; Raymond, 2000) describe F/OSS communities as absolute virtual systems that defy geographical boundaries through exclusive use of the Internet. Others (Krishnamurthy, 2002; O'Mahony & Ferraro, 2004) argue that the majority of communication and collaboration exists outside the virtual realm and within the 'real world', and that a large proportion of F/OSS development is undertaken not by groups but by individuals. In reality F/OSS projects vary significantly from one to the next, while some will have a large collective of developers involved, others will have a select few or a single developer. Furthermore online communication will not be an exclusive medium for all communities, some projects, primarily those confined within organisational boundaries between core members prefer that it be conducted offline (Schofield & Mitra, 2005).

2.8   F/OSS Contributors

The contributors to the development of open source products are typically viewed as a disparate group of developers with a common objective and passion for a product; they are inimical to corporate profits and do not characterise target users, whether they be corporate or individuals. In relation to F/OSS communities, *"A company that views a community as its competitor is welcome to look at its entire source code, whereas the opposite is never true"* (Feller et al., 2005). The contributor's primary objectives are to produce the product and

disseminate the source code without the intention of personal gain; an additional service provided is that of support following the release of the product and dissemination of code. The following figure provides a visual representation, as illustrated by (Feller et al., 2005).
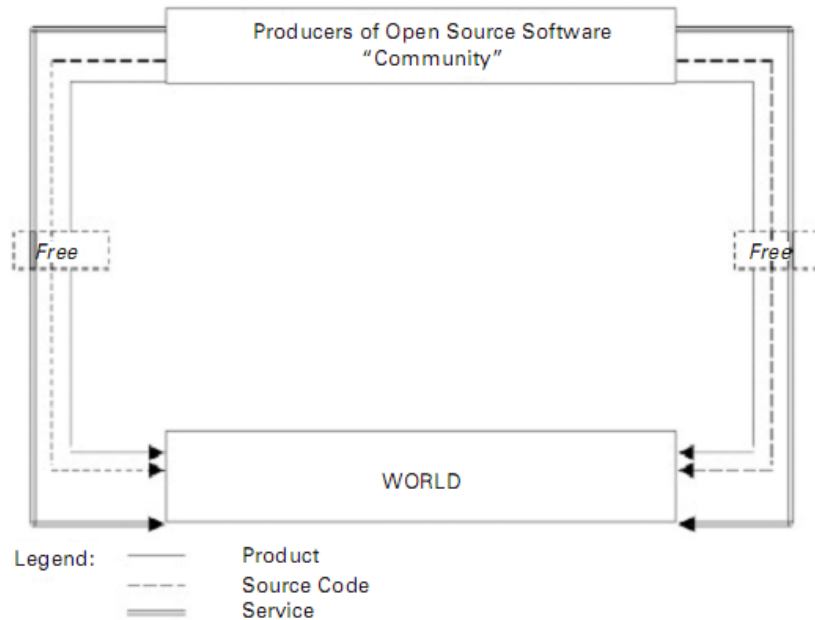
Figure 2-1: Producers of open source products, extracted from: (Feller et al., 2005)

2.9   Individualism Dominates the Creation of Open Source Software

It is usually the perception of many that F/OSS communities require developers to be mutually dependent and collaborate on a frequent basis to ensure the development of a complex product, such as software. However interviews conducted by (Sowe et al., 2007) suggest otherwise, (McCormick, 2003) states the general principle in OSS communities to reflect that of an environment where independent decisions are made by those willing to exert themselves, persevering to produce a viable technical solution with increased developer support. Unfortunately this work ethic has three primary consequences as defined by (Sowe et al., 2007):

First, there is no assurance that task duplication will be avoided as each developer is working independently of other developers with little or no control over each others activities. Second, an activity will not be performed unless it is

considered of high priority to one or more community developers, unfortunately this truly reflects the 'open source philosophy'. The third consequence of 'individualism' is that developers are unable to supervise, or in other words act as a 'big brother' on other developer's activities within the community; therefore there is no insight into what others may or may not be doing. Despite these consequences, developers are able to create and refine high calibre software that nevertheless functions more efficiently than that of propriety software. The following information will justify this unstructured phenomenon, focusing upon developer roles, potential motivations for participation and leadership and coordination of developer activities.

2.10   Individual Roles and Motivation for Participation

The motivational factors associated with participating in F/OSS projects can be classified as either extrinsic reward, e.g. improving job prospects and career progression, or intrinsic motivation which can be separated into two distinct components; enjoyment-based intrinsic motivation and obligation/community-based intrinsic motivation (Lindenberg, 2001).

Although F/OSS communities are portrayed as being a completely volunteer approach as discussed previously, the possibility of paid participation should not be overlooked as a prime example of an extrinsic incentive. (Lerner and Tirole, 2002) classify extrinsic benefits as either being immediate or delayed payoffs. Immediate payoffs for F/OSS project participation may result in a user/developer being subsidised for their services provided or the creation and direct use of a software solution that satisfy's their own requirements (von Hippel, 1988). Delayed payoffs for F/OSS participation may result in career progression (job signalling market (Holmström, 1999)), and enhancing their technical expertise through sharing knowledge and active peer reviews that inevitably prevalent within F/OSS projects (Moody, 2001; Raymond, 2001; Wayner, 2000). However (Brown and Diguid (2000) and Nonaka, 1994) argue that significant levels of knowledge will not be exchanged within these networks. As cited by (Otto and

Simon, 2008) "*If people who share their knowledge lose the unique value they once possessed, only the recipients of the shared knowledge really benefit*" (Thibaut and Kelley, 1959; Thorn and Connoly, 1987).

In contrast, enjoyment-based motivation reflects that of enjoying ones self whilst participating in an activity, representing the core of intrinsic motivation (Deci and Ryan, 1985). (Nakumura and Csikszentmihalyi, 2003) reviewed the psychological aspects behind this component, defining a state of 'flow' that indicates the maximum level of enjoyment; this is achieved through the alignment of related constituents, such as a merging of action and awareness and confidence in ones own ability. Thus there is greater probability that F/OSS participants will select a project that justifies a 'worthy' challenge, something of which may compensate for lack of enjoyment elsewhere. According to (Amabile, 1996), creativity stems from that of intrinsic motivation, furthermore creativity is viewed in a different light by each and every person, for instance, persons engaged in the project of developing a device driver may consider it to be highly creative problem solving process than that of observers. (Lindenburg, 2001) holds the view that acting on the basis of principle, and conforming to the norms and mannerisms of the community is considered to be a form of intrinsic motivation, also referred to as obligation/community-based intrinsic motivation. This form of intrinsic motivation thrives off deterring private gain seeking within a community environment, typically known as 'free riders'. If the project succeeds in producing the required deliverable, everybody benefits, including those who chose not to collaborate. Thus if everyone adopted this approach the project would surely fail, however this can be overcome by recognising the 'free rider' problem early and offering selective incentives to help entice each and every person to collaborate.

Essentially open source projects are typically considered a public good with a wide range of beneficiaries; as a result motivational factors tend to be more intrinsic oriented, however multiple motivations, both intrinsic and extrinsic can exist at the same time (Lindenburg, 2001). The distribution of these motivational factors exists among five distinct and disparate roles, all of which lend

themselves to the development of open source products and are differentiated on the basis of their associated functions and interrelations (Koch, 2004):

- Developers
- Distributors
- System Integrators
- Software and Hardware Companies
- Users

The prime stakeholders/roles that are relevant to this study pertain to that of developers and users, these persons are the primary contributors to an open source project.

2.10.1 Motivation of F/OSS Developers

To reiterate, due open source software not having a monetary value, the motives of developers are typically not concerned with making a profit or receiving a form of income; but rather a vast array of human motivations (Hertel, Niedner & Herrmann, 2003). The incentives associated with developers and commonly found in literature are those that yield enjoyment, success, challenging ones intellectual capacity, technical curiosity (Hars and Ou, 2002), achievement, personal development and belief, and idealism (Raymond, 1999) among many others. However, it is important to remember that the majority of members from academia and industry are paid for their services, whilst others persevere to improve their personal qualification and offer consulting services at a later date (Hars, 2001).

2.10.2 Motivation of F/OSS Users

From a user's perspective, open source software yields many more benefits than that of proprietary software, predominately its tag free price, lower Total Cost of Ownership (TCO) (BMWi, 2001); license fees are not inclusive; exemplary price to performance ratio; openness and permission to modify source code; improved stability (Wichmann, 2002), functionality (University of Dortmund, 2003) and

security (Raymond, 1999); and less dependency on a single source of contact for support, among many others. However (Roy, 2003) argues that with the prices for high level packages and propriety add-ons, coupled with dictation from some OSS providers is increasingly blurring the line that once distinguished OSS and commercial software.

It is important to note that both users and developers are far from mutually exclusive, developers can be classified as users and respectively users as developers, the following table summarises the actions performed by both groups in three states, as clients (beneficiaries), actors (agents of change) and owners (decision makers).

Note: Shaded cells indicate their primary role.

Table 2-3: Comparison of stakeholder groups and their associated actions (Feller and Fitzgerald, 2001)

	as Client	**as Actor**	**as Owner**
Developers	Regularly use OSS products to support development	Act as the main implementers of changes in systems both In a proactive and reactive mode	Exhibit prime concern for the system direction, but do not necessarily posses the power to terminate the system
Users	Both directly and indirectly use OSS products	Can use OSS as a black box, or actually make changes; Can also effect change through bug reports, etc.	Have as much claim to ownership (not authorship) as the creator of the software

Undoubtedly, open source software has captured the attention of many due to the overwhelming number of benefits that challenge that of propriety software. (Iacono and Kling, 1996) identify traits that facilitate technology movements, primarily those that are counter-cultural and challenge the status quo; OSS is a realistic example to support this statement and one that has been adopted and sustained predominately by the younger generation (Lakhani and Wolf, 2005; Ghosh, 2005).

2.11 F/OSS Leadership and Coordination

It is no secret that if individuals were look from the outside in on these widely distributed and disparate communities that they would be mistaken for chaos and disorder, unfortunately this is a common misconception. F/OSS communities are often depicted as the 'new' revolution to developing software; this is primarily due to Raymond's distinction between the conventional software development approach, or what he referred to as the "cathedral" and the "bazaar" which reflects that of the F/OSS development approach. The "cathedral" characterises that of closely coordinated and centralised teams that follow a formal development process; in contrast the "bazaar" was intended to reflect that of disputes and apparent confusion of the Middle East marketplace. Furthermore there is no formal process, developers use their own initiative and follow their own agenda. If there is no oversight how will duplication be controlled? In conventional software development a form of auditing exists to prevent wasted effort; however the "bazaar" suggests that duplication provides a greater exploration of the problem domain, ensuring survival of the fittest remains an inherent feature in selecting the best possible solution to be incorporated into the end software product (Feller et al., 2007). According to (Brooks, 1995) increasing the number of developers should exacerbate and extenuate the software development process rather than facilitate it, however many theorists stipulate the opposite. Furthermore upon closer examination it appears the well established principles of the formal software development process are encapsulated within OSS, examples include facilitating distributed development

through code modularity, active peer review, configuration and release management. In reality this is achieved through the use of a great number of tools and mechanisms that enable decentralised individuals to collaborate and adapt to a formal structure that ensures the development of a credible software solution. However this is just one dimension of the dilemma that is the "software crisis". In order fully appreciate the use of these tools and mechanisms, otherwise known as technological interventions one must adopt a leadership style that satisfies the requirements of the OSS project to ensure efforts to coordinate, typically the core challenge of any organisation (March and Simon, 1993) surpass those anticipated, for example motivating individuals.

OSS leaders are expected to be modest to ensure that other contributive efforts are of value; else developers will be highly un-inclined to facilitate the project, e.g. Torvald's introductory message in 1991 submitted to a vast array of recipient's inviting them to help develop the Linux platform. Amongst modesty other characteristics must be present, including raw talent and charisma. Bearing in mind that developers are of different cultures and sparsely distributed across the globe, if a pioneer of an OSS project is seen to posses the talent of a mere 'mortal' and not that of a 'code god' then their authority will undoubtedly be questioned.

Unfortunately these characteristics are in short supply within any area of human exertion, let alone the software battlefield. (Otto and Simon, 2008) have defined policy levers or structural interventions that can be used to build and sustain online communities from the perspective of an organisation or governing body, and theoretically project leaders, examples include the application of rules and regulations (terms and conditions) for individuals who contribute and share resources. Ensuring community members ease of access and transparency to resources will aid the network grow, however rules and policies would have to be enforced to ensure content quality. Finally, group commitment through activities and incentives to strengthen bonds between members, e.g. acknowledging

contributive efforts from the community positively influences their motivation and role activeness.

As projects grow and become more complex it becomes difficult for developers to manually manage, at which point the dependency is shifted from a human endeavor to a technological routine. The key to the success of open source projects and avoiding falling victim to Brook's Law which states "adding man power to a late software project makes it later", is efficient information management. Within an open source environment the majority of communication is written, sophisticated systems have evolved to control the routing and labeling of data; minimise redundancy; store and retrieve data; analysing and correcting data that does not meet data quality standards; and establishing links between disparate fragments of information as new relationships are observed.

However although technological mechanisms exist to simplify the process of managing information, humans are still required at specific points in the process with many active participants encapsulating the level of detail and performing complex manual procedures to ensure the information is routed to the correct destination. Unfortunately there is no "cut-and-dried solution" to efficient information management; it requires a combination of technical and people skills. Technical skills are required to ensure the software is configured correctly and scalable to the project requirements, however projects grow and adapt to technological change, therefore it is strongly suggested that over-automating be avoided. In contrast, social skills are required to ensure that each and every individual contributes to the management of information; this is achieved through timely encouragement (Fogel, 2005).

The majority of open source projects provide at least a minimum, standard set of mechanisms for managing information and facilitating collaboration and coordination of activities, these include:

- Version Control

- Bug Tracking

- Mailing Lists

- Live Chat

- To-Do Lists

The following information will describe each mechanism, providing insight into what it is, how it enables coordination of individual efforts and why it relieves a lot of the responsibility of managing information, allowing participants to focus on more pressing matters.

2.11.1 F/OSS Version Control

The majority of open source communities employ the use of a software versioning system to support development and maintenance activities, e.g. Concurrent Versioning System (CVS) and Subversion (SVN). These systems enable developers remotely access the source code and synchronise their work with that of their fellow developers. Furthermore the systems ensure that regular backups are made to prevent critical damage to the software, however some communities restrict access to the system to those participants that have gained 'committer' status. Furthermore to upload source code participants must indirectly submit it to another party that has committer status, or gain it through satisfying predefined requirement(s).

According to an interviewee as cited by (Sowe et al., 2007), the versioning system that supports the software development process in the Apache community initiates with a new version of the software, once amendments are made another version is created; the version trail also referred to as the 'head' extends to account for this addition. If the developer is not satisfied with the current version they can make amendments to a prior version; once the necessary amendments have been made an explanation is required as part of a log file documenting reasons for change.

To clarify, version control supports the decentralised development process (Himanen, 2001) of OSS in various ways. First, developers do not require time slots to access the versioning system, simultaneous access is granted and developer activity synchronised. Second, log files provide a written audit of the changes that were made and why. Third, developers are able access and make changes to prior versions of the software, enabling a commit to be undone without worrying about the intricate detail. Furthermore this alleviates the need for developers to monitor and analyse every commit.

2.11.2 F/OSS Bug Tracking

Bugs as they are commonly referred to within software terminology, represent errors, mistakes or flaws within the source code. The vast majority of bugs are discovered during run time and recorded by the user themselves or automatically as a response from the system. (von Hippel, 2001) states that users record any bugs encountered within "bug reports" accompanied by details describing the problem. Within the description details such as type of hardware and software installed on the computer, current configuration of the software and error message prompted must be included. To effectively manage and automate the processes that take precedence when a bug is reported through to its solution, communities have created and adopted disparate systems. These systems differ in complexity; advanced bug tracking systems typically require the bug be documented in a particular format, so as to store in the system for later rectification. To clarify, bug tracking systems eliminate the need for developers to notify others of a bug identified and persuade them to provide a fix, in effect relieving the communicative dependency of developers.

2.11.3 F/OSS Mailing Lists

The existence and adoption of mailing lists is another component of the infrastructure that facilitates collaboration (Bauer & Pizka, 2003; Edwards, 2001; Kogut & Metiu, 2001). The majority of communities have mailing lists that provide a platform for the discussion of various issues; each list has a different purpose

and target audience, e.g. specific lists provide a forum for posting questions and receiving answers. Mailing lists are an important tool for OSS development as users and developers are able to share ideas and debate on topics that may not have been considered otherwise. To clarify, mailing lists provide a platform for the exchange of information, including ideas, questions and answers.

2.11.4 F/OSS Live Chat

The majority of communities have configured and setup real time chat rooms that use Internet Relay Chat (IRC) in conjunction with mailing lists allowing users and developers to ask each other questions and receive instant responses. Communication between parties takes place over a channel that is typically assigned to a project; furthermore it is possible to have more than one channel for additional projects and/or subtopics, e.g. installation problems. To clarify, a real time chat room or IRC is a shared space with complete oversight, potentially IRC conversations are nominally public but generally thought of as informal, semi-private conversations (Fogel, 2005).

2.11.5 F/OSS To-Do Lists

Typically developers have a mass of ideas regarding the development of software, particularly the features and functionality that should be added. Unfortunately for some developers this isn't possible as they either lack the time, skills or motivation to do so, however discarding potentially valuable ideas would constitute a loss as they may be needed by the much wider community. To ensure ideas make the transition from a concept to being implemented to-do lists are created, acting as a coordinative mechanism indicating to the wider community issues that others find pressing. There is no justification why they are considered important; instead the ideas are prompted to users and developers, remaining static until action is taken upon them. To-do lists are a good example of demand and supply, and represent another mechanism with the aim of structuring individual efforts within a community.

The following section will review various technologies that are open source oriented; the technologies will be illustrated through a brainstorm and a sample selected and compared against the mechanisms for coordinating and collaborating as discussed previously. The brainstorm is segmented into three sections with open source technologies extracted from the following resources:

- Open Source Software Project Hosting (Wikipedia, 2009a)
- Social Networking Sites (SNS) (Wikipedia, 2009b)
- Crowd Sourcing Sites (CSS) (Wikipedia, 2009c)

The brainstorm is by no means an exhaustive summary of all the open source technologies that exist within their given domain, however it does illustrate those that are widely recognised with a high number of registered users.

Open Source
Software Project
Hosting

Alioth

Bitbucket

CodePlex

Codendi

CVSDude

Google Code

Gitorious

GitHub

GNU Sevanna

Assembla

Origo

Project Kenai

Fedora Hosted

Source Forge

Tigris.org

Launchpad

TuxFamily

Amazon Mechnical
MTurk

Crowd Sourcing
Sites (CSS)

Innocentive

Innovation
Exchange

**Open Source
Technologies**

Social Networking
Sites (SNS)

Flickr

Last.fm

Facebook

Friendster

LiveJournal

Habbo

WAYN

MySpace

LinkedIn

hi5

Bebo

Netlog

Classmates.com

Badoo

Adult FriendFinder

Flixster

Windows Live
Spaces

Twitter

Orkut

Tagged.com

Friends Reunited

Figure 2-2: A mind map illustrating open source technologies

2.12   F/OSS Project Hosting (FOSPHost)

Free/Open Source Project Hosting Sites commonly referred to as FOSPHost are an infrastructure that uses the Internet as a primary medium for supporting and coordinating the development of F/OSS projects. Typically FOSPHost provide an array of services to manage a project, in addition to the mechanisms discussed previously an announcement area, document manager, task manager and file release system. FOSPHost can be classified as either external hosting or self hosting, the primary difference being the level of control granted to users. In relation to self hosting, internal configurations for services provided are subject to change at the user's discretion, by contrast external hosting provides a fixed set of services with a standard configuration. Examples of self hosting sites include, Apache, Linux and Mozilla, furthermore external hosting sites include those illustrated on the previous figure. It may appear obvious but regardless of restrictions external hosting sites increasingly attract a high number of users, the primary reason being that initiating a project requires a lot less physical and mental exertion. This statement may portray external hosting sites as being a 'one stop shop'; unfortunately they only cater for commonly used tools, therefore under no assumption are services such as IRC provided. However these services are provided elsewhere or in some cases by the developers themselves.

The following figures provide a comparison between a sample of external hosting sites, using the features/mechanisms that each site offers as a form of benchmark. It is important to note that although the infrastructure has been developed solely for open source software development, the concept can be applied elsewhere, therefore features/mechanisms, including bug trackers and version control should not be considered static, but dynamic artifacts.

Table 2-4: Tabular comparison of open source project hosting sites, extracted from (Wikipedia, 2009a)

Name	Bug Tracker	Wiki	Mailing List	Forum	Announcements	CVS	SVN
Microsoft CodePlex	Yes	Yes	Yes	Yes	No	No	Yes
Source Forge	Yes	Yes	Yes	Yes	Yes	Yes	No
Launchpad	Yes	No	Yes	No	Yes	Yes	Yes
Assembla	Yes	Yes	No	Yes	Yes	No	Yes
Tigris.org	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The above table provides a clear representation of what features/mechanisms are supported by a sample of external hosting sites, the majority of which support the 'standard' set of tools and void those which are viewed as additional services, e.g. IRC. The external hosting sites with the highest number of registered users formed the sample.

In an investigative study conducted by (Heng So, 2005) external hosting sites were further classified as being infrastructure and non-infrastructure sites, the distinguishing characteristic being that developer and project information is stored in a database, comparative to non-infrastructure whereby a database is voided and users are expected to construct their project page using static HTML. Furthermore (Heng So, 2005) conducted a comparative study, analysing features distributed among six self-defined categories; however the most prominent category relevant to the research has been listed:

- Project Tools – Tools for Public/Developers

(Heng So, 2005) deduced the list of features from those available on SourceForge, an established infrastructure site with a credible reputation, hosting a number of acclaimed projects to date and from which many 'spin offs' have been developed, for example BerliOS developer FOSPHost was one of the first to utilise the SourceForge v1.5 (Moen 2002), providing an intermediary for developers, users and businesses within the area of Open Source. An advantage of the site was its trilingual interpretation, providing support for English, Danish and Spanish through amendments made to the SourceForge v 1.5 source code.

The category 'Project Tools – Tools for Public/Developers' contains a large set of features from which three sub categories were defined, the first sub category compared features that assist those who are not concerned with development and participation but have an interest in the final product produced. The second sub category provided a discussion of features that facilitate communication between developers and users, the discussion initiated with a Delphi survey revealing those of highest importance, respectively among the top five features were version control, bug tracking and mailing lists. Furthermore, additional features that appeared in the comparison include, IRC, Webmail, Forum and Wiki. The third sub category includes all other features that were discovered whilst investigating sites within the sample. The following figures illustrate an extract from the comparison made by (Heng So, 2005).

Table 2-5: Tabular comparison of external FOSPHost sites, extracted from: (Heng So, 2005)

Site	Type	Source Code Repository	Mailing List	Tracker
SEUL	NI	CVS Server and View CVS and CVSweb	Majordomo + MHonArc	Jitterbug
Icculus.org	NI	CVS Server and View CVS	Ezmlm-idx	Bugzilla
SunSITE.dk	NI	CVS Server and View CVS	Ezmlm, Mail Filtering	DIY
GBorg	I	CVS Server and View CVS	Mailman	Bug/Feature/Task
BerliOS	I	CVS Server and View CVS	Mailman	Bug/Feature/Patch/Task

Table 2-6: Tabular comparison of external FOSPHost sites, extracted from: (Heng So, 2005)

Site	Type	IRC	Forum	Wiki	Survey	Other Tools
Asynchrony	I	Via a Java client interface on site	Yes	Unknown	Ratings on predefined attributes of a project	
Savannah	I	No	Yes	No	Unknown	
Freepository	I	No	No	No	No	
SourceForge	I	No	Yes	DIY	DIY	
GForge	I	No	Yes	DIY	Yes	Task Manager and Gantt Chart

2.13   Harnessing the Wisdom of the Crowd

It has become apparent in recent years with the introduction of distributed problem solving and collaborative multidisciplinary practice that traditional methods no longer seem fit. (Brabham, 2008) states that the reality of advanced design is dictated by three concepts, distributed, plural and collaborative. Crowdsourcing is understood to be a distributed problem solving model and not one that is accustomed to open source practice. However, (Helms, 2007) argues that it does borrow many of its features from open source software development, but doesn't necessarily fixate on providing solutions to technical problems. Furthermore the problems solved and products designed by the crowd become an asset of the company, who in response yield higher profits. (Brabham, 2008) cites that Jeff Howe (Editor of Wired Magazine) reinforces this notion stating that *"it's only crowdsourcing once a company takes that design, fabricates [it] in mass quantity and sell[s] it"* (Howe, 2006).

To clarify, a company advertises a problem online, a vast array of individuals respond with solutions, the most promising ideas are selected and awarded a monetary prize, and the company initiates mass production of the idea expecting a profitable ROI. Many modern day crowdsourcing examples exist, including Threadless, iStockphoto, Innocentive, CNN's I-Report and onForce.com, but one of the most prominent and original examples that truly reflects the nature of this study was conducted in 1714. The project was devised by the British government aiming to develop a device that is able to determine the longitude of a ship whilst at sea (Taylor, 1971) , this decision was influenced by the fact many ships were lost due to poor visibility of the shoreline, in other words the British government's resources and revenue lost. The persons sponsoring the project offered varying sums of money to inventors who could develop or aid in the development whilst satisfying the device requirements. Overall the project was a success with several inventors being recognised for their innovative contributions, providing a catalyst for the propagation of future projects. Furthermore, since this period the

'web' has been introduced among many other technological advancements, centralising individuals from around the globe; (Brabham, 2008) cites (Terranova, 2004) stating that the web is *"not simply a specific medium but a kind of active implementation of a design technique able to deal with the openness of systems"*. In other words, acknowledging that users are sparsely separated, from disparate cultural backgrounds, the web has facilitated the exchange of individual thoughts and opinions in a decentralised manner, a prime example being open source.

2.14   Why Crowdsourcing Is Not Open Source

Open source is primarily associated with software development, as some of the most recognised examples of the model illustrate, furthermore by many it is seen as an overall philosophy for generic product development. However, despite its success with products like the Mozilla Firefox web browser and Linux operating system this does not necessarily imply that the model is suited for all applications. The prominent reason to justify this doubt of the open source model is situated in the concept of egocentricity and materials required for production. (Brabham, 2008) cites (Ghosh, 1998; Raymond, 2003) stating *"there is an intrinsic, feel-good reward in solving the puzzle"*; further adding *"thousands of minds working on a problem and none of them compensated for cash"*. In elementary economics it is apparent that software can be produced without incurring an abundance of overhead costs.

However, not all products exist as virtual entities; the majority of products within the 'real' world require machines and materials to produce, and experience initial and recurring costs at each stage of the product life cycle. Thus, (Brabham, 2008) argues if a product will ultimately be sold to turn a profit, would a person with an innate sense of egoism want to exert themselves without a cut of the profits? Having to ask these questions inflicts a sense of doubt onto whether the open source model can really be applied as a generic model for product development. In contrast, crowdsourcing overcomes these potential barriers that

exist within the open source model, providing a clear arrangement where contributors will be compensated. It exists as a hybrid model amalgamating the transparency and equality of open source into a model that makes it possible for businesses to turn a profit, utilising the web to facilitate all transactions.

"A society that values the quality and innovation of open source production, but is locked into a capitalist system of ownership, capital, and overhead, can have their cake and eat it too with crowdsourcing" (Brabham, 2008)*.*

Within the modern era many examples of crowdsourcing projects exist, some of which have stated previously, one of the reputable examples being InnoCentive, an online intermediary that provides a direct link between companies ('seekers') requiring solutions to problems and individuals ('solvers') capable of solving the problems. The individuals respond to the request by providing innovative solutions worthy of a bounty, between $10,000 and $100,000 dependent upon how satisfied the company is with solutions provided. Innocentive is Research and Development (R&D) centric, their service outsources specific R&D tasks to those further afield than organisational boundaries, utilising cross-domain knowledge from a larger pool of researchers from academia and professional backgrounds.

As cited by (Helms, 2007), "*researchers with expertise at the periphery of a domain are faster, on average, to find a solution than researchers in the domain"* (Lagace, 2006). The predominant reason for InnoCentive's success is its direct approach to addressing to problems associated with the existing R&D model; the competitive nature of researchers to publish and IPR concerns (Lagace, 2006). InnoCentive has mitigated the effects of these problems through full online disclosure of the problem and the individuals consent to selling their idea once it has been submitted. However, by disclosing problems concerned with corporate research there is a possibility of competitors being able to 'read between the lines' and gain insight into their strategy and future work (Helms, 2007).

2.15   Chapter Summary

To summarise the proceeding literature review, (Wasko and Faraj, 2005) selectively define 'electronic' networks of practice as an independent, open activity system predominately focused upon a shared practice, where network members are willing to engage with one another through computer-mediated communication in providing solutions to problems and contributing to the common practice. The majority of knowledge creation and sharing is accomplished through a process of discussion with questions and answers, collaborative editing or through a process of storytelling, the epitome of which are discussion forums, wikis and blogs (Wagner and Bolluju, 2005). This statement is later proven through a tabular comparison of F/OSS project hosting services with the majority opting to use these technologies as the primary enablers for knowledge exchange.

Other services that employ the use of Web 2.0 technologies pertain to Medicine 2.0/Health 2.0 and SNS. In 2003 Linden Lab founded by Philip Rosedale developed a virtual environment accessible via the Internet, known as Second Life (SL). Its intended use was to allow users, referred to as 'residents' within the virtual environment to interact through the use of avatars, its most prominent functionality being able to create and trade virtual property (Wikipedia 2009d). However, regardless of its inability to support detailed 3D models and engineering analyses and simulations it does cater for small collaborative design studies with high dependency on communication and collaborative facilities (van Nederveen, 2007).

F/OSS communities operate as distributed project teams in a production environment (O'Mahony and Ferraro, 2004, p. 10) and utilise version control, bug tracking, mailing lists, live chat and to-do-lists as a standard set of mechanisms for managing information and facilitating collaboration and coordination of activities. However, this environment may not be possible when applied to product development. (Brabham, 2008) argues if a product will ultimately be sold

to turn a profit, would a person with an innate sense of egoism want to exert themselves without a cut of the profits? In contrast, crowdsourcing overcomes these potential barriers that exist within the open source model, providing a clear arrangement where contributors will be compensated.

2.16   Research Gaps

It is evident that the 'open source' concept has been successfully applied to software development, however product development remains relatively novel with limited practical applications. The research suggests that the number of error rates associated with closed source is continually escalating and economically, even large OEMs are releasing they can't afford to recruit a sufficient number of internal developers to suffice the requirements of many large scale projects. It is for this reason that organisations need to distribute the workload, utilising resources located further a field than corporate boundaries. With reference to open source software development, organisations that have adopted this approach include both formal consortia such as Apache Software Foundation, and informal collective efforts that employ open source licensing (Messerschmitt, 2009). However, as open source product development is relatively novel, the project will address this issue by producing and disseminating a semi-structured questionnaire to all stakeholders concerned to capture and validate stakeholder requirements for the development of the infrastructure.

FOSPHost can be classified as either external hosting or self hosting, the primary difference being the level of control granted to users. In relation to self hosting, internal configurations for services provided are subject to change at the user's discretion, by contrast external hosting provides a fixed set of services with a standard configuration. Furthermore it may appear obvious but regardless of restrictions external hosting sites increasingly attract a high number of users, the primary reason being that initiating a project requires a lot less physical and mental exertion (Heng So, 2005). However, at present external hosting for product development does not exist and therefore the project will address this issue by

developing an infrastructure from the derived stakeholder requirements to initially support medical device development, providing 'convenient' project hosting for all stakeholders concerned.

(Heng So, 2005) provides a comparison of features, including personal information, skills and experience, utility to monitor files, forums and trackers, related projects, assigned and submitted issues from trackers, bookmark, diary, survey and capital gained. Furthermore it is apparent that the features stated form the basis of a 'profile', something of which is commonly associated with Social Networking Sites (SNS). However, whilst the research addresses how communities are sustained through user profiles, it does not give a clear indication as to how communities are built. The project will address this issue by quantifying the impact of social networking sites, providing users with the ability to utilise these services from creating a profile to building their own community from within the infrastructure.

3.   **CHAPTER THREE: SCOPE, METHODOLOGY AND DELIVERABLES**

3.1 Project Scope

3.1.1 Inside Scope

In order to achieve the aim of the project as previously stated, the scope must be defined to ensure the correct boundaries are in place to limit the level of research conducted. The research will include the prime stakeholders, including:

- Medical Profession:
    - Doctors
    - Nurses
    - Clinicians
- Patients
- Original Equipment Manufacturers (OEMs) that develop and manufacture medical products and services.
- Small Medium Enterprises (SMEs) that develop and manufacture medical products and services and/or are diversifying into healthcare technologies.

3.1.2 Outside Scope

The project will primarily focus upon standards and practices used within the United Kingdom, the study will provide a simple web infrastructure for designing medical devices within an open environment and will avoid a potentially complex system.

3.2 Methodology

3.2.1 Phase One: Client Brief

Note: Prerequisite of the project prior to start.

3.2.2 Phase Two: Comprehensive Literature Review

The project research will initiate with a comprehensive literature review to provide the reader with an understanding of open source development. The scope of the project will be defined at the later part of the literature review. The

comprehensive literature review will review the areas: communities of practice (CoP), Web 2.0 technologies and services, with the predominant focus upon free/open source software development and the factors that contribute towards its success as open source product design remains relatively novel. The research conducted will primarily be based upon a 'keyword' search to limit the number of result returned, yielding 'only' those of relevance, examples include, 'open source collaboration', 'online communities', 'open source design', 'open source web technologies' and 'open source software'.

3.2.3   Phase Three: Define Stakeholders

The research will identify the 'relevant' stakeholders that have an involvement within the design of medical devices, primarily those that design and/or use medical devices on a daily basis, including doctors, nurses, clinicians, patients, OEMs, SMEs and the administrative individual or team responsible for maintaining the open source web based infrastructure. Innovations Factory, its associates and members of the medical profession from St Peters and Wexham Park Hospital are anticipated to be prime candidates.

3.2.4   Phase Three: Capture Stakeholder Requirements

Once the 'relevant' stakeholders have been identified, knowledge capture methods and techniques will be utilised, namely semi-structured questionnaires in an attempt to extract the stakeholder requirements. Due to time constraints the stakeholders will be contacted following an initial development of the open source web based infrastructure, although not considered the 'norm', it does however provide stakeholders with a visual aid to realise the development direction and potential to be exploited. The questionnaire will be created online as to aid the process of dissemination and/or embedded within an email and sent to each stakeholder.

3.2.5   Phase Three: Validate Stakeholder Requirements

The responses for each questionnaire will then be cross-referenced with responses from stakeholders pertaining to the same or similar occupation to

ensure validity and consistency among responses. Unfortunately, as the questionnaires will be completed online there is not direct supervision or control over responses prior to submission. The validated responses will provide the foundation for the development of the open source web based infrastructure.

3.2.6   Phase Four: System Requirements Specification (SyRS)

The research will then focus upon producing a written document detailing an explicit set of requirements to be satisfied by the open source web based infrastructure, referred to as a 'System Requirements Specification' (SyRS). The detailed specification will utilise the previously identified stakeholder requirements and the functional system requirements.

3.2.7   Phase Five: Prototype of Open Source Web Based Infrastructure

The prototype will utilise the SyRS as a guideline for its development whilst satisfy the documented requirements. The infrastructure will be developed using open source technologies, namely 'Joomla', a Content Management System (CMS) designed for ease of use and extensibility.

3.2.8   Phase Six: Prototype of Open Source Web Based Infrastructure

To reiterate, combining 'open source' and 'product design' is relatively novel, therefore a level of uncertainty is to be expected. In order to validate the open source web based infrastructure, a multitude of in-house design sessions will be held with a sample of stakeholders, the stakeholders will be expected to perform a series of 'supervised' operations on the open source web based infrastructure, utilising sample data extracted from an existing project. Once the in-house design sessions are complete knowledge capture methods and techniques will again be utilised, namely closed-ended questionnaires in an attempt to immediately identify areas for improvement pertaining to the infrastructures current state. The questionnaire will be created online as to aid the process of dissemination and/or embedded within an email and sent to each stakeholder.

3.2.9   Phase Six: Validate Feedback from Stakeholders

Note: Refer to section 3.4.5.

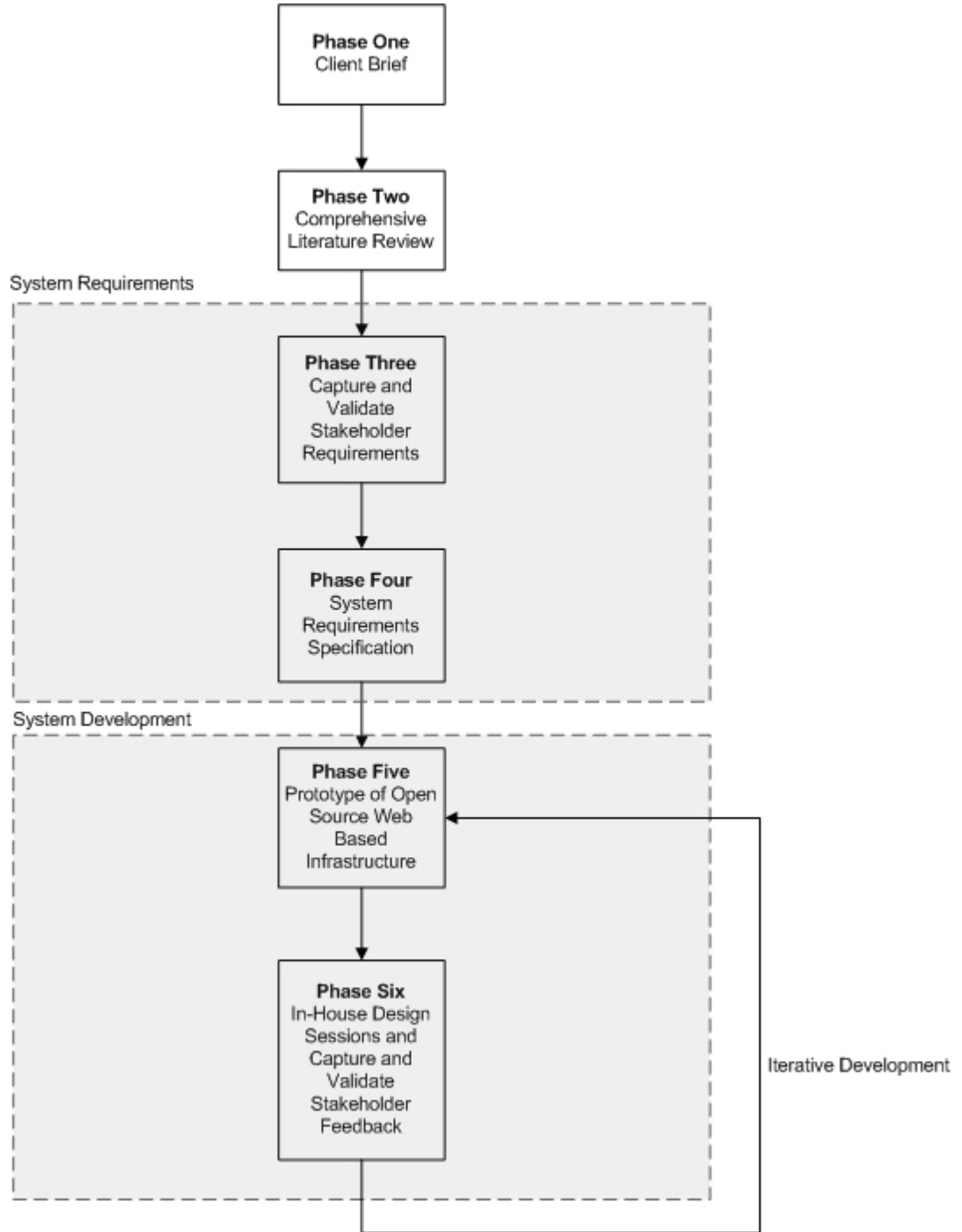### 3.2.10   Diagrammatic Summary of Methodology

Figure 3-1: Process diagram illustrating methodology structure

3.3 Deliverables

The deliverables for the project can be summarised as follows:

June
- A comprehensive literature review that will predominately focus upon free/open source software development, as the area of open source product development remains relatively novel.
- A thorough investigation into the stakeholder and functional requirements for the development of the open source web based infrastructure.

July
- A detailed specification outlining an explicit set of requirements to be satisfied by the open source web based infrastructure.
- A prototype open source web based infrastructure for the design of medical devices within an open source environment.

August
- A multitude of in-house design sessions will be conducted with prime stakeholders.
- A survey will be conducted using the web infrastructure as a method of providing feedback for the improvement of the open source web based infrastructure.

3.4 Chapter Summary

This chapter initially outlines what falls 'inside' the project scope and what falls 'outside', this will identify the boundary between the current research and future research as to prevent false expectations. The methodology for the project consists of six phases, each of which has been described in detail and represented within the figure 3-1. The research methodology provides a set of milestones to be completed over the projects duration and is a critical facet to ensuring a project is completed under a time constraint, furthermore it will be used in conjunction with the project deliverables which have been defined on a month by month basis.

4.   CHAPTER FOUR: STAKEHOLDER REQUIREMENTS CAPTURE AND VALIDATION

4.1 Introduction

4.1.1 Purpose

The following section will concentrate on the analysis of a semi-structured questionnaire written and disseminated amongst stakeholders for the capture and validation of stakeholder requirements to be utilised for the development of the infrastructure, supporting open source medical device design.

4.1.2 Document Conventions

The document conventions that apply pertain to closed ended questions analysed using pie charts and bar graphs and open ended questions using a tabular view depicting the similarities, differences and uniqueness. It is important to note that each respondents use in language differs; therefore responses will be grouped on the respondents intended meaning to avoid redundancy in the responses listed.

4.1.3 Questionnaire Development

The questionnaire was developed utilising knowledge gained from the preceding literature review, predominately focusing upon the infrastructures design and community building comparative to concept creation as this facet of the infrastructure development is covered by another researcher in part one of the project. Furthermore, the questions were grouped into sections, including the profile, communication, project management, accessibility and layout. For guidance on how to structure and disseminate the questionnaire fellow researchers within open source were consulted.

4.1.4 Key Questions

The following questions have been extracted from the complete questionnaire which can be found in the appendices under Appendix A; two questions from each section have been listed based upon their priority:

Profile:

- What personal details would you like others to see in your profile?

  - Justification: The preceding question identifies the information stakeholders are willing to advertise to others. Information security is a necessity for any system advertising personal user information.

- Would you like the ability to add/remove friends from your profile?

  - Justification: The preceding question identifies whether users would like the option to network with users of the infrastructure. Social networking is a key aspect in building a community, however not everyone uses social networking sites and may not consent to having the option. Others may find it a repetition on what is already available through alternate services.

Communication:

- Do you consider a forum to be valuable within a community?
- Do you consider a weblog to be valuable within a community?

  - Justification: The preceding question identifies whether users would like a discussion forum to communicate with members in the community. With reference to the literature review it is identified that discussion forums and weblogs are primary technological enablers for knowledge exchange when applied to F/OSS communities, however how true is this statement when applied to product design?

Project Management:

- As a coordinator how many project members would like to restrict access to?

  - Justification: The preceding question identifies whether users would like to restrict the total number of members authorised to access any single project when a project coordinator. If a project bars no restriction, projects become overwhelming and in some cases unmanageable for project coordinators. In contrast, with a restriction in place the level of contribution will controlled, thereby discouraging innovation?

- As a coordinator of a project would you consent to disclosing information about a project to members outside the project community?
  - Justification: The preceding question identifies whether users would like advertise information about any single project to users outside of the project community when a project coordinator. If project information is available to external users this allows users to fully understand a project prior to joining, however it may also act as a catalyst for others to replicate projects of the same nature, thereby discouraging innovation?

Accessibility:

- If you have a Facebook account, would you like to be able to register and login with it?
  - Justification: The preceding question identifies whether users would like the option to register and login with Facebook if they have an existing account. Social networking is a key aspect in building a community, however not everyone uses social networking sites and may not consent to having the option. Others may find it a repetition on what is already available through alternate services.

- What information would you like to have direct access to when visiting Cranfield OPD3?
  - Justification: The preceding question identifies what information users would like direct access to when visiting the site. In any circumstances the first impression of any system is often the last; therefore it is essential that the most important information for capturing user's attention and aiding them to understand the system is displayed at the forefront.

4.1.5   Identification of Stakeholders

The stakeholders pertain to those that have an involvement or interaction with the infrastructure, for example a set of users, or developers sharing the same characteristics and relationships within the infrastructure. As stated within the methodology the prime stakeholders are those that design and use medical devices on a regular basis, including doctors, nurses, clinicians, patients, OEMs,

SMEs and the administrative individual or team responsible for maintaining the infrastructure. In total fifteen stakeholders provided responses to the questions for both the requirements capture and experience questionnaire, for a full list of the stakeholder details including, name, organisation, position and email please refer to the appendices under Appendix A1. Unfortunately, due to a limited contact list and unresponsiveness from some, none of the respondents pertain to medical equipment designers. All respondents would like to remain anonymous, however a brief background summary of all respondents has been provided below:
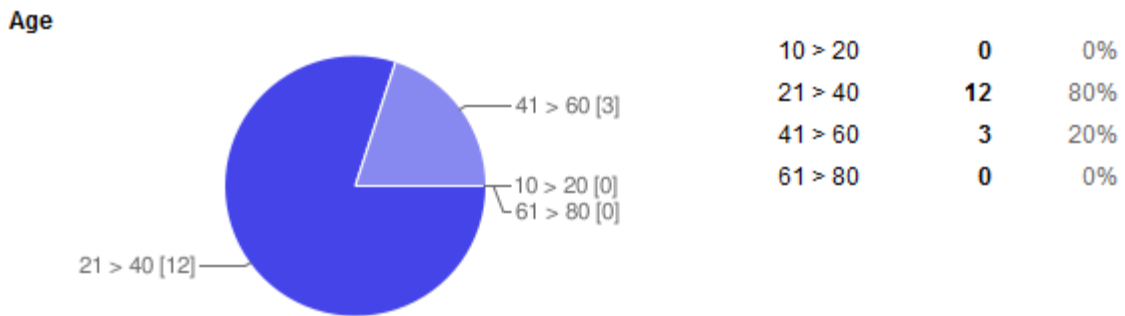

Age

10 > 20	0	0%
21 > 40	12	80%
41 > 60	3	20%
61 > 80	0	0%

Figure 4-1: Pie chart summary of respondent's ages

Figure 4-1 illustrates that the majority of respondents (80%) are aged between 21 and 40 years.

Ethnicity

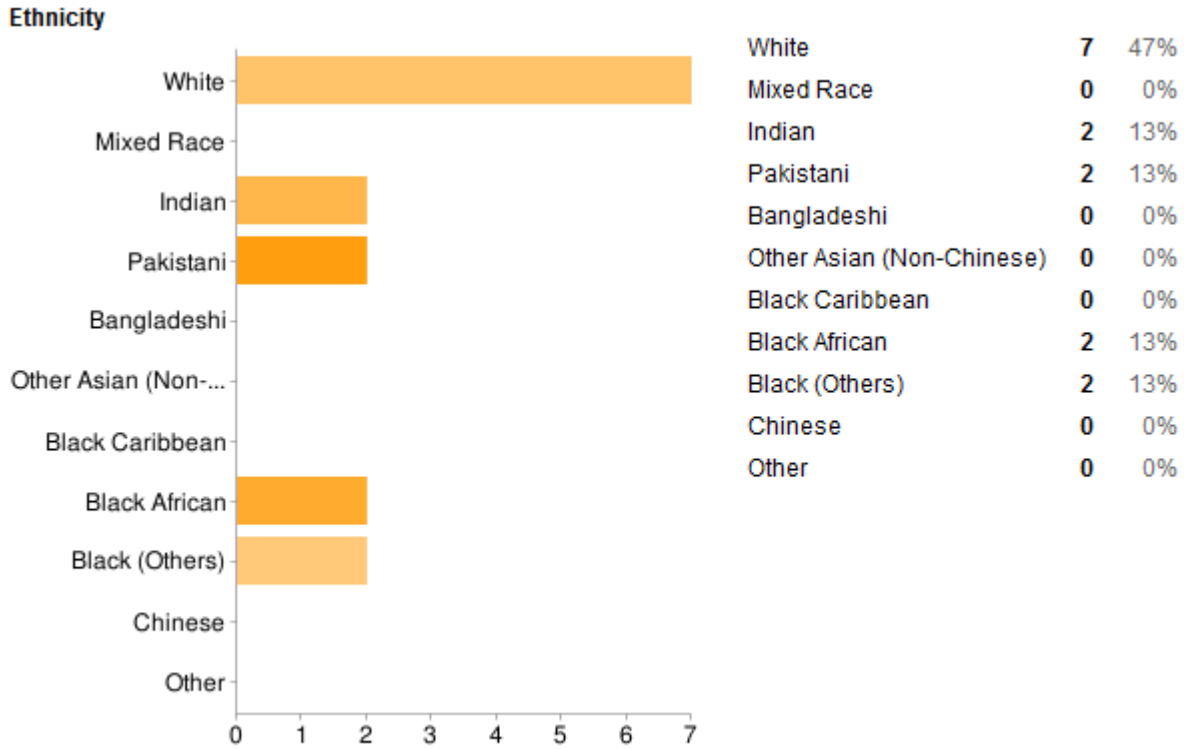|		
White	7	47%
Mixed Race	0	0%
Indian	2	13%
Pakistani	2	13%
Bangladeshi	0	0%
Other Asian (Non-Chinese)	0	0%
Black Caribbean	0	0%
Black African	2	13%
Black (Others)	2	13%
Chinese	0	0%
Other	0	0%

Figure 4-2: Pie chart summary of respondent's ethnic group

Figure 4-2 illustrates that the majority of respondents (47%) of respondents are of ethnic original 'White'.

Highest Achieved Qualification

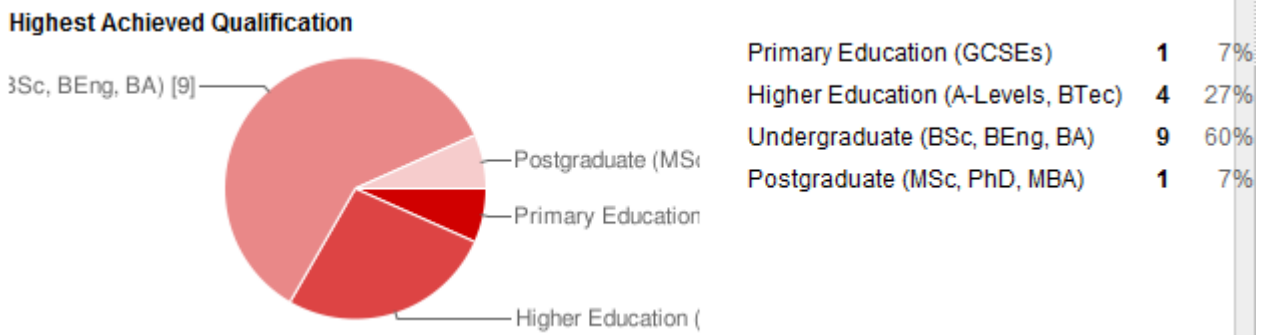|		
Primary Education (GCSEs)	1	7%
Higher Education (A-Levels, BTec)	4	27%
Undergraduate (BSc, BEng, BA)	9	60%
Postgraduate (MSc, PhD, MBA)	1	7%

Figure 4-3: Pie chart summary of respondent's highest qualification achieved

Figure 4-3 illustrates that the majority of respondents (67%) have attained an undergraduate qualification or higher.

The following table summarised the fifteen respondent's organisation and current position held within the organisation, in no particular order:

Note: Fields that are marked with '-' signifies that the person did not want to disclose that piece of information when asked.

Table 4-1: Tabular summary of respondent's organisations and position held

<u>Organisation</u>	<u>Position Held</u>
NHS	Senior Staff Nurse
Cranfield University	Student
Griffin IT Services	IT Consultant
Cranfield University	Student
Cranfield University	Student
NHS	Doctor
Webexpectations	Designer
IBS Software Services	-
Cranfield University	Student
Kent University	Student
-	Designer
NHS	Health Consultant

4.1.6   Collecting and Analysing Questionnaire Responses

To clarify, the questionnaire was created online utilising Google Documents, a free web based office suite allowing users to create and edit word documents, spreadsheets, presentations and/or form applications whilst collaborating in real-time with others. The responses to the questions were collected in a spreadsheet and an automated summary displayed, open-ended questions were documented

whilst closed-ended questions were analysed and displayed in the form of a pie chart or bar chart. However, the open-ended responses were later extracted from the spreadsheet and analysed on the basis of their similarities, differences and uniqueness.

4.2   Questions and Analysis of Responses

Section:

- Profile

Question 1#:

- What personal details would you like others to see in your profile?

Response Summary:

Table 4-2: Tabular summary of responses for question #1

Similarities	Differences	Uniqueness
• First Name • Surname • Email	• Occupation • Gender	• Organisation • Age

Discussion of Result:

Table 4-2 indicates that the majority of respondents agree that only their first name, surname and email address should be displayed as part of their profile. In contrast a lesser number of respondents felt that their occupation and gender should be displayed. However social networking sites, e.g. Facebook do provide their members with option of what information they would like to display, the option is available to update at any point in time.

Section:

- Profile

Question #2:

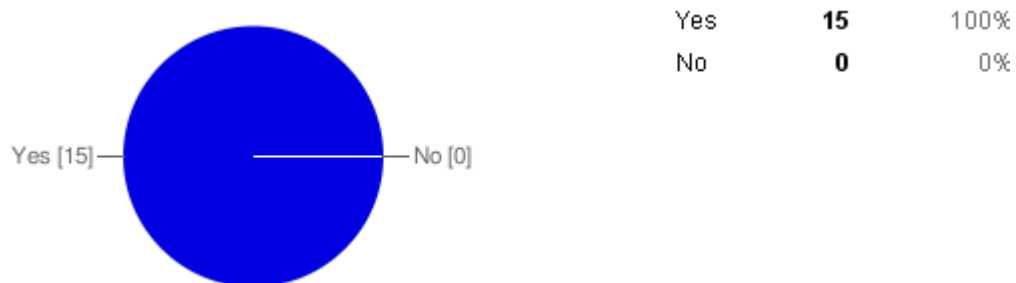- Would you like the ability to edit and customise your profile?

Response Summary:

Yes	**15**	100%
No	**0**	0%

Figure 4-4: Pie chart summary of responses for question #2

Discussion of Result:

Figure 4-4 illustrates that all respondents would like the ability to customise and edit their profile.

Section:

- Profile

Question #3:

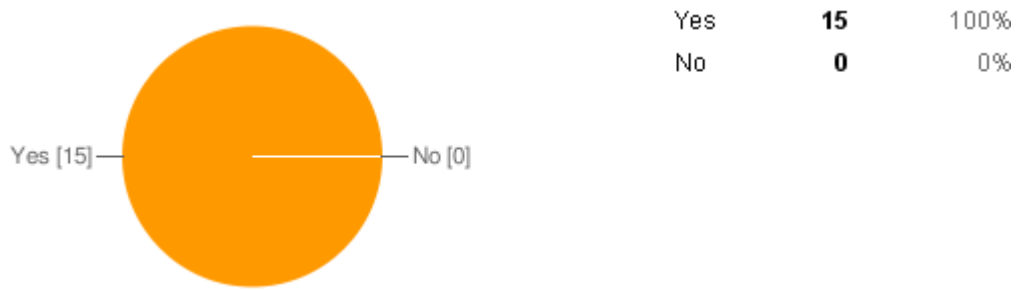- Would you like your profile to be connected to all communicative facilities provided?

Response Summary:

Figure 4-5: Pie chart summary of responses for question #3
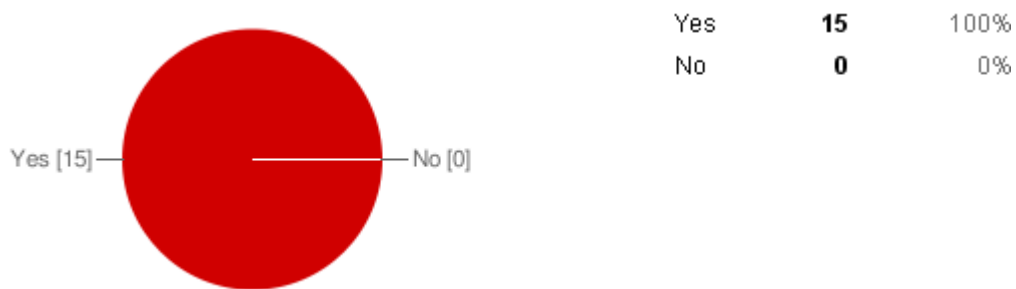
Discussion of Result:

Figure 4-5 illustrates that all respondents would like their profile connected to the communicative facilities provided, this avoids any inconsistencies in information provided and reduces the time consumption for each member when registering or logging into the site.

Section:

- Profile

Question #4:

- Would you like the ability to add/remove friends from your profile?

Response Summary:

Figure 4-6: Pie chart summary of responses for question #4

Discussion of Result:

Figure 4-6 illustrates that all respondents would like the ability to add/remove friends from their profile.

Section:

- Communication

Question #5:

- What are your preferred methods of online communication?

Response Summary:

Table 4-3: Tabular summary of responses for question #5

Similarities	Differences	Uniqueness
• Email • MSN Messenger	• Skype • Facebook • Yahoo Messenger • Comments • Discussion Forums	• Web Conferencing • Instant Messaging

Discussion of Result:

Table 4-3 indicates that the majority of respondents agree that their preferred methods of communication are the use of email and msn-messenger. In contrast a lesser number of respondents suggested Skype, Facebook, Yahoo Messenger, Comments and Discussion Forums. Notably the majority of social networking sites, namely Facebook have replicated such features in order to accommodate its member preferences.

Section:

- Communication

Question #6:

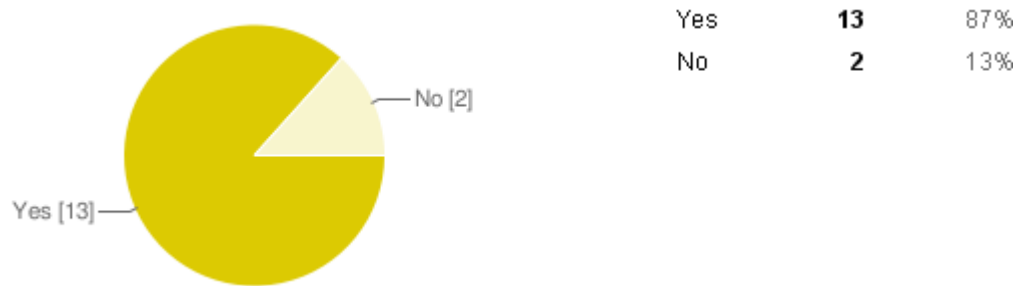- Do you consider a forum to be valuable within a community?

Response Summary:

Yes	**13**	87%
No	**2**	13%

Yes [13] No [2]

Figure 4-7: Pie chart summary of responses for question #6
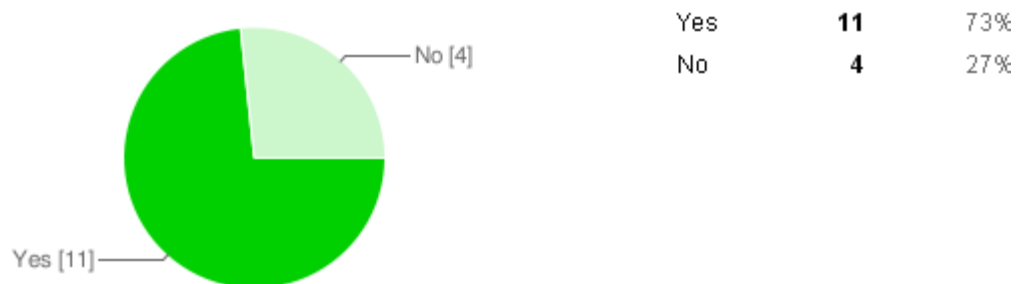
Discussion of Result:

Figure 4-7 illustrates that the majority of respondents (87%) consider a forum to be a valuable commodity within a community. The vast majority of open source communities have discussion forums or equivalents such as mailing lists.

Section:

- Communication

Question #7:

- Do you consider a weblog to be valuable within a community?

Response Summary:

Yes	**11**	73%
No	**4**	27%

No [4] Yes [11]

Figure 4-8: Pie chart summary of responses for question #7

Discussion of Result:

Figure 4-8 illustrates that the majority of respondents (73%) consider a weblog to be a valuable commodity within a community; in contrast 27% oppose the idea. Typically weblogs aren't seen as standard practice within the open source community and therefore not widely deployed, however by no means does this deter their use.

Section:

- Communication

Question #8:

- If yes to either one of the above, please suggest topics that would you like to see discussed within a forum or weblog?

Response Summary:

Table 4-4: Tabular summary of responses for question #8

Similarities	Differences	Uniqueness
- Design Tutorials - New and Innovative Medical Devices	- Creating and Managing a Project - Best Practices - Project Developments - FAQs	- Design Constraints - Lessons Learnt - New Members and Projects - Standards and Licensing - User Examples and Concepts

Discussion of Result:

Table 4-4 indicates that the majority of respondents would like to see design tutorials, new and innovative medical devices discussed within the communicative facilities provided, namely a discussion forum and/or weblog. In contrast a lesser number of respondents suggested creating and managing a project, best practices, project developments and FAQs. The result provides a good indication of what topics should be created, but does by no means provide a restriction.

Section:

- Communication

Question #9:

- Which page would you suggest the discussion for a project reside?

Response Summary:

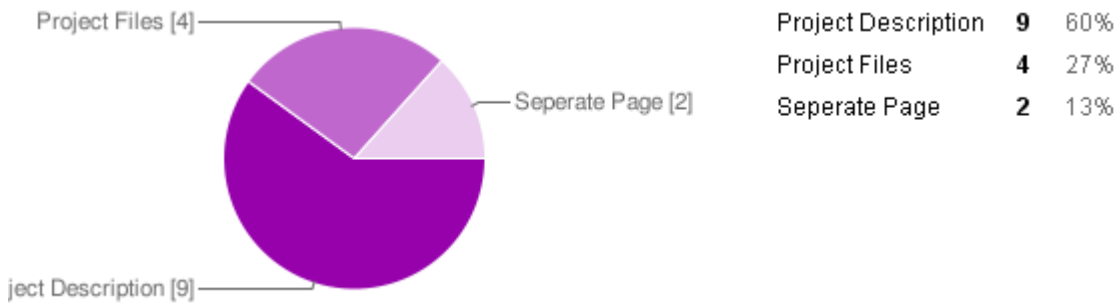|		
Project Description	9	60%
Project Files	4	27%
Seperate Page	2	13%

Figure 4-9: Pie chart summary of responses for question #9

Discussion of Result:

Figure 4-9 illustrates that the majority of respondents (60%) would prefer that the discussion for a project reside inline with project description. However this is dependent upon the length of project discussion, as to prevent exhaustive page scroll it may be better to put the discussion on its own page.

Section:

- Project Management

Question #10:

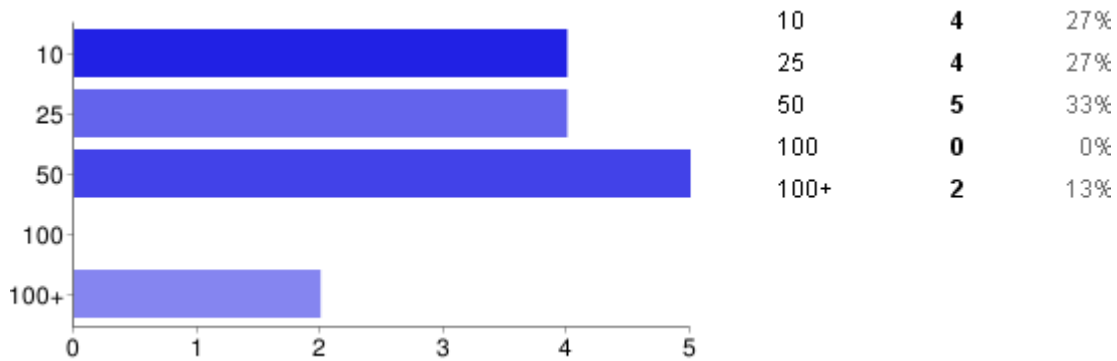- As a coordinator how many project members would like to restrict access to?

Response Summary:

10	4	27%
25	4	27%
50	5	33%
100	0	0%
100+	2	13%

Figure 4-10: Bar chart summary of responses for question #10

Discussion of Result:

Figure 4-10 illustrates that the majority of respondents (33%) would prefer to have a limit of 50 members per project. Furthermore 27% of respondents suggest a limit of either 25 or 10 members. Within the majority of open source communities there isn't a limit on the number of members per project, however in order to reduce the level of conflict handling it may be preferable.

Section:

- Project Management

Question #11:

- As a coordinator of a project would you like the option to delegate responsibility of project tasks/activities to 'selected' members?
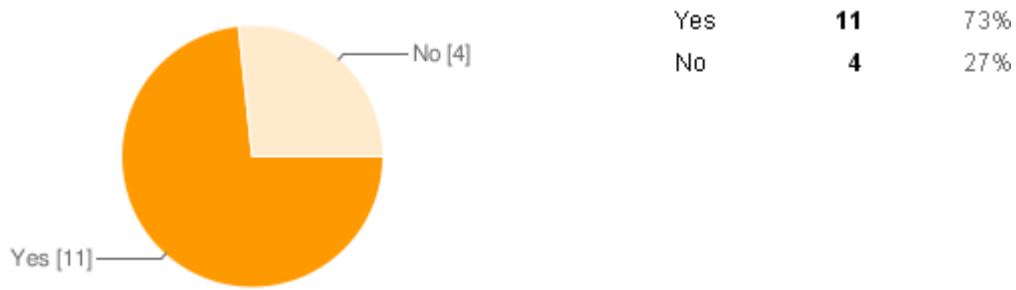
Response Summary:

Figure 4-11: Pie chart summary of responses for question #11#
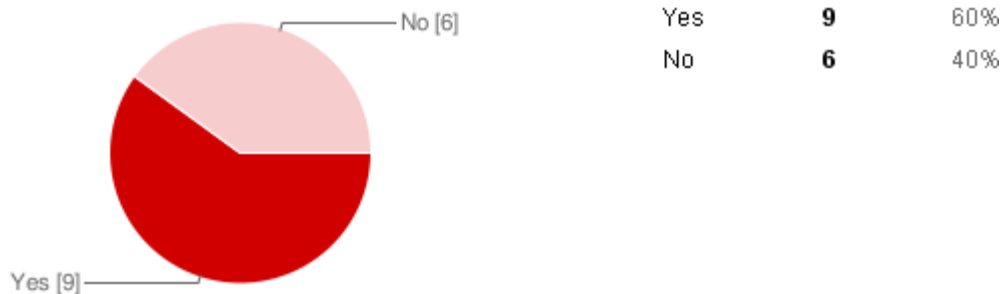
Discussion of Result:

Figure 4-11 illustrates that the majority of respondents (73%) as a coordinator would like the option to delegate responsibility of project tasks/activities to selected members. Within the vast majority of open source communities this option implicitly occurs, however the proposed option would reflect that of the administrator and moderator user groups that exist within discussion forums.

Section:

- Project Management

Question #12:

- As a coordinator of a project would you consent to disclosing information about a project to members outside the project community?

Response Summary:

Figure 4-12: Pie chart summary of responses for question #12

Discussion of Result:

Figure 4-12 illustrates that the majority of respondents (60%) as a coordinator would consent to disclosing information about a project to members outside the project community. In contrast 40% of respondents oppose this idea, however in order to encourage participation and community growth it would be more rewarding to expose projects to external members.

Section:

- Project Management

Question #13:

- As a coordinator of a project would you like the option to add/remove members from a project?

Response Summary:

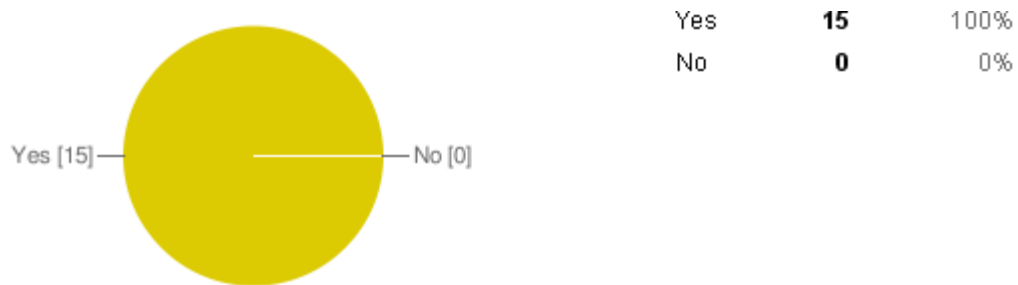|		
Yes	**15**	100%
No	**0**	0%

Figure 4-13: Pie chart summary of responses for question #13

Discussion of Result:

Figure 4-13 illustrates that all respondents as project coordinators would like the option to add/remove members from a project.

Section:

- Accessibility

Question #14:

- If you have a Facebook account, would you like to be able to register and login with it?
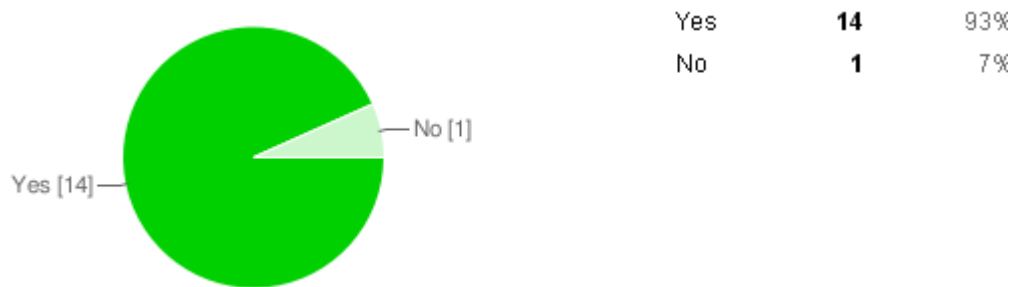
Response Summary:

Yes	14	93%
No	1	7%

Figure 4-14: Pie chart summary of responses for question #14

Discussion of Result:

Figure 4-14 illustrates that the majority of respondents (93%) would like the ability to login and register with their Facebook account. This reinforces the notion that a vast number of people use social networking sites, providing this option will enhance site usability and promote the site more effectively.

Section:

- Accessibility

Question #15:

- If any, which other social networking sites do you use to communicate with friends or colleagues?
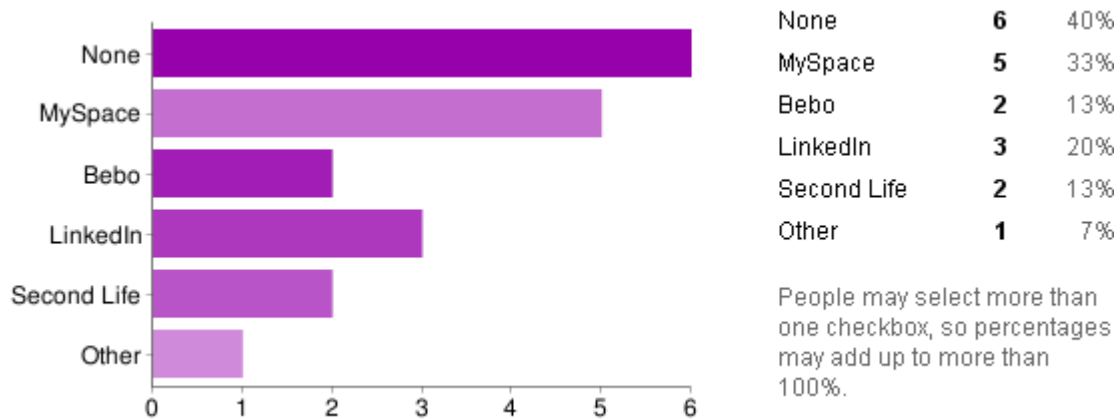
Response Summary:

Figure 4-15: Bar chart summary of responses for question #15

Discussion of Result:

Figure 4-15 illustrates that the majority of respondents (40%) solely use Facebook or no other social networking site to communicate with friends and/or colleagues. This reinforces figure 4-14, however it is not uncommon to provide more than one alternative to register or login to a site, other methods include the use of the Twitter login Application Programmable Interface (API) and or Google login API.

Section:

- Accessibility

Question #16:

- What information would you like to have direct access to when visiting Cranfield OPD3?

Response Summary:

Table 4-5: Tabular summary of responses for question #16

Similarities	Differences	Uniqueness
• Latest Projects	• Latest 'Open' News • All Projects • Advancements and/or Breakthroughs • Latest Site Updates • External Links to Associated Sites	• Useful Tips • Commercial Projects • Recommended Projects • Latest Forum Posts • Latest Project Comments

Discussion of Result:

Table 4-5 indicates that the majority of respondents would like to have direct access to the latest projects when visiting the site. In contrast a lesser number of respondents suggested the latest open source news, all projects, latest advancements and/or breakthroughs, latest site updates and external links to associated sites. The result provides a good indication of what information should be readily available; by default information on the initiative will have to be provided to all visitors.

Section:

• Layout

Question #17:

• What theme would you suggest be used for Cranfield OPD3, please stipulate colours, font and layout?

Response Summary:

Table 4-6: Tabular summary of responses for question #17

Similarities	Differences	Uniqueness
• Light Colours	• Arial Font Size 12 • Adjustable Font Sizes • Clear Navigation	• Black and White Colours • Green Colour • Let Project Managers Choose Colour Scheme for Own Projects • Warm-Layout • Limit Content to Fit in Users Browser Window

Discussion of Result:

Table 4-6 indicates that the majority of respondents would like the site to feature light colours. In contrast a lesser number of respondents suggested the use of Arial size 12 font in conjunction with the ability to adjust the font size and clear navigation that is consistent throughout the site. The result provides a vague indication of the sites aesthetics; however it is based on a small sample.

Section:

• Layout

Question #18:

• Would you like the theme to be consistent?

Response Summary:

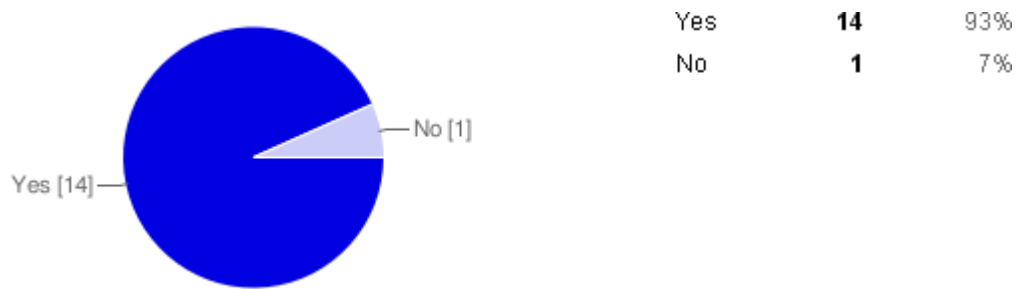|		
Yes	**14**	93%
No	**1**	7%

Figure 4-16: Pie chart summary of responses for question #18
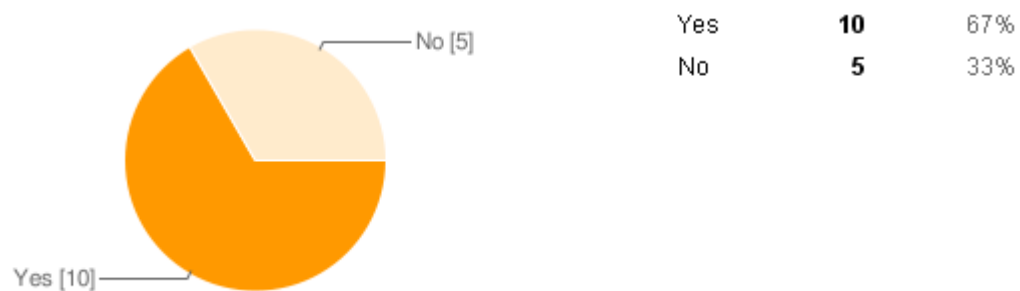
Discussion of Result:

Figure 4-16 illustrates that the majority of respondents (93%) would like the sites theme to be consistent across all pages.

Section:

- Layout

Question #19:

- Do you consider Real Simple Syndication (RSS) to be valuable in providing news updates?

Response Summary:

Yes	**10**	67%
No	**5**	33%

Figure 4-17: Pie chart summary of responses for question #19

Discussion of Result:

Figure 4-17 illustrates that the majority of respondents (67%) consider RSS to be a valuable resource for providing news updates. In contrast 33% oppose the idea; however this may be dependent upon their understanding of RSS. RSS subscription is by no means mandatory; therefore it will be left to the visitor's discretion.

Section:

- Layout

Question #20:

- If yes, please specify information you would like to receive?

Response Summary:

Table 4-7: Tabular summary of responses for question #17

Similarities	Differences	Uniqueness
	• New Projects • Project Member Responses to Comments • Latest 'Open' News • Site Updates • Project(s) Progress	• Latest Weblog Entries • User Workflows

Discussion of Result:

Table 4-7 indicates differences amongst all members in response to the question, those that responded suggested new projects, project member responses to comments, latest open source news, site updates and current projects progress be RSS feeds that are available for subscription. The result provides a good indication of what RSS feeds should be created, but does by no means provide a restriction.

4.3   Chapter Summary

In summary the number of responses received was limited compared to the anticipated number; however those that were received will be considered for the development of the infrastructure, with reference to each question the answers with the highest number of responses will take precedence over others, the identified stakeholder requirements of primary concern with respect to the development of the open source web based infrastructure have been listed below:

- Ensuring the email address, first name and surname of each user are the only details visible to others users when their profile is viewed.
- Providing users with the ability to edit and customise their personal profile
- Connecting user profiles to all communicative facilities offered by the infrastructure, including discussion forum, weblog and project comments
- Providing users with the ability to edit and customise their personal profile
- Providing users with ability to add or remove other users from within their profile
- Providing users with the ability to communicate with others members using a discussion forum
- Providing users with the ability to communicate with others members using a weblog
- Providing users with the ability to add or remove members from a project when a project coordinator
- Situating the discussion for a project within the project description
- Providing users with the option to register and/or login with their existing Facebook account.
- Ensuring users have direct access to the latest projects when visiting the site
- Ensuring the theme for the site remains consistent throughout the entire hierarchy

5. CHAPTER FIVE: INFRASTRUCTURE SYSTEM REQUIREMENTS SPECIFICATION (SyRS)

5.1 Introduction

5.1.1 Purpose

The purpose of this document is to identify the infrastructures functionality, external interfaces, performance, attributes, and design constraints imposed on the implementation as to provide the basis for the development of an open source web based infrastructure for designing medical devices.

5.1.2 Document Conventions

The document conventions that apply pertain to source code listed with 'Arial' Italic typeface, with emphasised sections in bold type.

5.1.3 Intended Audience and Reading Suggestions

The document is intended to be read by persons that have an active involvement in the development of the infrastructure, including developers and testers; however this does not exclude 'other' interested parties. It is suggested that the document be read in a top-down approach, however parties excluding developers and testers will predominately focus upon the introduction and system features.

5.2 Overall Description

5.2.1 Product Perspective

There is presently no web infrastructure for designing medical devices in an open source environment; the concept of designing medical devices in this manner is relatively novel with no prior work being reported. However, the infrastructure will borrow many of its features from existing solutions to open source development, namely software. Furthermore, within open source software (OSS) development developers and/or users are provided with collaborative Web 2.0 technologies, coordinative mechanisms and facilities to view and share files.

5.2.2 Stakeholder Roles and Responsibilities

The following table lists each stakeholder group as identified in the previous chapter, with the assignation of access rights for each of the resources available within the infrastructure.

Key:

R: Read

W: Write

(RA): Request Authorisation

5.2.3 Stakeholder Roles and Responsibilities

Table 5-1: Prime stakeholder groups and access rights

P	N	D	C	OEMs	SMEs	SA	Rights	Resources
X	X	X	X	X	X	X	R	Profile
X	X	X	X	X	X	X	W	
X	X	X	X	X	X	X	R	Private
X	X	X	X	X	X	X	W	Messaging
X	X	X	X	X	X	X	R	Project
X	X	X	X	X	X	X	W	Creation
X	X	X	X	X	X	X	R	Invite
X	X	X	X	X	X	X	W	Friends
X	X	X	X	X	X	X	R	Forum
X	X	X	X	X	X	X	W	
X	X	X	X	X	X	X	R	Weblog
X	X	X	X	X	X	X	W	
X (RA)	X (RA)	X (RA)	X (RA)	X (RA)	X (RA)	X	R	Comments

X	X	X	X	X	X	X	W	
X (RA)	X (RA)	X (RA)	X (RA)	X (RA)	X (RA)	X	R	Project Details, Files, Utilities
X	X	X	X	X	X	X	W	
X	X	X	X	X	X	X	R	Contacts
X	X	X	X	X	X	X	W	
X	X	X	X	X	X	X	R	News
X	X	X	X	X	X	X	W	
X	X	X	X	X	X	X	R	FAQs
X	X	X	X	X	X	X	W	
						X	R	Accounts
						X	W	

5.2.4   Use Case Diagrams for Stakeholder Groups

The following figures illustrate how the features will be represented within the infrastructure and the interactions that will occur from the perspective of each stakeholder group.
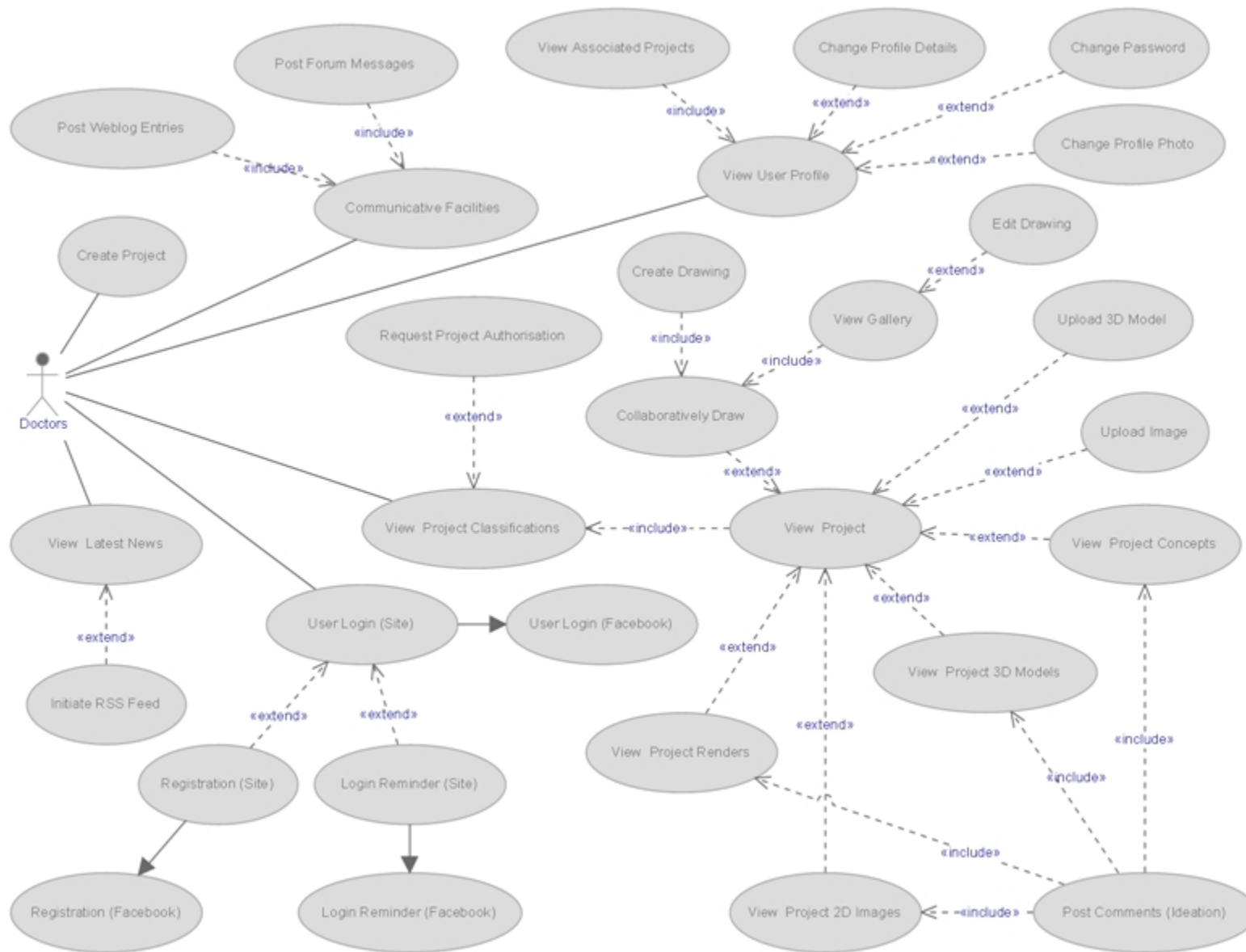
Figure 5-1: Use Case diagram from the stakeholder group 'Doctors'
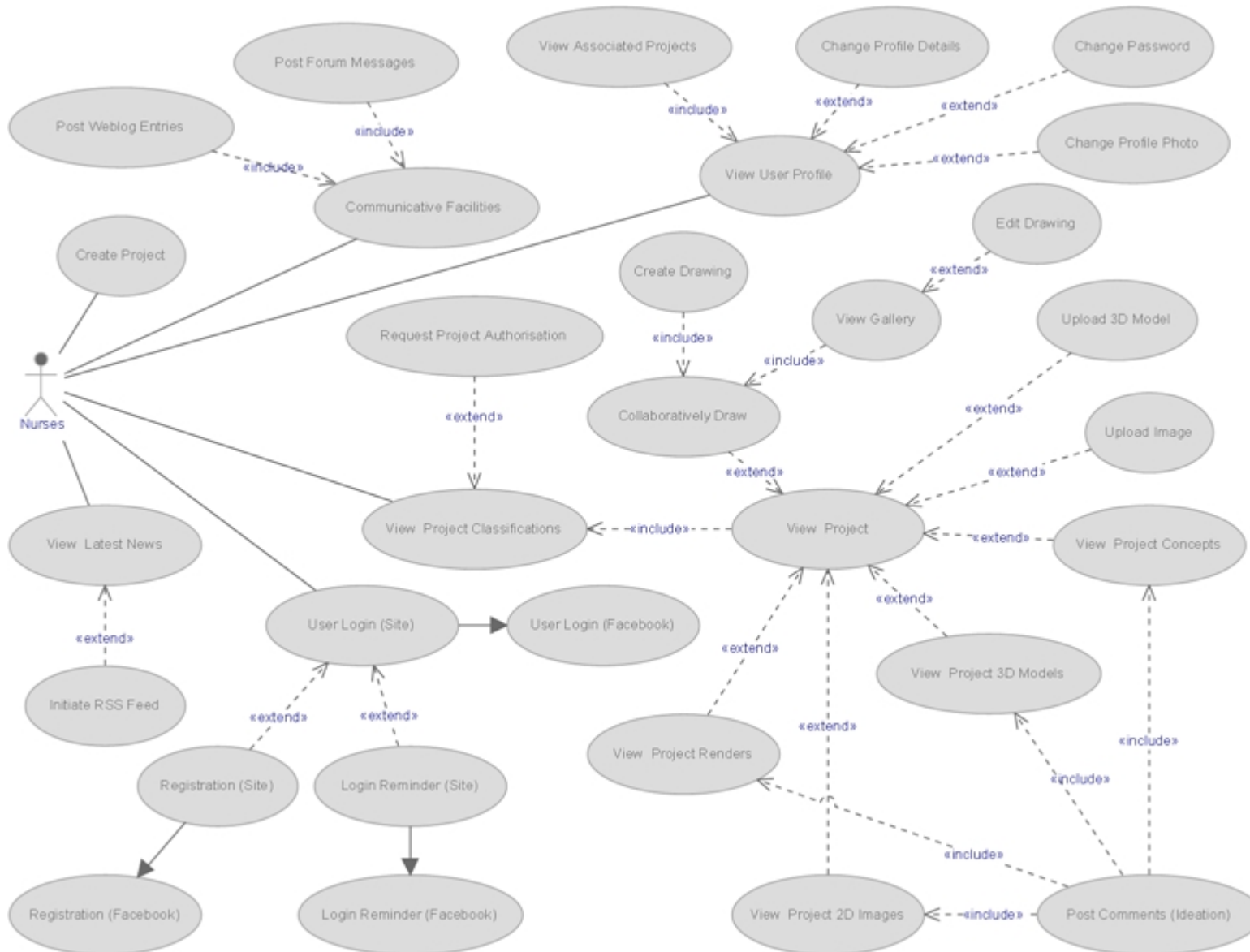
Figure 5-2: Use Case diagram from the stakeholder group 'Nurses'
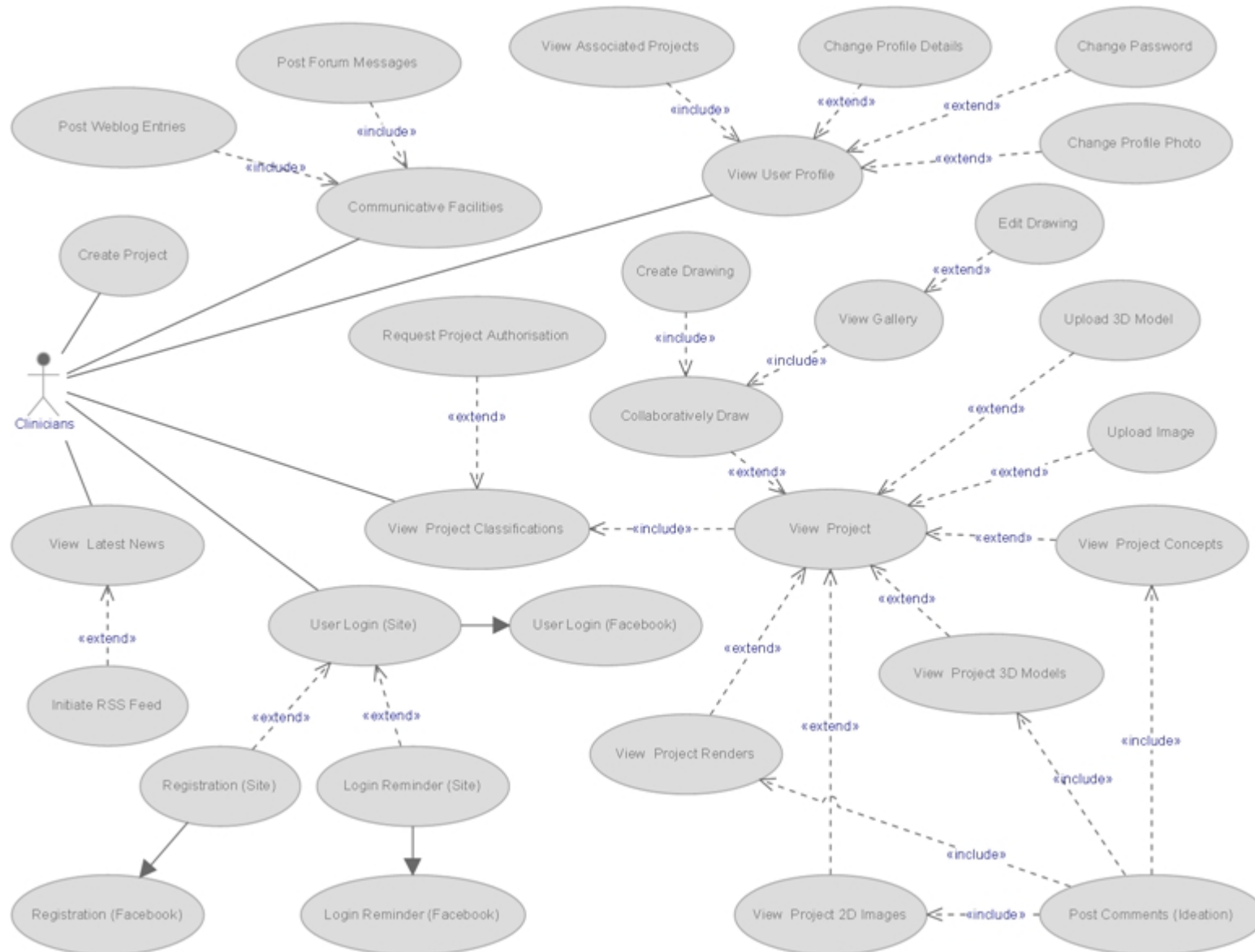
Figure 5-3: Use Case diagram from the stakeholder group 'Clinicians'

Figure 5-4: Use Case diagram from the stakeholder group 'Patients'
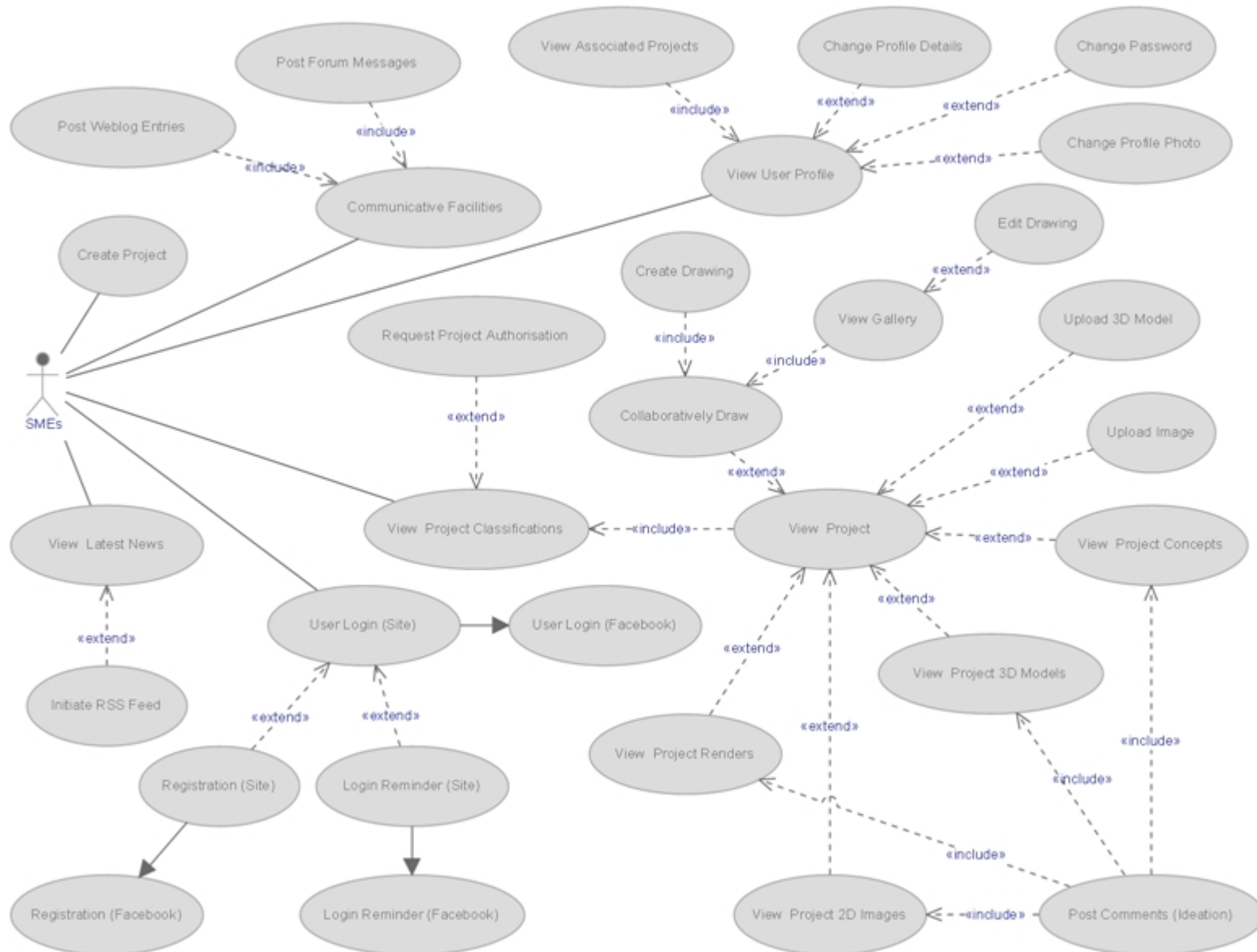
Figure 5-5: Use Case diagram from the stakeholder group 'SMEs'
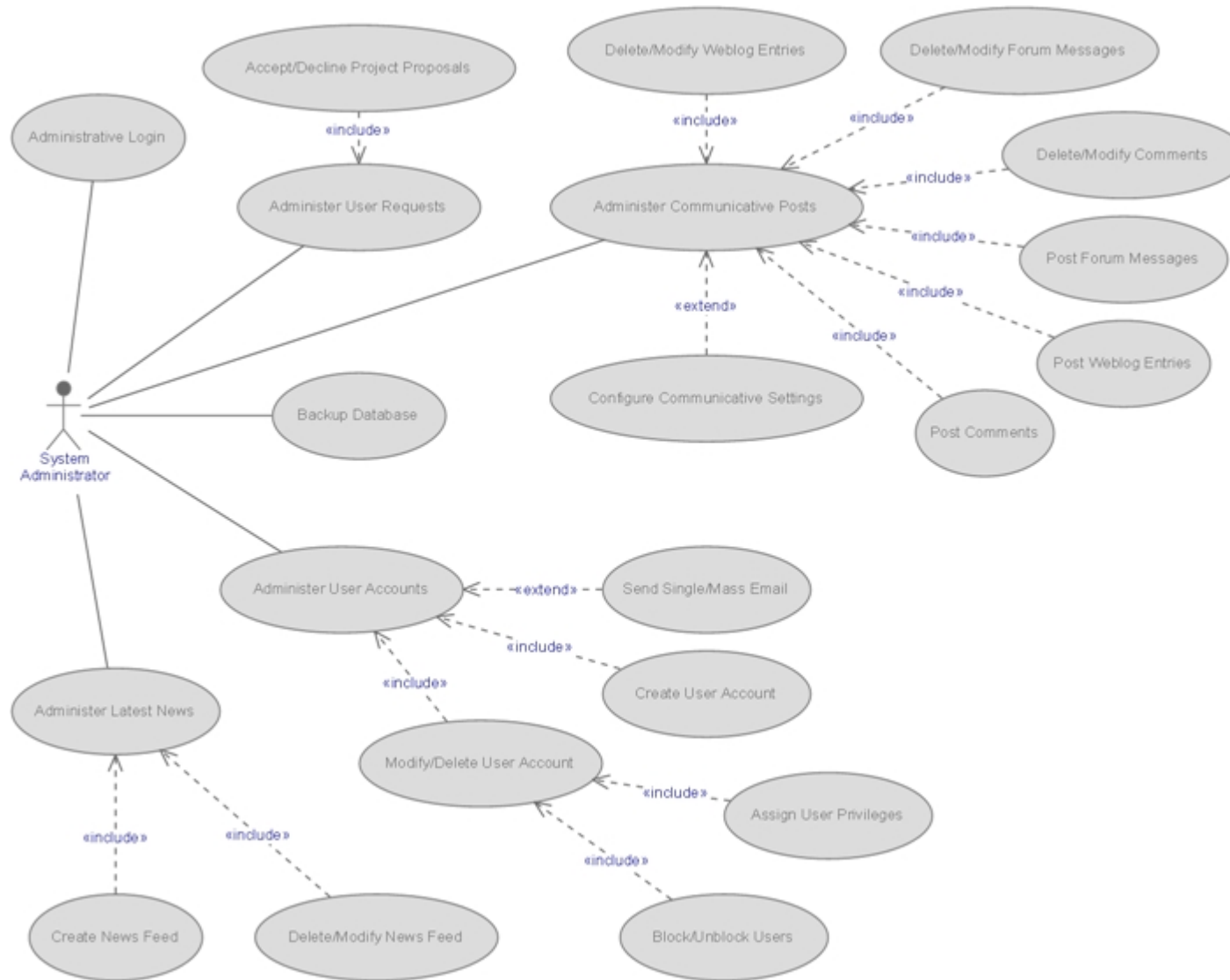
Figure 5-6: Use Case diagram from the stakeholder group 'System Administrator'
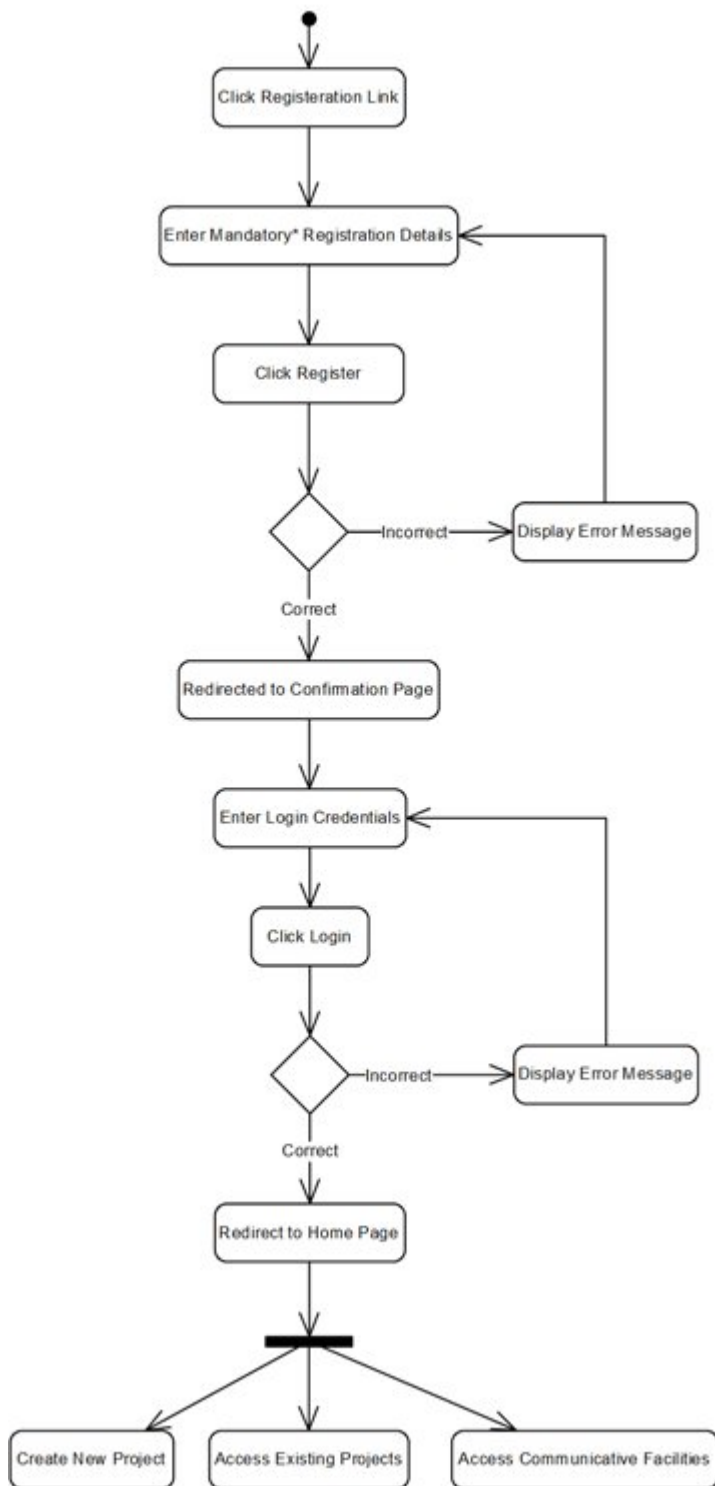
Stakeholder Site Interaction Activity Diagram

Figure 5-7: Top level activity diagram illustrating stakeholder site interaction

Figure 5-7 illustrates the interaction that would take place from the perspective of a stakeholder upon entering the site. It does not represent all interaction but serves as a top level view, further activity diagrams have been provided at latter stages in the chapter for four of the primary interfaces associated with new projects and existing projects. However additional activity diagrams can be found in the appendices under Appendix F pertaining to the communicative facilities that will provided as part of the infrastructure.

5.2.5   Product Features

With reference to the project focus, there will be four primary aspects of the system, all of which will be developed manually without the aid of a Graphical User Interface (GUI):

1. Create Project – The user shall be able to create a project pertaining to the development of an innovative medical device, if an existing member
2. Request Authorisation – The user shall be able to request authorisation from the coordinator to join the project, if an existing member.
3. Upload Image– The user shall be able to create a project pertaining to the development of an innovative medical device, if an existing member
4. Upload 3D Model – The user shall be able to request authorisation from the coordinator to join the project, if an existing member.

Details of the system features are provided in Section 4

5.2.6   User Classes and Characteristics

The primary user classes associated with the use of this infrastructure will be prime stakeholders as outlined in the use case diagrams; however this does not exclude other parties from registering and using the infrastructure for the purpose for which it was designed. It is not essential that 'all' users of the infrastructure are familiar with the product development lifecycle and posses the ability to draw and use graphics packages, however as a minimum requirement 'all' users are expected to contribute textually using the facilities provided. The frequency in-

use of the infrastructure is not a pre-determined factor, therefore it cannot be stated.

5.2.7   Operating Environment

The infrastructure is web based and will operate under a Linux, Apache, PHP and MySQL (LAMP) server configuration as specified by the remote host service provider; however Version 1.0 of the infrastructure has been tested and will operate under a Windows, Apache, PHP and MySQL (WAMP) server configuration. The infrastructure will be administered and maintained utilising an open source Content Management System (CMS), namely Joomla. The latest stable versions that are currently being used to support the infrastructure have been listed below:

Table 5-2: Infrastructure technologies and versions

Hardware/Software Vendor	Version
Apache	2.2.12 (Unix)
PHP	5.2.10
MySQL	5.0.81 (Community)
Joomla	1.5

Version 1.0 of the infrastructure has been tested and supported by most modern browsers, including Internet Explorer, Mozilla Firefox, Apple Safari, Google Chrome and Opera. However, this does not imply that legacy browsers will not support the infrastructure. The latest stable versions that are currently available have been listed below:

Table 5-3: Infrastructure supported browsers and versions

Browser Vendor	**Version**
Internet Explorer	8
Mozilla Firefox	3.5.2
Apple Safari	4
Google Chrome	2.0.172.39
Opera	9.64

The infrastructure will utilise minimal resources on the user's machine, namely memory and clock cycles, however the server will incur a higher dependency as the prominent language used to develop the infrastructure is PHP, therefore response time isn't immediate. The infrastructure does not require the user meet a set of specific hardware requirements, however the user must be able to run one of the specified supported browsers.

5.2.8   Design and Implementation Constraints

The infrastructure shall be developed under a LAMP server configuration as specified by the remote host service provider and will require the use of additional plug-ins, namely VRML and Flash and JavaScript to correctly display the content. Although not necessitate, by not installing or disabling such plug-ins will negatively impact the infrastructures operation, thereby limiting its functionality, however under no circumstances will the system be unusable. The system shall adhere to the standards as defined by the World Wide Web Consortium (W3C).

5.2.9   User Documentation

There will be an online user guide, and floating field tips will be employed in the infrastructure to assist users.

5.2.10 Assumptions and Dependencies

The infrastructure shall require the support of the project industrial supervisor 'Innovations Factory' with regard to its deployment and maintenance.

5.3 System Features

Note: The following system features will be programmatically developed and will not be dependent upon the components/extensions/plug-ins provided by the Joomla community, each feature documented inherit many of the same features, including form fields and validation for user input and a single user interface, therefore the process for each of the activity diagrams will inevitably be similar.

5.3.1 Create Project

5.3.1.1 Description

The infrastructure shall enable users to create a project(s) pertaining to the design and development of a medical device; assuming the user is logged in the infrastructure shall aim to capture a 'complete' description of the project as to aid others to understand. It is important to note that the infrastructure shall enforce that all fields are complete and accurate prior to submission with the aid of icons through the use of JavaScript calls and that all projects require the approval of the system administrator prior to advertisement.

5.3.1.2 Fundamental Functional Requirements

REQ-1: A label and text field to enter the project title

REQ-2: A label and select field to select the project risk level

REQ-3: A label and text area to enter the project purpose

REQ-4: A label and text area to enter the project scope

REQ-5: A label and text area to enter the project stakeholders

REQ-6: A label and text area to enter the project requirements

REQ-7: A label and text area to enter the project additional support

REQ-8: A submit button to store the project details in the database
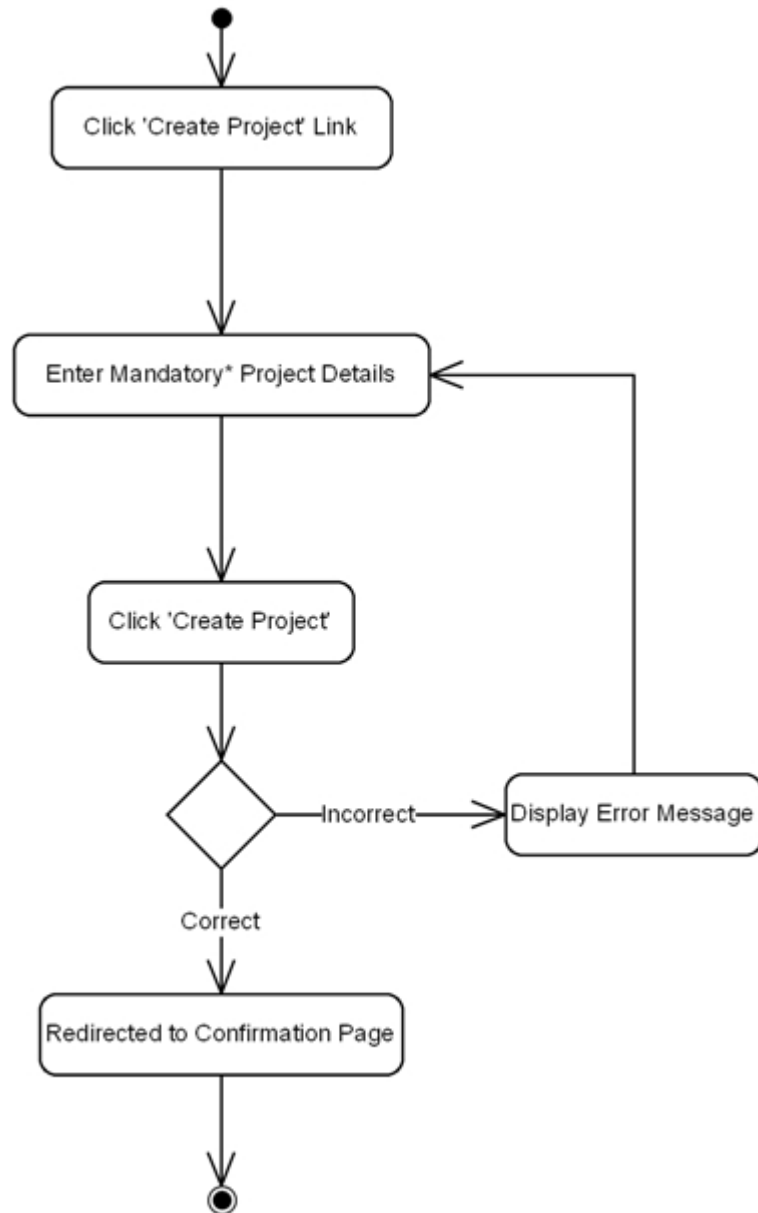
5.3.1.3 User Input Sequences

Figure 5-8: Activity diagram illustrating the user input sequence for the system feature 'Create Project'

5.3.2   Request Authorisation

5.3.2.1   Description

The infrastructure shall enable users to join a community orienting a project through requesting authorisation from the project coordinator; assuming the user is logged in the infrastructure shall aim to provide the coordinator with as much detail about the user requesting authorisation to ensure a fair decision. The infrastructure shall send the request to the coordinator's email address, in response to the decision an automated email will then be sent to the requester with notification of the decision.

5.3.2.2   Fundamental Functional Requirements

REQ-1:   A label and file upload field to browse and upload supporting files to aid the user's request

REQ-2:   A submit button to send the request to the project coordinator

5.3.2.3   User Input Sequences
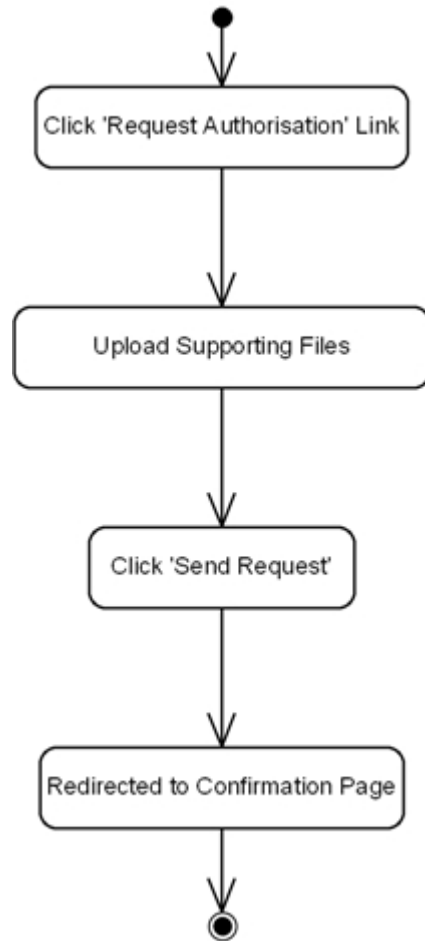
Figure 5-9: Activity diagram illustrating the user input sequence for the system feature 'Request Authorisation'

5.3.3 Upload Image

5.3.3.1 Description

The infrastructure shall enable user's to upload images for a specific project that illustrate respectively a Concept, 2D Image or Render, aiding the design and development of the associated medical device. It is important to note that the infrastructure shall enforce that all fields are complete and accurate prior to submission with the aid of icons through the use of JavaScript calls.

5.3.3.2 Fundamental Functional Requirements

REQ-1:   A label and text field for entering the image title

REQ-2:   A label and select field for selecting the image classification

REQ-3:   A label and text area for entering the image description

REQ-4:   A label and file upload field to browse and upload the image file

REQ-5:   A submit button to upload and store the image and its details within the database

5.3.3.3   User Input Sequences
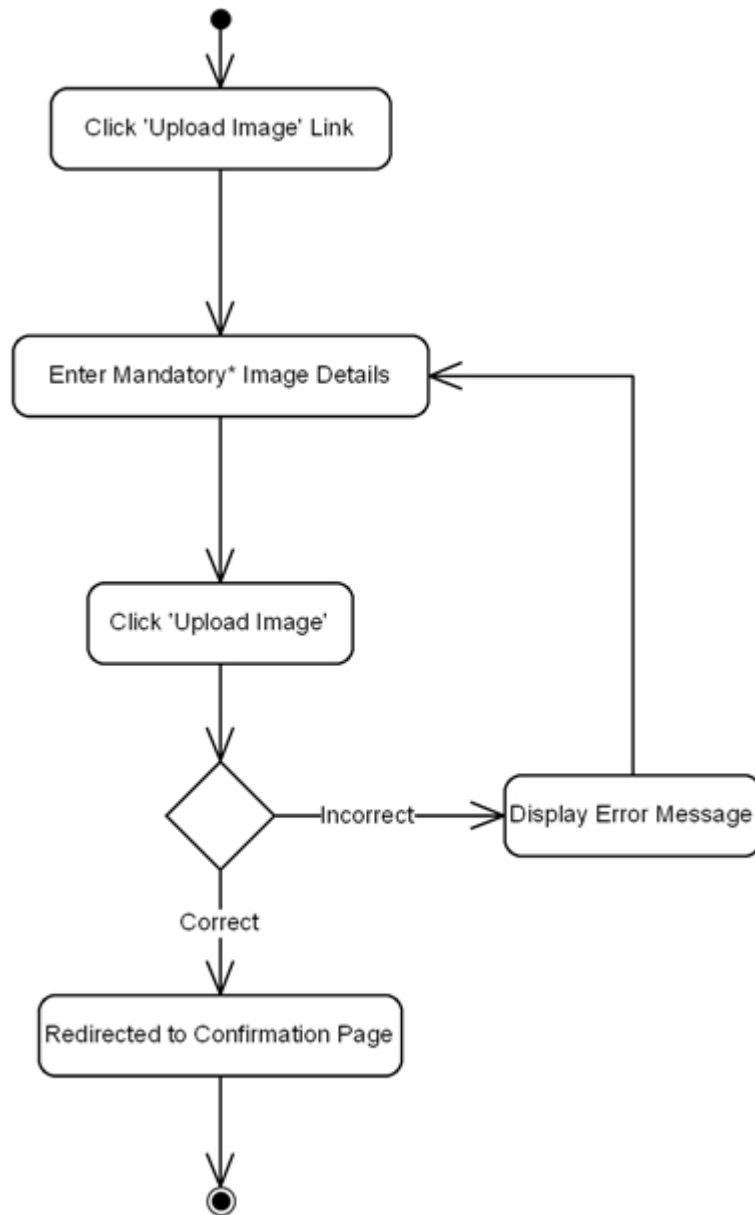
Figure 5-10: Activity diagram illustrating the user input sequence for the system feature 'Upload Image'

5.3.4   Upload 3D Model

5.3.4.1   Description

The infrastructure shall enable users to upload multiple files for a specific project that illustrate a 3D Model in various formats, aiding the design and development of the associated medical device. It is important to note that the infrastructure shall enforce that all fields are complete and accurate prior to submission with the aid of icons through the use of JavaScript calls.

5.3.4.2   Fundamental Functional Requirements

REQ-1:   A label and text field for entering the file title

REQ-2:   A label and text field for entering the file version number

REQ-3:   A label and text area for entering the file description

REQ-4:   A label and file upload field to browse and upload the file in VRML format

REQ-5:   A label and file upload field to browse and upload the file in U3D format

REQ-6:   A label and file upload field to browse and upload the original file in a compressed format

REQ-7:   A submit button to upload and store the files and the associated details within the database

5.3.4.3   User Input Sequences
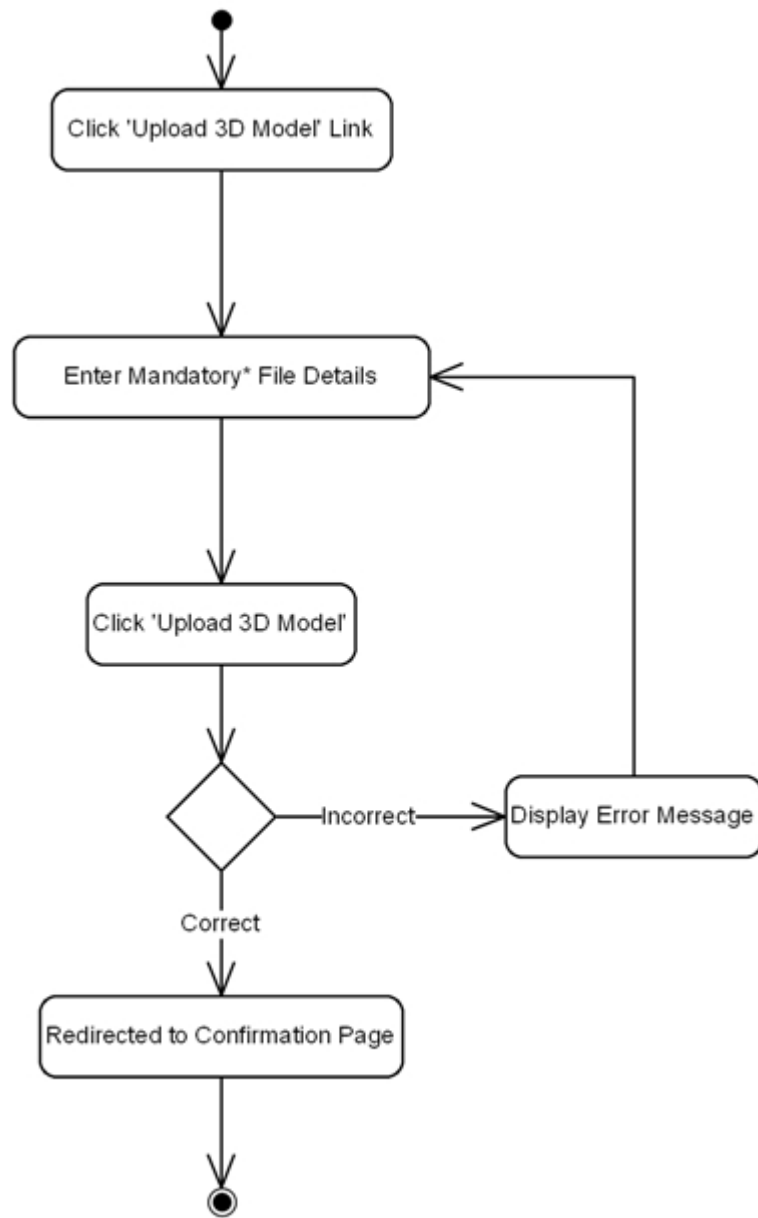
Figure 5-11: Activity diagram illustrating the user input sequence for the system feature 'Upload 3D Model'

5.4 External Interface Requirements

5.4.1 User Interfaces

The following figure illustrates the primary interface of the infrastructure, the majority of the infrastructures functionality can be accessed via mouse clicks, the systems features are distributed as follows:

Table 5.3: Mapping system features to their absolute position and location

System Feature	Page	Location	Additional
Create New Project	Project Details	*Header* Navigation Menu (Right)	The user must be logged in
Request Project Authorisation	Project Details	*Body* Navigation Menu (Right)	The user must be logged in and not a member of the project
Upload Image	Project Details	*Body* Navigation Menu (Right)	The user must be logged in and a member of the project
Upload 3D Model	Project Details	*Body* Navigation Menu (Right)	The user must be logged in and a member of the project

In the primary interface, from top to bottom, user login fields with a 'Facebook Connect' button for an alternate method to register/login, primary navigation, secondary navigation with a link to register on the website (page header, right), navigation with access to available projects - categorised by project risk level (page body, right higher), navigation with access to project files and utilities – inactive until a project is accessed (page body, right lower).
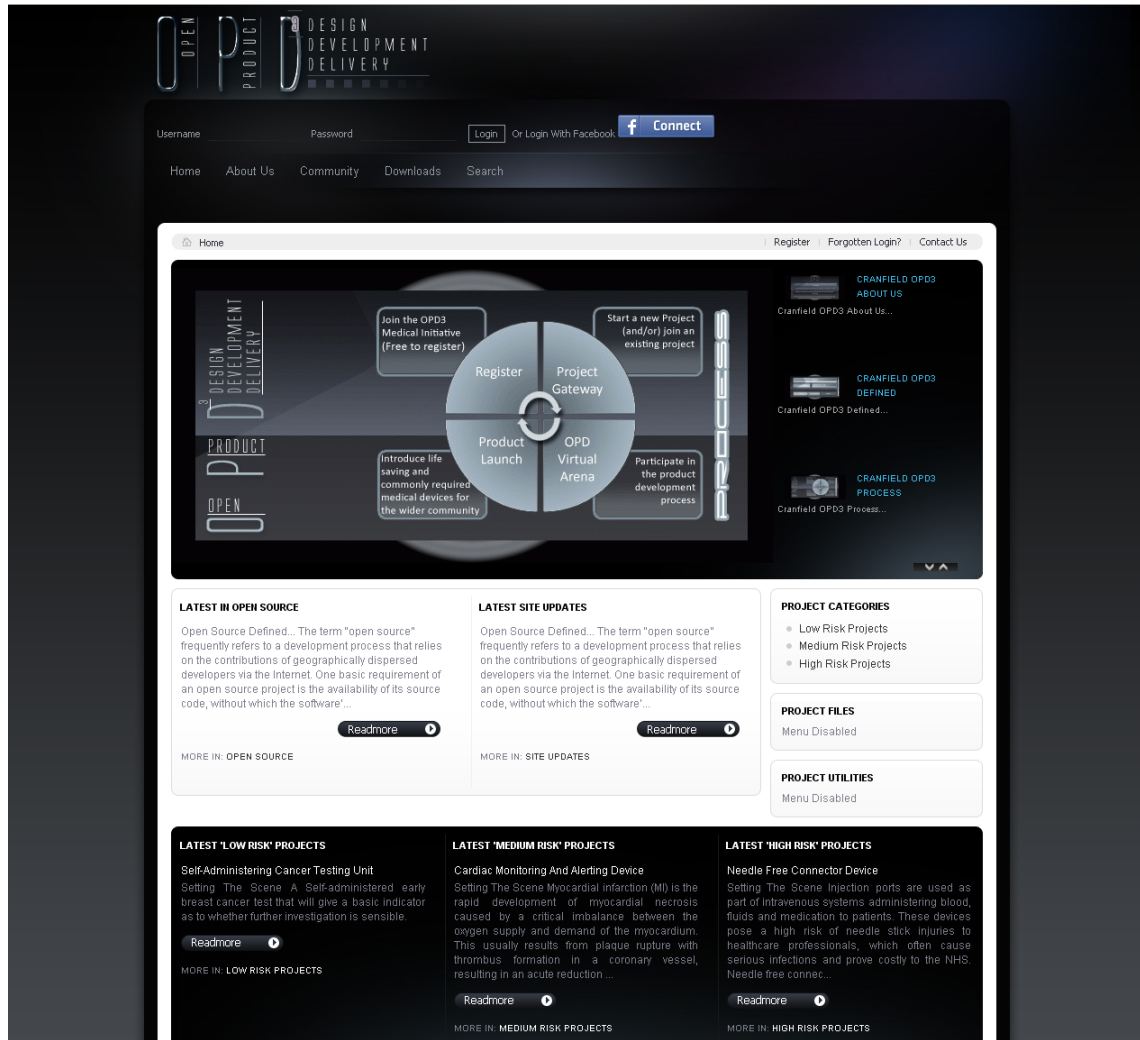
Figure 5-12: Screen capture for Version 1.0 of the infrastructure

5.4.2 Communications Interfaces

The infrastructure will operate using the HTTP communication protocol and as stated in section 2.4 the infrastructure has been tested under the majority of modern web browsers. The infrastructure shall use the remote host service providers pre-configured SMTP server to relay emails to users using the PHP mail() function, outbound emails generated by Cranfield OPD[3] will support both html and be capable of handling multiple file attachments in a wide variety of formats using the MIME email extension.

5.5   Other Non-Functional Requirements

5.5.1   Performance Requirements

The infrastructure must perform at pace that does not slow user input and server response times. The current implementation satisfies this requirement, however it has not been tested under abnormal conditions. Furthermore as stated in section 2.4 the prominent language used to develop the infrastructure is PHP, therefore as a future recommendation if performance requirements aren't met it would be preferable to relieve the dependency on the server through code migration.

5.5.2   Security Requirements

The infrastructure is connected to the internet therefore the number of security threats is limitless; however the most prominent threats will be addressed within the infrastructure design and development, including SQL Injection and Cross Site Scripting (XSS). Furthermore as the infrastructure will be primarily developed using Joomla as discussed in section 2.4, security precautions are automatically inherent, e.g. upon registration, all passwords are encrypted and stored in the database.

5.5.3   System Quality Attributes

The infrastructure will be designed and developed primarily using Joomla as discussed in section 2.4 for robustness and ease of maintenance. Joomla provides a user friendly administrative GUI to manage the infrastructures content, whilst being extensible through components, extensions and plug-ins developed and provided by the Joomla community, the majority of which require 'one click' installation and minimal configuration.

5.5.4   Other Requirements

The stakeholder requirements identified in the previous chapter will be satisfied by the development of the infrastructure, outstanding requirements will be documented for future development.

It is important to note that Joomla encapsulates all interaction with the database; thereby tables are implicitly created and updated. However, to suffice the infrastructure requirements and functionality, four additional tables will need to be added explicitly, the following figure illustrates an entity relationship diagram (ERD) representing the interrelationships between the additional entities to be added to the database:
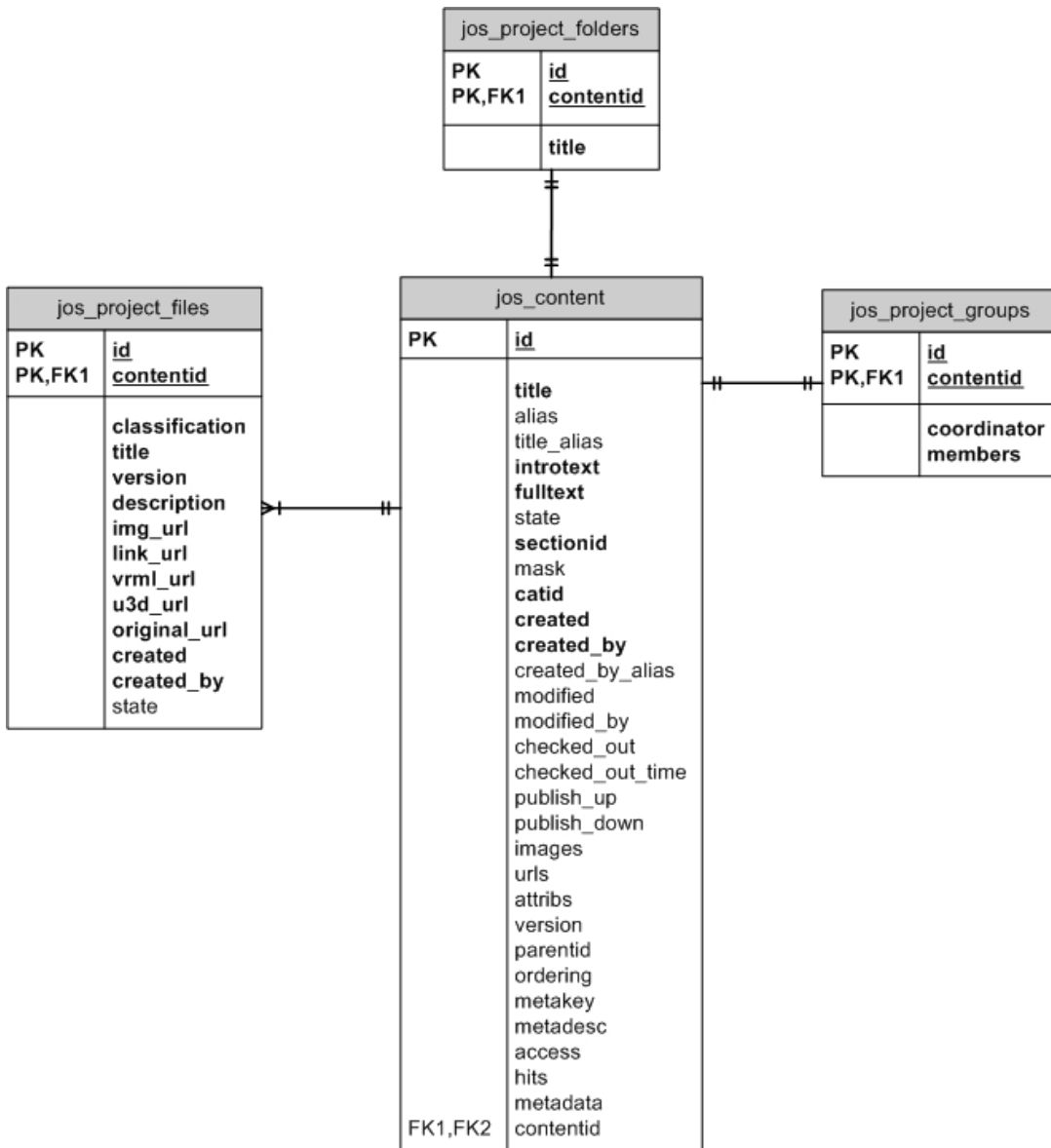

Figure 5-13: Entity relationship diagram (ERD) for additional entities to be added to the database

5.6   Chapter Summary

In summary, the System Requirements Specification (SyRS) provides a base document for the development of the open source web-based infrastructure; it identifies the prime stakeholders, their access rights and involvement within the infrastructure. It then describes the functional requirements of the primary interfaces that stakeholders will interact with when creating a project, requesting authorisation for a project, uploading images and/or models. The interface descriptions include a user input sequence to document the flow of interaction between the stakeholder and interface and a table of elements that will be required as part of the interface. In general the non-functional and functional requirements of the system have been discussed, those of which have been confirmed include the hardware/software vendors to be utilised as the platform for development. Joomla will be used as the Content Management System (CMS), enabling the infrastructure content to be easily administered, additionally the infrastructure will be developed under a LAMP server configuration as specified by the remote host service provider and will require the use of additional plug-ins, namely VRML and Flash and JavaScript to correctly display the content.

6.	**CHAPTER SIX: OPD3 Prototype Development and Validation**

6.1   Introduction

6.1.1   Purpose

The purpose of this document is to provide insight into the development of each of the four system features as discussed previously in the SyRS, the SyRS outlines what the infrastructure will do, the following section will act as a continuation, revealing and explaining a sample of the underlying source code with screen captures as visual aids to demonstrate what has been done. To clarify, the system features have been developed programmatically and adapted to the Joomla core files using a component developed and provided by the Joomla community, namely 'Joomla PHP Component' available from Fiji Web Design, therefore modification is not possible from within the Joomla GUI. It is important to note that while not all will be documented, the complete list of Joomla extensions used within the infrastructures design and development can be found in the appendices under Appendix B.

6.1.2   Document Conventions

The document conventions that apply pertain to source code listed with 'Arial' Italic typeface, with emphasised sections in bold type. The document is not a guide to installing and configuring Joomla, nor MySQL, it is assumed that the reader understands both are pre-requisites of the infrastructure, furthermore for the purpose and scope of this document it is recommended but not essential that the reader has a basic understanding of PHP and MySQL syntax.

6.2   System Feature - Page Reference

The following list has been provided for the purpose of the reader's reference and referral to the complete source code of the system features to be discussed, all pages are saved with a .php extension.

Table 6-1: Mapping system features to PHP pages for reference purposes

System Feature	Page Reference
Create Project	createproject.php
Request Authorisation	request.php
Upload Images	uploadimage.php
Upload 3D Models	uploadfile.php

6.3   Common Pages

It is important to note that the above pages reference additional pages within the source code, those that appear common amongst all of the system features include:

- connection.php
- constants.php
- formfunctions.php
- formvalidation.js
- form.css

6.4   Common Constructs

The system features whilst inheriting common pages inherit common constructs (source code); to prevent repetition the constructs have been listed below accompanied by a brief explanation detailing their function within the page.

6.4.1 Get Page URL

Construct Explanation:

Appendix E1 is a function 'cur_page_url' used to construct a new page URL, this is used as a safety precaution to prevent malicious web users from injecting code into the current page URL, known as Cross Site Scripting (XSS). The newly created URL is set to the variable $pageurl and returned back to where the function was initiated once 'cur_page_url' has finished executing.

6.4.2 Get Current Date/Time and User ID

Construct Explanation:

Appendix E2 utilises a predefined Joomla class and function to retrieve and set the currently 'logged in' user id to the variable $setuser, and a predefined PHP function 'date' to retrieve and set the current date and time to the variable $datetime, both of which are stored in the database for project purposes.

6.4.3 Input Form

Construct Explanation:

Appendix E3 creates an input form; the form creating the project is included within the source code from an external source using:

```
<?php include("includes/formproj.php");?>
```

The portion of source code that will differ between system features is the external page to be included as highlighted above. The system features and their associated external pages used to create each form have been listed below:

Table 6-2: Mapping system features to PHP form pages for reference purposes

System Feature	Page Reference
Create Project	formproj.php
Request Authorisation	request.php
Upload Images	formimg.php
Upload 3D Models	formfile.php

An additional difference between each system feature is the title of the submit button used in each form, the above source code is extracted from createproject.php, hence the title of button as highlighted in the footer of the source code.

Note: The cur_page_url() function is executed once the form is submitted, indicating that the form is submitted back to itself.

6.5   Unique Constructs

The unique constructs for each system feature exist in the portion of source code executed once the form is submitted, the constructs will be listed below with a screen capture of the system feature as viewed by a web browser and an explanation of the construct, however an exhaustive list will not be provided.

6.5.1   System Feature: Create Project

Figure 6-1: Screen capture for the system feature 'Create Project'

6.5.1.1 Prepare Form Fields for Database

Construct Explanation:

Appendix E4 loops through the information submitted by the user, the information is associated to its form field title. The form field title determines how the information entered by the user is formatted prior to being stored in the database. In this case a prime example has been highlighted, indicating all of the information other than the project's title, classification and purpose being concatenated and appended with html tags to justify the text for display purposes.

6.5.1.2 Check and Generate Random Folder Title

Construct Explanation:

Appendix E5 generates a random number using the predefined php function 'mt_rand()' and assigns it to the variable $randval. The user defined function check_multi_folders is used as a precaution against duplicity of folder titles; this ensures each project has a unique folder title as to prevent confusion for the database when loading files from a specific project folder.

6.5.2 System Feature: Request Authorisation
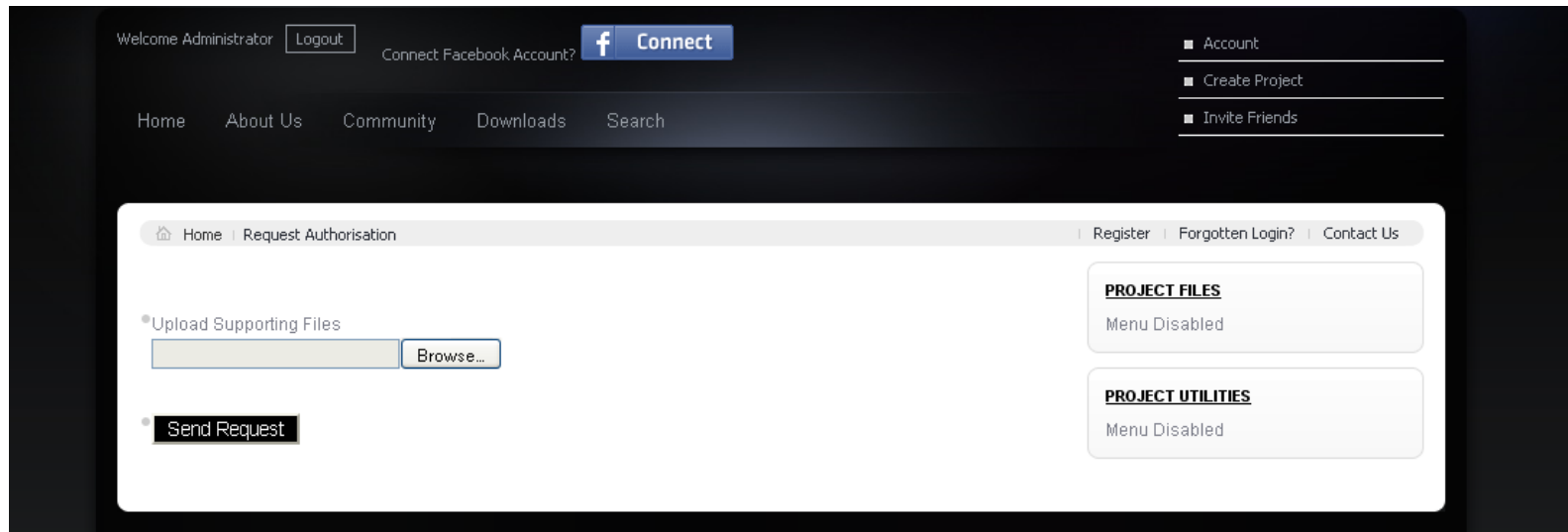
Figure 6-2: Screen capture for the system feature 'Request Authorisation'

6.5.2.1   Retrieving Multiple Fields Using a Table Join

Construct Explanation:

Appendix E6 utilises get_multi_db_fields() a user defined function to retrieve multiple fields from three tables and assign them to $mailinfo which is used as an associative array. The highlighted source code reflects variables respectively assigned the recipients email address and name, values returned from get_multi_db_fields().

Appendix E7 reflects the function get_multi_db_fields(), the SQL query is performed across three tables using a table join and utilises the project id that is passed into the function as the condition to which rows are retrieved from the tables. The field values from the rows returned include, the project title, coordinator email and name.

6.5.2.2   Generating an Email Using the MIME Email Extension

Construct Explanation:

Appendix E8 represents the first half of the source code for generating a MIME email message segmented into three segments, the first segment generates a random boundary string, the second segment attaches the headers for a file attachment and the third segment adds a multipart boundary above the plain message of the email. The remaining source code reads in the file that the user uploaded, encodes the data and attaches the file attachment to the message. To reiterate emails generated with a MIME type extension support both html and are capable of handling multiple file attachments in a wide variety of formats.

6.5.3   System Feature: Upload Image

Figure 6-3: Screen capture for the system feature 'Upload Image'

6.5.3.1 Resizing an Image Prior to Upload

Note: Source code extracted from 'filefunctions.php', but included within uploadimage.php

Construct Explanation:

Appendix E9 initially checks to see if the user has uploaded an image, if the user has uploaded an image then two variables are assigned a path where the image will be saved, the image classification depicts the save path. The image width and height are then obtained and two new variables determining the new width and height for the image are set, by default all images are resized to 640 x 480px. Using the new width and height the image is resampled and saved to the save path defined previously using the predefined php functions imagecopyresampled() and imagejpeg().

6.5.4   System Feature: Upload 3D Model

Figure 6-4: Screen capture for the system feature 'Upload 3D Model'

6.5.4.1   Uploading Multiple Files

Note: Source code extracted from 'filefunctions.php', but included within uploadfile.php

Construct Explanation:

Appendix E10 loops through all the files that have been uploaded by the user, assigning a temporary filename, extracting the file extension and then assigning a new file name of a random value as precaution against duplicity of file titles; this ensures each project folder contains unique file titles as to prevent confusion for the database when loading files from a specific project folder. A variable is then defined depicting the save path of the file and the file moved from the source to the save path using the predefined PHP function move_uploaded_file(). This process is executed three times, once for every file uploaded by the user; however for the system feature 'Upload Image' it is only executed once.

Note: Screen captures for the system features which have not been illustrated within this chapter can be found in the appendices under Appendix D.

6.6   Validation of the Open Source Web Based Infrastructure

The following section will concentrate on the analysis of 'primarily' a closed ended questionnaire written and disseminated amongst stakeholders for feedback on the infrastructures current state to be utilised for the future development.

6.6.1 Document Conventions

The document conventions that apply pertain to closed ended questions analysed using pie charts and bar graphs.

6.6.2 Questionnaire Development

The questionnaire was developed with the intention of obtaining responses that would immediately identify areas for improvement, predominately focusing upon the infrastructures design and community building comparative to concept creation as this facet of the infrastructure development is covered by another researcher in part one of the project. Furthermore, the questions were grouped into sections, including general aspects of the site, content and layout, site attributes and recommendations. For guidance on how to structure and disseminate the questionnaire fellow researchers within open source were consulted.

6.6.3 Key Questions

The following questions have been extracted from the complete questionnaire which can be found in the appendices under Appendix C, all questions from the section 'Site Attributes' have been listed on the basis of their ability to immediately identify areas for improvement pertaining to the infrastructures current state:

Site Attributes:
- Rank: Clarity of Navigation
- Rank: Aesthetic Appeal
- Rank: Quality of Information
- Rank: Ease of Uploading Images/Files
- Rank: Ease of Downloading Images/Files
- Rank: Ease of Communicating with Members
- Rank: Conflict Handling
- Rank: Creating and Managing a Project

6.6.4 Identification of Respondents

Note: Refer to section 4.1.5

6.6.5 Collecting and Analysing Questionnaire Responses

Note: Refer to section 4.1.6

Prior to the in-house design sessions and dissemination of the questionnaire three projects were setup cooperatively with another researcher to help respondents understand the potential of the infrastructure, each project reflects that of a different medical device classification as defined below:

- **High Risk Devices**

  - Classified as being life supports, critical monitoring, energy emitting amongst other devices whose failure or mal-practice may result in serious injury to patient or fellow colleagues, e.g. anaesthesia ventilators, aspirators and incubators

- **Medium Risk Devices**

  - Classified as being diagnostic instruments whose malpractice, failure or absence without replacement would inevitably have a significant impact on patient care, but is unlikely to result in serious injury, e.g. ECG, phototherapy units and radiant warmers.

- **Low Risk Devices**

  - Classified as being 'any' device whose failure or malpractice is unlikely to result in serious consequences, e.g. electronic thermometer, sphygmomanometers and temperature monitor.

  (Wikipedia, 2009e)

However, it is important to note that although the projects were setup in cooperation with another researcher, the questionnaire pertains to that of part two of the project focusing only upon the web infrastructure capability.

The following figures illustrate the three projects as cooperatively setup on the infrastructure, arranged from high to low by medical device classification:

6.6.5.1   High Risk Project: Needle Free Connector Device

Figure 6-5: Screen capture for the project 'Needle Free Connector Device' classified as being 'High Risk'

6.6.5.2   Medium Risk Project: Cardiac Monitoring and Alerting Device

Figure 6-6: Screen capture for the project 'Cardiac Monitoring and Alerting Device' classified as being 'Medium Risk'

6.6.5.3 Low Risk Project: Self-Administering Cancer Test Unit

Figure 6-7: Screen capture for the project 'Self-Administering Cancer Testing Unit' classified as being 'Low Risk'

6.7 Questions and Analysis of Responses

Section:

- General Aspects of the Site

Question #1:

- How did you find out about the site?

Response Summary:

Search Engine	1	7%
Facebook	3	20%
Recommendation	9	60%
Direct Mailing	1	7%
Other	1	7%

Figure 6-8: Bar chart summary of responses for question #1

Discussion of Result:

Figure 6-8 illustrates that the majority of respondents (60%) discovered the site through a recommendation from another person, for the site to gain more widespread promotion other technological mediums will have to be used and Search Engine Optimisation (SEO) improved.

Section:

- General Aspects of the Site

Question #2:

- What was your reason for visiting the site?

Response Summary:

Figure 6-9: Bar chart summary of responses for question #2

Discussion of Result:

Figure 6-9 illustrates that the majority of respondents (67%) visited the site for the purpose of discovering educational/commercial information, unfortunately this result is dependent upon the mediums used to promote the site, furthermore using other technological mediums will not only attract a wider audience but those interested in contributing to current projects.

Section:

- General Aspects of the Site

Question #3:

- Did you successfully complete the registration process?

Response Summary:
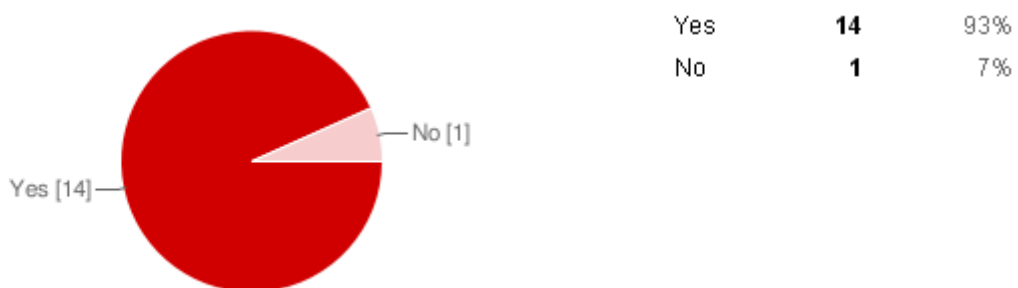
Figure 6-10: Pie chart summary of responses for question #3

Discussion of Result:

Figure 6-10 illustrates that the majority of respondents (93%) of respondents were able to complete the registration process on the site; this indicates that the registration process is user friendly and requires little or no improvement. The registration process is key aspect of the site as it provides the first impression of site usability.

Section:

- Content and Layout

Question #4:

- Is there sufficient information (on the homepage) with regard to the sites initiative?

Response Summary:

Yes	**11**	73%
No	**4**	27%
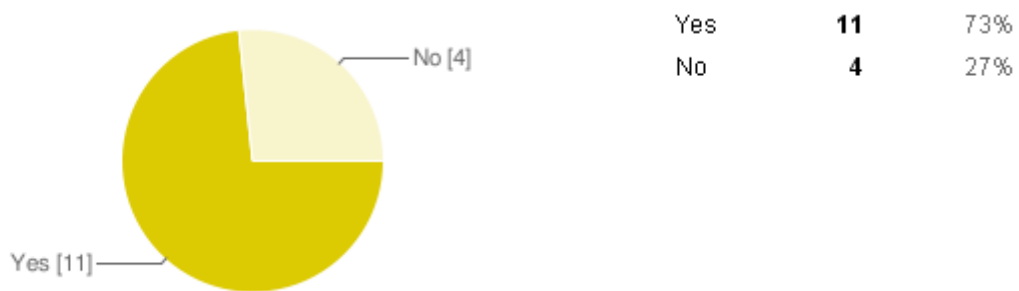
Figure 6-11: Pie chart summary of responses for question #4

Discussion of Result:

Figure 6-11 illustrates that the majority of respondents (73%) found the homepage to provide sufficient information on the sites initiative; however 27% of respondents oppose this view. This figure may reflect those who are not familiar with the open source initiative; however the information provided needs to cater for every visitor's requirements.

Section:

- Content and Layout

Question #5:

- What do you think of the design of the site?

Response Summary:

1 - Poor	**0**	0%
2	**0**	0%
3	**2**	13%
4	**8**	53%
5 - Very Good	**5**	33%

Figure 6-12: Bar chart summary of responses for question #5

Discussion of Result:

Figure 6-12 illustrates that the majority (86%) of respondents ranked the sites design at 4 (Good) and above out a total of 5 (Very Good); this indicates that there is little or no room for improvement. Furthermore design is relative to personal taste therefore it is almost impossible to meet every visitor's requirements.

Section:

- Content and Layout

Question #6:

- Did you find the contents and layout of the site to be clear in finding the required information?

Response Summary:

Yes, Without Any Problems **7** 47%
Yes, Only In Some Sections **7** 47%
Fairly **1** 7%
No, Layout Too Complicated **0** 0%
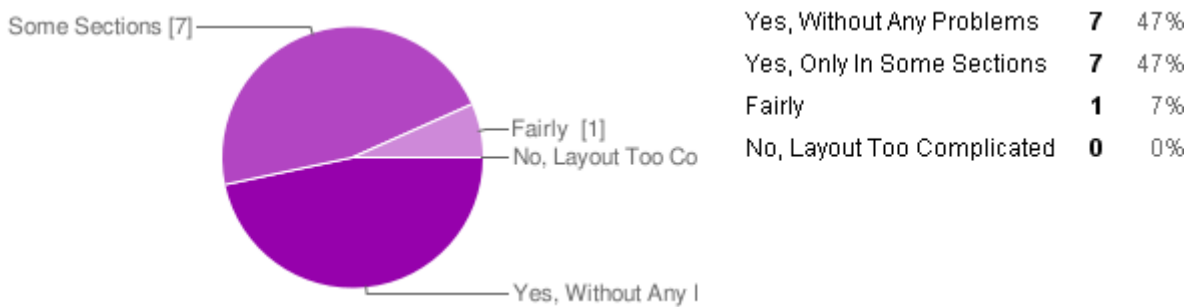
Figure 6-13: Bar chart summary of responses for question #5

Discussion of Result:

Figure 6-13 illustrates that 47% found the sites contents and layout to be clear in finding the required information, whilst 47% felt this applicable in some sections. This implies that although the site has aesthetic appeal it does not always promote ease of use in finding the required information.

Section:

- Site Attributes

Question #7:

- Rank: Clarity of Navigation

Response Summary:

1 - Very Poor **0** 0%
2 **0** 0%
3 **2** 13%
4 **9** 60%
5 - Very Good **4** 27%

Figure 6-14: Bar chart summary of responses for question #7

Discussion of Result:

Figure 6-14 illustrates that the majority (87%) of respondents ranked the sites clarity of navigation at 4 (Good) and above out a total of 5 (Very Good); this indicates that there is little or no room for improvement. With reference to figure 6-13, this implies that although 47% of visitor's could navigate to the content they could not necessarily find what they were looking for on the page.

Section:

- Site Attributes

Question #8:

- Rank: Aesthetic Appeal

Response Summary:

1 -	Very Poor	**0**	0%
2		**1**	7%
3		**3**	20%
4		**5**	33%
5 -	Very Good	**6**	40%
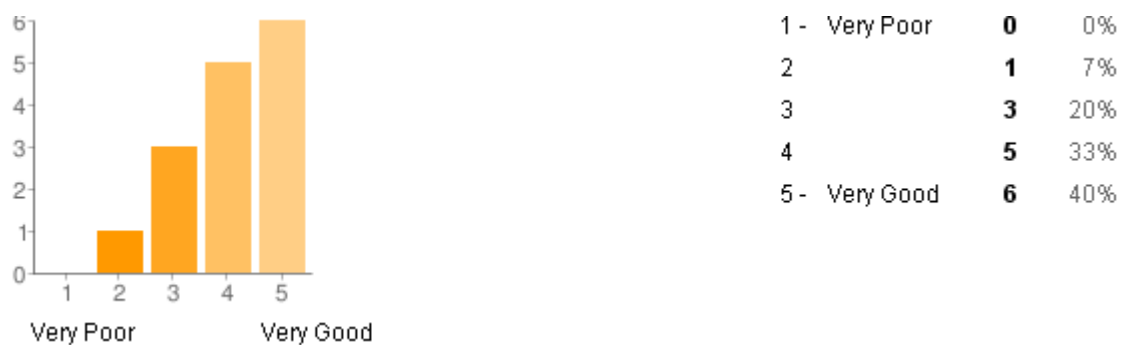
Figure 6-15: Bar chart summary of responses for question #8

Discussion of Result:

Figure 6-15 illustrates that the majority of respondents (73%) ranked the sites overall aesthetic appeal at 4 (Good) and above out a total of 5 (Very Good). With reference to figure 6-12 this implies that 2 respondents (13%) felt that the sites design is not the only factor that promotes aesthetic appeal.

Section:

- Site Attributes

Question #9:

- Rank: Quality of Information

Response Summary:

1 -	Very Poor	**0**	0%
2		**0**	0%
3		**3**	20%
4		**8**	53%
5 -	Very Good	**4**	27%

Figure 6-16: Bar chart summary of responses for question #9

Discussion of Result:

Figure 6-16 illustrates that the majority of respondents (80%) ranked the quality of information that the site provides at 4 (Good) and above out a total of 5 (Very Good). This implies that the site is a good resource for information; however with reference to figure 6-11, information on the initiative will need to be improved to ensure that visitor's do not only use the site as a resource but participate in current projects.

Section:

- Site Attributes

Question #10:

- Rank: Ease of Uploading Images/Files

Response Summary:

1 -	Very Poor	**0**	0%
2		**0**	0%
3		**1**	7%
4		**6**	40%
5 -	Very Good	**8**	53%

Figure 6-17: Bar chart summary of responses for question #10

Discussion of Result:

Figure 6-17 illustrates that the majority of respondents (93%) ranked the ease of uploading images/files at 4 (Good) and above out a total of 5 (Very Good); this indicates that two of the interfaces as mentioned in the System Requirements Specification (SyRS) are user friendly and require little or no improvement.

Section:

- Site Attributes

Question #11:

- Rank: Ease of Downloading Images/Files

Response Summary:

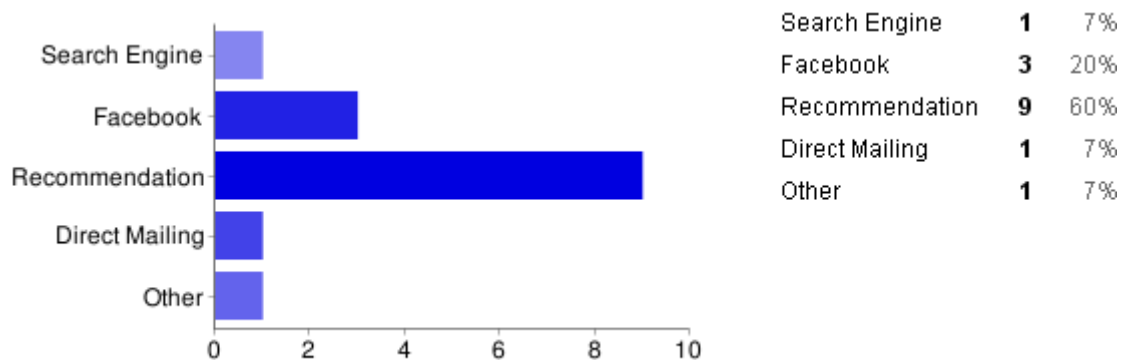|			
1 -	Very Poor	**0**	0%
2		**0**	0%
3		**1**	7%
4		**8**	53%
5 -	Very Good	**6**	40%

Figure 6-18: Bar chart summary of responses for question #11

Discussion of Result:

Figure 6-18 illustrates that the majority of respondents (93%) ranked the ease of downloading images/files at 4 (Good) and above out a total of 5 (Very Good); this signifies consistency in the respondents ability to upload and download files, although the interfaces are different.

Section:

- Site Attributes

Question #12:

- Rank: Ease of Communicating with Members

Response Summary:

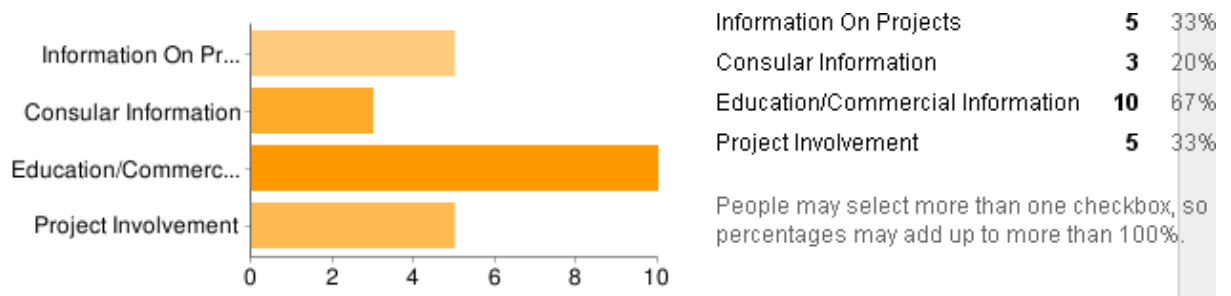|		
1 - Very Poor	**0**	0%
2	**0**	0%
3	**2**	13%
4	**5**	33%
5 - Very Good	**8**	53%

Figure 6-19: Bar chart summary of responses for question #12

Discussion of Result:

Figure 6-19 illustrates that the majority of respondents (86%) ranked the ease of communicating with members at 4 (Good) and above out a total of 5 (Very Good); this indicates that there is little or no room for improvement. However as communication underpins the whole purpose of open source it is important to consider additional communicative mediums, e.g. Internet Relay Chat (IRC).

Section:

- Site Attributes

Question #13:

- Rank: Conflict Handling

Response Summary:

|		
1 - Very Poor	**0**	0%
2	**0**	0%
3	**3**	20%
4	**8**	53%
5 - Very Good	**4**	27%

Figure 6-20: Bar chart summary of responses for question #13

Discussion of Result:

Figure 6-20 illustrates that the majority of respondents (80%) ranked the ease of communicating with members at 4 (Good) and above out a total of 5 (Very Good); this indicates that there is little or no room for improvement. At present there are a low number of members; however as the number of members increase auditing facilities will need to be in place for all communicative facilities in order to monitor member actions.

Section:

- Site Attributes

Question #14:

- Rank: Creating and Managing a Project

Response Summary:

|			
1 -	Very Poor	**0**	0%
2		**0**	0%
3		**2**	13%
4		**6**	40%
5 -	Very Good	**7**	47%

Figure 6-21: Bar chart summary of responses for question #14

Discussion of Result:

Figure 6-21 illustrates that the majority of respondents (87%) ranked the ease of creating and managing a project at 4 (Good) and above out a total of 5 (Very Good); this indicates that an interface as mentioned in the System Requirements Specification (SyRS) is user friendly and requires little or no improvement.

Section:

- Recommendations

Question #15:

- What would you like to see on the site that is currently not available?

Response Summary:

Table 6-3: Tabular summary for responses to question #15

<u>Similarities</u>	<u>Differences</u>	<u>Uniqueness</u>
• More Information on Initiative • Real-time Chat	• Wider Support for Multimedia Content • Links to External Sources of Information • Add or Remove Project Members	• View and/or Edit Projects From Within Profile • Project(s) Progress • Adopt a Project Theme and/or Logo

Discussion of Result:

Table 6-3 identifies that the majority of respondents agree that more information on the initiative should be provided on the sites home page, with reference to figure 6-11, although the majority of respondents agree the information on the home page regarding the sites initiative is sufficient, it only represents a very small proportion of people who will use the site. Additionally the majority of respondents suggested that a real-time chat facility should be a permanent feature of any open source community.

6.8 Chapter Summary

In summary the number of responses received were limited compared to the anticipated number, however those that were received will be considered for future development of the infrastructure, with reference to each question the answers with the highest number of responses or similarity will take precedence over others; a sample of the identified areas for improvement include:

- Improving the contents and layout of the site to ensure users are able to navigate the site and find content with ease.
- Providing more information with respect to the initiative to ensure users understand the sites purpose.
- Providing real-time chat for easier and more efficient communication amongst users of the site and members of a project.

## 7.	CHAPTER SEVEN: DISCUSSION OF RESULTS AND CONCLUSION

7.1   Methodology: Strengths and Weaknesses

It is important to note that although the methodology fulfilled the project requirements it does not insinuate that it is without its flaws, the following list reflects the weaknesses inherent within the methodology:

- It does not truly reflect the 'complete' systems development lifecycle (SDLC); the SDLC comprises 10 stages, two of which may be voided due to the nature of the project. However, respectively at present the methodology lacks or has partially completed:

  - Concept Development

  - Planning

  - Design

  - Integration and Testing

- It is prone to limited and inaccurate responses from stakeholders who have no interest or lack understanding within the projects deliverables; due to the specialist nature of the project primarily being targeted at those who use or design medical devices on a daily basis it is difficult to obtain responses, through analysis this was most common amongst 'patients'.

- It utilises only one form of knowledge capture technique, semi structured questionnaires thereby increasing the chances of inaccurate responses. An additional knowledge capture technique that could have been used as a deterrent to inaccurate responses pertains to informal interviews, respondents are less likely to provide falsified responses knowing they could be immediately identified and responded to.

However, the methodology in light of its weaknesses possesses strengths; the following list helps to clarify its effectiveness in fulfilling the project requirements:

- It adopts a Rapid Application Development (RAD) approach, a software development methodology which utilises minimal planning in favour of rapid prototyping, enabling faster development and facilitating application maintenance.

- It insists that stakeholder requirements are captured following an initial development of the system, although not considered the 'norm', it does however provide stakeholders with a visual aid to realise the development direction and potential to be exploited which in turn favours the quality of responses.

- It reviews disparate systems, technologies and services to incorporate the most prominent characteristics and features into the design and development of the prototype, comparative to focusing solely upon existing systems within the open source domain, for example Medicine/Health 2.0, Crowdsourcing and Social Networking.

7.2   Comprehensiveness of the Requirements

The infrastructure has been developed to accommodate all medical devices that are classified as high risk, medium risk or low risk devices. The infrastructure at present is restricted to 'only' cater for medical devices that reside under the above classifications; however this does not postulate that it cannot be adapted to facilitate devices external to this scope. Furthermore a way in which the infrastructure can be adapted pertains to dividing all devices by type, at present high risk devices, medium risk devices and low risk devices are the primary categories. Furthermore, 'medical devices' would become the 'new' primary category and its sub categories include high risk devices, medium risk devices and low risk devices; however, other device types will be organised using an alternate method. It is important to note that the infrastructure has been developed to support the new product

development process, a generic process used by all areas of industry; therefore the site would only require minor alterations to its navigation and product types available to the user when creating a new project whilst other areas remain unaffected. The infrastructure will support the open source movement towards medical device design by providing an 'initial' framework from which further developments can be derived and/or a catalyst for the propagation of equivalent or better open source web based infrastructures for medical device design and/or product design, reinforcing the notion that open source is not just software oriented.

7.3   Limitations of the Research

With reference to the weaknesses of the research methodology as discussed previously, the limitations of the research pertain to the:

- Lack of participation from stakeholders, persons who don't have an interest or lack understanding of the projects objective are more likely not to respond or provide answers that lack quality. Unfortunately limited responses were received for both questionnaires, however it should not be presumed to reflect stakeholder advocacy.

- Lack of diversity within knowledge capture techniques used, semi-structured questionnaires although a simple method to capture knowledge from sparsely separated stakeholders lack depth in the responses provided. An alternate and more efficient method would have been to arrange formal interviews with the prime stakeholders.

- Lack of stages performed within the development of the infrastructure, a RAD approach was adopted to accelerate development and facilitate maintenance, however in exchange it is stated that RAD approaches may entail comprises in functionality and performance.

(Wikipedia, 2009f)

7.4   Contributions to Knowledge

The project whilst delivering an open source web based infrastructure for designing medical devices contributes to the existing knowledge base within open source and its application to product development, the key findings indentified within the research include:

- Identification of the prime stakeholders, use cases (functions) and use case dependencies that exist within the infrastructure, utilising a behavioural diagram defined through use case analysis also referred to as a use case diagram.

- Identification of the user input sequences pertaining to the use of the infrastructure features predominately by the prime stakeholders, utilising a loosely defined diagramming technique for illustrating workflows also referred to as an activity diagram. Furthermore four activity diagrams were illustrated within the system requirements specification representing four of the system features manually developed.

- Identification of the infrastructure requirements, predominately those obtained from stakeholders otherwise seen as exempt the traditional IP model, e.g. doctors, nurses, clinicians and patients.

7.5   Relevance to Beneficiaries

In general, there will be three principal beneficiaries from the work conducted in this project. Firstly this work will encourage stakeholders that are seen as exempt from the current IP model and separated 'only' by distance to assist in the design of medical devices. Second, it will assist the wide range of companies who manufacture medical devices and utilise the existing IP model. The collaborative partner, Innovations Factory is a good example of a company, and the prime candidate to revolutionise the way in which medical devices are designed. Third, this work will aid the wider industrial and academic community by providing a body of knowledge on open source and its application to product design, namely medical device design.

7.6   Conclusion

The outcome of the research has been summarised below using the objectives as milestones towards the projects completion:

- (To define stakeholders that will contribute to open source medical device design and development.)
    - The prime stakeholders are defined as doctors, nurses, clinicians, patients, SMEs and OEMs that design medical devices on a daily basis, however this does not insinuate that others outside this scope are exempt from the process, the term open implies 'accessibility to all'.
- (To capture the defined stakeholder requirements.)
    - The stakeholder requirements were captured using a semi-structured questionnaire accessible online; the questions were structured in a manner that enabled almost anyone to answer, providing diversity in the responses. However, limited and inaccurate responses revealed an error in judgment by not using alternate knowledge capture techniques.
- (To develop a detailed specification of a web based infrastructure for the device development.)
    - The detailed specification was written using a template acquired from (processimpact, 2009) also referred to as a System Requirements Specification (SyRS). The SyRS represents a structured agglomeration of information that embodies the requirements of the infrastructure [IEEE Standard 1233-1998].
- (To develop a prototype web based infrastructure for the open source design.)
    - The prototype of the infrastructure was developed using a RAD approach to shorten development time and facilitate maintenance, the underlying foundation for the infrastructures development invokes the use of Joomla, an open source Content Management System and a subset of freely available

Joomla extensions that provide additional functionality to its standard codebase.

- (To assess the infrastructure based on in-house design sessions.)
    - The stakeholders were provided with a set of sample design data, user guide and invited to experiment with infrastructures facilities prior to answering a closed ended questionnaire with regard to the infrastructures current state. Utilising this method enabled immediate and direct responses to be obtained, identifying areas for improvement for future developments.

7.7   Further Work

The outcome of the research whilst delivering the project objectives identified areas for improvement, the majority of which were extracted from the stakeholder requirements prior to and after the infrastructures development; however due to time constraints and a strict project schedule these improvements have been documented and remain subject to future research and maintenance of the infrastructure:

7.7.1   Maintenance of the Infrastructure

- To provide users with the ability to access and edit 'authorised' projects from within their profile.
- To provide users with access to alternate social networking platforms in aid of user accessibility and community building.
- To provide support for an array of multimedia content other than images accessible within each project, including audio and video, aiding users to communicate an idea.
- To provide project coordinators with the option to add or remove users manually without the need for administrative intervention.
- To provide project coordinators with the option to limit the number of users authorised to access a project.

- To provide users with a real-time chat facility or access to an Internet Relay Chat (IRC) channel as utilised by F/OSS communities within their projects.

7.7.2   Further Research

- To critically research stakeholder capabilities to gain insight into the assignation of access levels to various stakeholder types, utilising an analytics tool and/or knowledge capture techniques.

- To critically research auditing tools for projects, primarily within the areas of version control, bug tracking and consider the possibility of adapting tools utilised within open source software development.

8. References

Amabile, T.M. 1996. *Creativity in context.* Boulder, CO: Westview Press.

Anderson, P. 2007. *What is Web 2.0? Ideas, technologies and implications for education.* Technology and Standards Watch.

APQC. 2000. Building and sustaining communities of practice: Final report. American Productivity and Quality Centre Report.

Baalen, P., Bloemhof-Ruwaar, J., Heck, E. 2005. Knowledge sharing in an emerging network of practice: the role of a knowledge portal. ERIM Report Series: Research in Management, Erasmus University Rotterdam, Netherlands.

Bauer, A., Pizka, M. 2003. The contribution of free software to software evolution. Paper presented at the *Sixth International Workshop on Principles of Software Evolution (IWPSE'03)*, Helsinki, Finland.

BMWi. 2001. Open-source software: *A guideline for small and middle-sized enterprises.* 1st edition. German Federal Ministry for Economy and Technology.

Boulos, M.N.K., Maramba, I., Wheeler, S. 2006. Wikis, blogs and podcasts: a new generation of Web-based tools for virtual collaborative clinical practice and education. BMC Medical Education. [Online] 6:41. Available from: DOI: 10.1186/1472-6920-6-41 [Accessed 15th August 2009].

Brabham, D.C. 2008. Crowdsourcing as a Model for Problem Solving. *The International Journal of Research into New Media Technologies*. [Online] 14(1), 75–90. DOI: 10.1177/1354856507084420 [Accessed: 28th June 2009].

Brooks, F. P. 1995. *The mythical man-month: Essays on software engineering*, 2nd editon, 20th anniversary edition. Reading, MA: Addison Wesley.

Brown, J.S., Duguid, P. 2000. *The Social Life of Information*. Harvard Business Press: Boston, MA.

Ciborra, C.U., Patriota, G., 1998. Groupware and teamwork in R&D: limits to learning and innovation. R&D Management 28 (1), 1, 10.

combinedstory, DMD New York, Market Truths. 2007. *The Virtual Brand Footprint: The Marketing Opportunity In Second Life*.

Cross, R., Borgatti, S.P., Parker, A. 2002. *Making Invisible Work Visible: Using Social Network Analysis to Support Strategic Collaboration*. University of Virginia.

Cross, R., Borgatti, S.P., Parker, A. 2002. *Making Invisible Work Visible: Using Social Network Analysis to Support Strategic Collaboration*. University of Virginia.

Dafermos, G. N. 2001. Management & decentralised Virtual Structures. *The Case of the Linux Project*. [Online]. Available from: www.firstmonday.org

Deci, E.L, and Ryan, R.M. 1985. *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.

Dwyer, C., Hiltz, S.R, and Widmeyer, G. 2008. Understanding Development and Usage of Social Networking Sites: The Social Performance Model. In: Pace University, New Jersey Institute of Technology: Proceedings of the 41st Hawaii International Conference on System Sciences, 2008. pp 2-3

Edwards, K. 2001. Epistemic communities, situated learning and open source software development. Paper presented at the *Epistemic Cultures and the Practice of Interdisciplinary Workshop* at NTNU, Trondheim.

Eysenbach, G. 2008. Medicine 2.0: Social Networking, Collaboration, Participation, Apomediation, and Openness. Journal of Medical Internet Research. [Online] 10(3): e22. Available from: DOI: 10.2196/jmir.1030 [Accessed 14th August 2009].

Feller, J, and Fitzgerald, B. 2001.*Understanding Open Source Software Development*. Addison Wesley.

Feller, J., Fitzgerald, B., Hissam, S.A & Lakhani K.R (eds.). 2005. *Perspectives on Free and Open Source Software*. MITPress.

Fiji Web Design. 2009. *Joomla PHP Pages* [Online]. Available from: http://www.fijiwebdesign.com/products/joomla-php-pages.html [Accessed 17th August 2009].
Fogel, K. 2005. *Producing Open Source Software: How to Run a Successful Free Software Project*. O'Reilly Media, Inc.

Gattiker, U.E. 2001*. The internet as a diverse community: Cultural, organizational and political issues*. NJ: Lawrence Erlbaum Associates, Inc.

Ghosh, R.A. 1998. FM Interview with Linus Torvalds: What Motivates Free Software Developers? First Monday 3(3). [Online]. Available from: http://www.firstmonday.org/issues/issue3_3/torvalds/index.html [Accessed: 29th June 2009].

Ghosh, R.A. 2005. Cooking-pot markets and balanced value flows. In: Ghosh, R.A. (ed.) *Collaboration and ownership in the digital economy*. Cambridge, MA: MIT Press.

Hars, A., and Ou, S. 2002. Working for free? Motivations for participating in opensource projects. *International Journal of Electronic Commerce* 6 (3): 25–39.

Hars, A., Ou, S. 2001. Working for free? – Motivations for participating in open source projects. In *Proceedings of the 34th Hawaii International Conference on System Sciences (HICSS-34),* January 3-6.

Helms, M. 2007. *Crowdsourcing: Harnessing the Wisdom of the Crowd.* The University of Arizona.

Heng So, H.H. 2005. *Construction of an Evaluation Model for Free/Open Source Project Hosting Sites.* PhD Thesis. RMIT University.

Herman, A., Coombe, R.J, and Kay, L. 2006. Your Second Life? Goodwill and performativity of intellectual property in online gaming. *Cultural Study.* [Online] 20, 184-210. Available from: DOI: 10.1080/09502380500495684 [Accessed 28th June]

Hertel, G., Niedner, S, and Herrmann, S. 2003. Motivation of software developers in open source projects: an Internet-based survey of contributors to the Linux kernel. *Research Policy.* 32 (7): 1159–1177.

Hildreth, P., Kimble, C and Wright, P. 1998. Computer mediated communications and international communities of practice. *In Proceedings of Ethicomp '98,* Netherlands.

Himanen, P. 2001. The hacker ethic and the spirit of the information age. New York: Random House.

Holmström, B. 1999. Managerial incentive problems: A dynamic perspective. Review of Economic Studies 66:169–182.

Holsthouse, D., 1998. Knowledge research issues. California Management Review 40 (3), 277, 280.

Howe, J. 2006. Customer-Made: The Site. *Crowdsourcing: Tracking the Rise of the Amateur.* Weblog. [Online] Available from: http://crowdsourcing.typepad.com/cs/2006/06/ customermade_th.html [Accessed: 26th June 2009]

HowStuffWorks. 2009. *How Facebook Works?* [Online]. Available from: http://computer.howstuffworks.com/facebook.htm [Accessed 6th June 2009].

HowStuffWorks. 2009. *How MySpace Works?* [Online]. Available from: http://computer.howstuffworks.com/myspace.htm [Accessed 6th June 2009].

Hughes, B., Joshi, I., Wareham, A. 2008. Health 2.0 and Medicine 2.0: Tensions and Controversies in the Field. Journal of Medical Internet Research. [Online] 10(3): e23. Available from: DOI: 10.2196/jmir.1056 [Accessed 14th August 2009].

Iacono, S, and Kling, R. 1996. Computerization movements and tales of technological utopianism. In: Kling, R. (ed.) *Computerization and Controversy.* 2nd edition. San Diego: Academic Press.

Innovations Factory. 2009. About Us [Online]. Available from: http://www.innovationsfactory.co.uk/5.html [Accessed 06th September 2009].

Janis, I. 1982. Groupthink: Psychological Studies of Policy Decisions and Fiascoes. Boston, MA: Houghton-Mifflin

Koch, S. 2004. *Free/Open Source Software Development*. IGI Publishing.

Kogut, B., Metiu, A. 2001. Open-source software development and distributed innovation. *Oxford Review of Economic Policy*, 17(2), 248-264.

Kollock, P., Smith, M.A., 1996. Managing the virtual commons: cooperation and

154

conflict in computer communities. In: Herring, S. (Ed.), Computer-Mediated Communication: Linguistic, Social and Cross Cultural Perspectives. John Benjamins, Amsterdam, pp. 109, 128.

Koninklijke Philips Electronics (2009) Open source product design. [Online]. Available from: http://www.livesimplicity.net/topics/open-source-product-design [Accessed 21st May 2009].

Krishnamurthy, S. 2002. *Cave or community? An empirical examination of 100 mature open source projects*. Available from: http://opensource.mit.edu [Accessed 29th August 2009].

Lagace, M. 2006. Open Source Science: A New Model for Innovation. *Harvard Business School*, November 20, 2006. Available from: http://hbswk.hbs.edu/pdf/item/5544.pdf. [Accessed: 27th June 1099]

Lakhani, K.R, and Wolf, R.G. 2005. Why Hackers Do What They Do: Understanding Motivation in Free/Open Source Software Projects. In: Feller, J., Fitzgerald, B., Hissam, S.A & Lakhani K.R. (eds.) *Perspectives on Free and Open Source Software*. MITPress.

Lanzara, G.F., Morner, M. 2003. The knowledge ecology of open source software projects. Paper presented at seminar on *ICTs in the Contemporary World*, LSE Department of Information Systems.

Lave, J., Wenger, E. 1991. Situated Learning: Legitimate Peripheral Participation. Cambridge University Press: Cambridge, UK.

Lighthouse Case Studies. 1999. *Open Source Software: A Grassroots Development Model*.

Lindenberg, S. 2001. Intrinsic motivation in a new light. Kyklos 54 (2/3): 317–342

March, J.G., Simon, H.A. 1993. *Organisations*, 2nd Edition. Wiley-Blackwell.

McCormick, C. 2003. The big project that never ends: Role and task negotiation within an emerging occupational community. Unpublished recent summary of findings, as part of PHD Research, University of Albany. Available from: http://opensource.mit.edu [Accessed 16th August 2009]

McKenna, K., Bargh, J. 2000. Plan 9 from cyberspace. The implications of the Internet for personality and social psychology. *Personality and Social Psychology Review*, 4, 57-75.

Messerschmitt, D.G. (2004). Back to the user. *Software, IEEE* [Online]. 21 (1), 89-91. Available from: 10.1109/MS.2004.1259234 [Accessed 13th May 2009].

Moen, R. 2002. *GForge: possible renaissance for open-source SourceForge.* [Online]. Available from: http://lwn.net/Articles/17369/ [Accessed 23rd July 2009].

Moody, G. 2001. Rebel code: Inside Linux and the open source revolution. New York: Perseus Press.

Nakamura, J, and Csikszentmihalyi, M. 2003. The construction of meaning through vital engagement. In *Flourishing: Positive psychology and the life well-lived*, C. L. Keyes and J. Haidt, eds. Washington, DC: American Psychological Association.

Nonaka, L. 1994. A dynamic theory of organisational knowledge creation. *Organisation Science* 5(1): 14-35.

O'Mahony, S., Ferraro, F. 2004. *Hacking alome? The effects of online and offline participation on open source community leadership*. Available from: http://opensource.mit.edu [Accessed 29th August 2009].

Oh, W., Jeon, S. 2004. Membership dynamics and network stability in the open source community: The ising perspective. *Twenty-Fifth International Conference on Information Systems.*

Otto, P., Simon, M. 2008. Dynamic Perspectives on Social Characteristics and Sustainability in Online Community Networks. *Systems Dynamics Review.* [Online] 24 (3), 321-347. Available from: DOI: 10.1002/sdr.403 [Accessed 8th June 2009].

Otto, P., Simon, M. 2008. Dynamic Perspectives on Social Characteristics and Sustainability in Online Community Networks. *Systems Dynamics Review.* [Online] 24 (3), 321-347. Available from: DOI: 10.1002/sdr.403 [Accessed 8th June 2009].

Perrow, C. 1986. Complex Organizations: A Critical Essay. New York, NY: McGraw Hill.

Pitta, A.D., Franzak, F., Katsanis, L.P., 1996, Redefining New Product Development Teams: Learning to Actualise Consumer Contributions, Journal of Product and Brand Management, v.5, i.6

Prasad, G. 2001. *Open Source-onomics: Examining some pseudo-economic Arguments About Open Source.* [Online]. Available from: www.freeos.com

Professor Steenstra, James. Managing Director (Innovations Factory). (Personal communication, 14th May 2009)

Raymond, E. 1999. The cathedral and the bazaar: Musings on Linux and open source by accidental revolutionary. Sebastopol, CA: O'Reilly and Associates.

Raymond, E. 2000. The cathedral and the bazaar. Available from: http://www.catb.org/~esr/writings/cathedral-bazaar/ cathedral-bazaar [Accessed 27th August 2009]

Raymond, E. S. 2001. The cathedral and the bazaar: Musings on Linux and open source by an accidental revolutionary. Sebastopol, CA: O'Reilly.

Raymond, E.S. 2003. *The Art of UNIX Programming*. Boston, MA: Addison Wesley.

Rheingold, H. 2000. *The virtual community*. MIT Press.

Ribeiro, G.L. 1997. Transnational virtual community? Exploring implications for culture, power and language. *Organization Science*, 4(4).

Rosenman, M.M., Merrick, K., Maher, M.L, and Marchant, D. 2006. DesignWorld: A multidisciplinary collaborative design environment using agents in a virtual world, In: J. Gero. (ed.) *Design Computing and Cognition '06*, Springer, 2006.

Roy, A. 2003. Microsoft vs. Linux: Gaining traction. *Chartered Financial Analyst* 9 (5): 36–39.

Schoberth, T., Preece, J and Heinzl, A. 2003. Online communities: A longitudal analysis of communication activities. *Hawai'I International Conference on System Sciences*, Hawaii.

Schofield, A., Mitra, A. 2005. Free and open source software communities as a support mechanism. *UK Academy of Information Systems conference 2005*, Newcastle, UK.

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Schultze, U., 1999. Investigating the contradictions in knowledge management. In: Larsen, T.J., Levine, L., deGross, J.I. (Eds.), Information Systems: Current Issues and Future Changes. IFIP, Laxenberg, pp. 155, 174.

Shmugar, C. 2008. The Future of Social Networking Sites. Mcafee Security Journal [Online]. Available from: http://www.mcafee.com/us/local_content/misc/threat_center/msj_future_social_networking.pdf [Accessed: 22nd June]

Siedlok, F. 2001. *Characteristics and applicability of Open Source-based Product Development Model in Other than Software Industries*. Masters Dissertation. University of Durham Business School.

Smith, M.A., Kollock, P. 1994. *Managing the virtual commons: Cooperation and conflict in computer communities*. American Sociological Association.

Sowe, S.K., Stamelos, I.G and Samoladas, I. 2007. *Emerging Free and Open Sofrware Practices*. IGI Publishing.

Sproull, L., Faraj, S., 1995. Atheism, sex and databases: the net as a social technology. In: Keller, B.K.J. (Ed.), Public Access to the Internet. MIT Press, Cambridge, MA, 62, 81.

Stallman, R. 2007. Why Open Source misses the point of Free Software [Online]. Available from: http://www.gnu.org/philosophy/open-source-misses-the-point.html [Accessed 02nd September 2009].

Szulanski, G., 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. Strategic Management Journal 17, 27, 44.

Taylor, E.G.R. 1971. *The Haven-finding Art: A History of Navigation from*

Odysseus to Captain Cook, Hollis & Carter, London 1971.

Terranova, T. 2004. *Network Culture: Politics for the Information Age*. London: Pluto Press.

Thamhaim, H., 1990, Managing Technologically Innovative Team Efforts Toward New Product Success, Journal of Product Innovation Management , 7

Thibaut, B.K, and Kelly, H.H. 1959. *The Social Psychology of Groups*. Wiley: New York.

Thorn BK, Connolly T. 1987. Discretionary data bases: a theory and some experimental findings. *Communication Research* 14(5): 512–528.

University of Dortmund. 2002. Entrepreneurial evaluation of open source software. An online-survey carried out by the University of Dortmund in cooperation with the MATERNA Gmbh. Available from: http://www.it-surveys.de/itsurvey/pages/studie_oss_executive_summary.html [Accessed 16th August 2009].

Van Nederveen, S. 2007. Collaborative Design In Second Life. In: Prof. H.A.J. de Ridder, Prof. J.W.F. Wamelink. (eds.) *Second International Conference World of Construction Project Management*, TU Delft, The Netherlands.

Vaughn, D. 1996. The Challenger Launch Decision: Risky Technologies, Culture and Deviance at NASA. Chicago, IL: University of Chicago Press.

von Hippel, E. 1988. The sources of innovation. New York: Oxford University Press.

von Hippel, E. 2001. Innovation by user communities: Learning from open-source software. *Sloan Management Review*, 42(4), 82-86.

Wagner, C., Bolloju, N. 2005. Supporting Knowledge Management in Organisations with Conversational Technologies. Journal of Database Management. [Online] 16, 2; ABI/INFORM Global. Available from: http://wagnernet.com/tiki/tiki-download_file.php?fileId=7 [Accessed 15th August 2009].

Walther, J.B. 1996. Computer-mediated communication: Impersonal, interpersonal and hyperpersonal interaction. *Communication Research*, 23, 3-43.

Wasko, M.M., Faraj, S. 2000. "It is what one does": why people participate and help others in electronic communities of practice. Strategic Information Systems. [Online] 9, 155 – 173. Available from: DOI: 10.1016/S0963-8687(00)00045-7 [Accessed 15th August 2009]

Wasko, M.M., Faraj, S. 2005. Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. MIS Quarterly 29(1): 35-57.
Wayner, P. 2000. Free for all: How Linux and the free software movement undercut the high-tech titans. New York: HarperBusiness.

Wellman, B., Gulia, M. 1995. *The reality of virtual communities*. American Sociological Association.

Wheelwright, S. C., Clark, K. B., 1992, Revolutionising Product Development. Quantum Leaps in Speed, Efficiency, and Quality. The Free Press, New York

Wichmann, T. 2002. *Free/libre open source software: Survey and study, Use of open source software in firms and public institution, Evidence from Germany, Sweden and UK. FLOSS Final Report – Part 1*. Berlin: Berlecon Research.

Wikipedia. 2009a. Comparison of open source software hosting facilities. [Online]. Available from: http://en.wikipedia.org/wiki/Comparison_of_free_software_hosting_facilities. [Accessed 20th June 2009].

Wikipedia. 2009b. Crowdsourcing. [Online]. Available from: http://en.wikipedia.org/wiki/Crowd_sourcing [Accessed 7th June 2009].

Wikipedia. 2009c. List of social networking sites. [Online]. Available from: http://en.wikipedia.org/wiki/List_of_social_networking_websites [Accessed 7th June 2009].

Wikipedia. 2009d. Second Life. [Online]. Available from: http://en.wikipedia.org/wiki/Second_Life [Accessed 7th June 2009].

Wikipedia. 2009e. Medical device [Online]. Available from: http://en.wikipedia.org/wiki/Medical_device [Accessed 06th September 2009].

Wikipedia. 2009f. Rapid application development. http://en.wikipedia.org/wiki/Rapid_application_development [Accessed 06th September 2009].

Yang J., Yu L., (2002), Electronic New Product Development – a Conceptual framework, *Industrial Management and Data Systems* , vol. 102, i.4.

9.   Appendices

9.1   Appendix A: Stakeholder Requirements Questionnaire

Cranfield OPD3 Requirements Questionnaire

Project Aim
The aim of the project is to introduce a web infrastructure whereby medical devices are designed and developed in an open environment, to reduce costs, impacting both availability and accessibility. The research will aim to alleviate restrictions inherent in traditional product development, encouraging diverse contribution from those that were otherwise seen as exempt from the process. In summary the process used to take a product from concept to commercialization will become more transparent and accurate subjective to diverse contribution and opinions.

Why Answer This Questionnaire?
The Cranfield OPD3 Team understand how important it is to satisfy user requirements, your answers to the proceeding questions will help us to understand what you want from the system at present and for the future; please answer the questions honestly and to the best of your ability as your answers will provide the basis for the system design.

Please visit, register and browse the Cranfield OPD3 website prior to answering this questionnaire:

http://www.opensource-cranfield.org

* Required

Full Name *

Organisation *

Position *

Email *

Profile

What personal details would you like others to see in your profile? *

Example: First Name

Would you like the ability to edit and customise your profile? *

○ Yes
○ No

Would you like your profile to be connected to all communicative facilities provided? *

Communicative Facilities: Forum, Weblog, Comments
○ Yes
○ No

Would you like the ability to add/remove friends from your profile? *

○ Yes
○ No

Communication

What are your preferred methods of online communication? *

Example: Email

Do you consider a forum to be valuable within a community? *

○ Yes
○ No

Do you consider a weblog to be valuable within a community? *

○ Yes
○ No

If yes to either one of the above, please suggest topics that would you like to see discussed within a forum or weblog? *

Example: Design Tutorials

Which page would you suggest the discussion for a project reside? *

Project Description ▼

Project Management

As a coordinator how many project members would like to restrict access to? *

[10 ▾]

As a coordinator of a project would you like the option to delegate responsibility of a projects tasks/activities to 'selected' members? *

○ Yes
○ No

As a coordinator of a project would you consent to disclosing information about a project to members outside the project community? *

○ Yes
○ No

As a coordinator of a project would you like the option to add/remove members from a project? *

○ Yes
○ No

Accessability

If you have a Facebook account, would you like to be able to register and login with it? *

◯ Yes
◯ No

If any, which other social networking sites do you use to communicate with friends or colleagues? *

☐ None
☐ MySpace
☐ Bebo
☐ LinkedIn
☐ Second Life
☐ Other

If Other, please specify?

[   ]

What information would you like to have direct access to when visiting Cranfield OPD3? *

Example: Latest Projects

Layout

What theme would you suggest be used for Cranfield OPD3, please stipulate colours, font and layout?

Would you like the theme to be consistent? *

○ Yes
○ No

If No, please suggest an alternate theme?

Other

Do you consider Real Simple Syndication (RSS) to be valuable in providing news updates?
*

○ Yes
○ No

If Yes, please specify information you would like to recieve?

Additional Comments/Requirements

Submit

9.2 Appendix A1: Results of the Stakeholder Requirements Questionnaire

Timestamp	Full Name	Organisation	Position	Email	What personal details would you like others to see in your profile?	Would you like the ability to edit and customise your profile?	Would you like your profile to be connected to all communicative facilities provided?
29/08/2009 20:43:44	Faye Mortimer	NHS	Senior Staff Nurse	fairy10princess3@y	First Name, Surname	Yes	Yes
29/08/2009 20:46:29	Isaac Sanya	Cranfield University	Student	i.o. sanya@cranfield. ac.uk	First Name, Surname, Occupation, Gender, Email Address	Yes	Yes
29/08/2009 21:00:58	Allie Gac	NHS	Senior Staff Nurse	allieg82@aol.com	First Name. Surname, Gender, Email Address	Yes	Yes

Would you like the ability to add/remove friends from your profile?	What are your preferred methods of online communication?	Do you consider a forum to be valuable within a community?	Do you consider a weblog to be valuable within a community?	If yes to either one of the above, please suggest topics that would you like to see discussed within a forum or weblog?	Which page would you suggest the discussion for a project reside?	As a coordinator how many project members would like to restrict access to?	As a coordinator of a project would you like the option to delegate responsibility of a projects tasks/activities to 'selected' members?
Yes	Email, Facebook	Yes	No	Design 101, Best Practices	Project Description	50	No
Yes	MSN Messenger, Yahoo Messenger, Facebook, Skype	Yes	Yes	Design Constraints, Creating and Managing a Project, Lessons Learnt and Best Practices for Projects	Project Files	50	Yes
Yes	Email, Facebook	Yes	Yes	New and Innovative Medical Devices, Design Tutorials, Project Member Recruitment	Project Description	25	No

As a coordinator of a project would you consent to disclosing information about a project to members outside the project community?	As a coordinator of a project would you like the option to add/remove members from a project?	If you have a Facebook account, would you like to be able to register and login with it?	If any, which other social networking sites do you use to communicate with friends or colleagues?	If Other, please specify?	What information would you like to have direct access to when visiting Cranfield OPD3?	What theme would you suggest be used for Cranfield OPD3, please stipulate colours, font and layout?	Would you like the theme to be consistent?
No	Yes	Yes	None		Latest Projects, Useful Tips, Latest in Open Design		Yes
Yes	Yes	Yes	MySpace		New Projects, Advancements and/or Breakthroughs, Commercial Projects		Yes
Yes	Yes	Yes	None		Latest News, Latest Projects, External Links to Associated Sites		Yes

If No, please suggest an alternate theme?	Do you consider Real Simple Syndication (RSS) to be valuable in providing news updates?	If Yes, please specify information you would like to recieve?	Additional Comments/Require
	Yes	Latest in Open Design, Project Member Responses to Comments	
	Yes	New Projects, Member Responses to Comments, Latest in Open Design	Within the project there could be an option for lessons learnt which may include discussion regarding the designs created by members.
	Yes	New Projects, Latest Weblog Entries, Member Responses to Comments	

Timestamp	Full Name	Organisation	Position	Email	What personal details would you like others to see in your profile?	Would you like the ability to edit and customise your profile?	Would you like your profile to be connected to all communicative facilities provided?
29/08/2009 21:22: 43	Richard Griffin	Griffin IT Services	Technical Consultant	trickyg2000@hotma	Name, Surname, Occupation, Gender	Yes	Yes
30/08/2009 02:45: 13	Rahman Alam	Cranfield University	Senior Designer	rahman. alam@cranfield. ac.uk	Name, Role, Email	Yes	Yes
30/08/2009 14:09: 17	Adoyin Bakere	University of Greenwich	Student Ambassador	doyinbaks@hotmail	First Name, Surname, Gender, Email	Yes	Yes
30/08/2009 15:39: 20	Priyank Chirodian	Cranfield University	Student	p. chirodian@cranfield	First Name, Surname, Gender, Role, Age	Yes	Yes
01/09/2009 17:33: 27	Dr Somparkash Metha	NHS	General Practitioner	metha@hwph-tr. nhs.uk	First Name, Role	Yes	Yes
01/09/2009 17:36: 08	Stacey Miles	Design Ports	Designer	stacey@fishnet. com	First Name, Surname, Email	Yes	Yes

Would you like the ability to add/remove friends from your profile?	What are your preferred methods of online communication?	Do you consider a forum to be valuable within a community?	Do you consider a weblog to be valuable within a community?	If yes to either one of the above, please suggest topics that would you like to see discussed within a forum or weblog?	Which page would you suggest the discussion for a project reside?	As a coordinator how many project members would like to restrict access to?	As a coordinator of a project would you like the option to delegate responsibility of a projects tasks/activities to 'selected' members?
Yes	Email, MSN Messenger, Skype	Yes	Yes	Guidance on Creating and Managing Projects, Recruiting Members, Standards and Licenses Regarding Open Design, Design Tutorials, Tips and Techniques	Project Description	100+	Yes
Yes	Discussion Forums, Comments	Yes	Yes	New and Innovative Medical Devices	Project Files	50	Yes
Yes	MSN Messenger, Yahoo Messenger	Yes	Yes	New and Innovative Medical Devices	Seperate Page	10	Yes
Yes	Email, Discussion Forums, Facebook	Yes	No	New and Innovative Medical Devices, Design Tutorials	Seperate Page	25	Yes
Yes	Skype	Yes	Yes	Project Developments	Project Description	100+	Yes
Yes	Email, Web Conferencing	Yes	Yes	Design Tutorials, Project FAQs	Project Description	50	Yes

As a coordinator of a project would you consent to disclosing information about a project to members outside the project community?	As a coordinator of a project would you like the option to add/remove members from a project?	If you have a Facebook account, would you like to be able to register and login with it?	If any, which other social networking sites do you use to communicate with friends or colleagues?	If Other, please specify?	What information would you like to have direct access to when visiting Cranfield OPD3	What theme would you suggest be used for Cranfield OPD3, please stipulate colours, font and layout?	Would you like the theme to be consistent?
No	Yes	Yes	LinkedIn		Recent Projects, External Links to Associated Sites, Medical Breakthroughs and Advancements	Light colours, preferably Arial font size 12, simple but effective animation, navigation located top of page and limit content to fit in users browser window to prevent over-scrolling	Yes
Yes	Yes	Yes	None		Latest News	Black and white colours preferably, Arial size 12 font	Yes
Yes	Yes	Yes	Other	MSN Messenger	Sports News	Green colour preferably, Times New Roman/Arial font	Yes
Yes	Yes	Yes	None		Latest Technology News, Latest Projects		Yes
Yes	Yes	Yes	MySpace, Bebo, LinkedIn		Latest Forum Posts, Latest News	Keep It Simple Stupid	Yes
Yes	Yes	Yes	MySpace		Latest Projects	Modern, visually eye catching, user adjustable font sizes	Yes

If No, please suggest an alternate theme?	Do you consider Real Simple Syndication (RSS) to be valuable in providing news updates?	If Yes, please specify information you would like to recieve?	Additional Comments/Requirer
	Yes	All Latest Site Updates	
	Yes	Project Progress (s) and Site Updates	
	No		Additional information to clarify the sites purpose
	No		
	Yes	Project(s) Progress	
	Yes	Site Updates	

Timestamp	Full Name	Organisation	Position	Email	What personal details would you like others to see in your profile?	Would you like the ability to edit and customise your profile?	Would you like your profile to be connected to all communicative facilities provided?
01/09/2009 17:38:31	Steve Nickson	Cripson Enterprise	Resource Manager	steve@cripson.org	First Name, Surname	Yes	Yes
02/09/2009 15:12:40	Yasmin Ahmed	Cranfield University	Student	y.ahmed@cranfield.ac.uk	First Name, Surname, Organisation	Yes	Yes
02/09/2009 21:26:50	Kamaldeep Ajimal	Kent University	Student	ak539@gre.ac.uk	First Name, Surname	Yes	Yes

Would you like the ability to add/remove friends from your profile?	What are your preferred methods of online communication?	Do you consider a forum to be valuable within a community?	Do you consider a weblog to be valuable within a community?	If yes to either one of the above, please suggest topics that would you like to see discussed within a forum or weblog?	Which page would you suggest the discussion for a project reside?	As a coordinator how many project members would like to restrict access to?	As a coordinator of a project would you like the option to delegate responsibility of a projects tasks/activities to 'selected' members?
Yes	Email and Msn Messenger	Yes	Yes	Project Developments	Project Description	10	Yes
Yes	Chat, Skype, Not Email	Yes	Yes	Design Tutorials, Advances in Open Source and its Applications, Advances in Relevant Subject Area, e.g.in this medical-based project, advances in other medical devices (modern medical advances), The Reality of Open Source	Project Files	10	Yes
Yes	Instant Messaging	Yes	Yes	Design Tutorials	Project Description	10	Yes

As a coordinator of a project would you consent to disclosing information about a project to members outside the project community?	As a coordinator of a project would you like the option to add/remove members from a project?	If you have a Facebook account, would you like to be able to register and login with it?	If any, which other social networking sites do you use to communicate with friends or colleagues?	If Other, please specify?	What information would you like to have direct access to when visiting Cranfield OPD3?	What theme would you suggest be used for Cranfield OPD3, please stipulate colours, font and layout?	Would you like the theme to be consistent?
Yes	Yes	Yes	Second Life		Latest Project Comments, Latest Projects		Yes
No	Yes	No	LinkedIn, Second Life		All Projects	Change logo font, light colours as current theme is too dark	Yes
No	Yes	Yes	None		All Projects	Warm layout, user-friendly, clear navigation	Yes

If No, please suggest an alternate theme?	Do you consider Real Simple Syndication (RSS) to be valuable in providing news updates?	If Yes, please specify information you would like to recieve?	Additional Comments/Requirer
	Yes	Latest Projects, User Workflows	
	Yes		
	No		

Timestamp	Full Name	Organisation	Position	Email	What personal details would you like others to see in your profile?	Would you like the ability to edit and customise your profile?	Would you like your profile to be connected to all communicative facilities provided?
03/09/2009 18:56:02	Tom McQuillan	Tom McQuillan Design	Owner	tmba22801@blueyc	First Name, Email	Yes	Yes
04/09/2009 11:53:37	Richard Ambrose	University of Greenwich	Student	ar509@gre.ac.uk	First Name, Surname, Email	Yes	Yes
05/09/2009 14:24:13	Sharon Dyer	NHS	Health Consultant	sharonriley70@hotr	First Name, Occupation	Yes	Yes

Would you like the ability to add/remove friends from your profile?	What are your preferred methods of online communication?	Do you consider a forum to be valuable within a community?	Do you consider a weblog to be valuable within a community?	If yes to either one of the above, please suggest topics that would you like to see discussed within a forum or weblog?	Which page would you suggest the discussion for a project reside?	As a coordinator how many project members would like to restrict access to?	As a coordinator of a project would you like the option to delegate responsibility of a projects tasks/activities to 'selected' members?
Yes	Comments, Status Updates	Yes	Yes	Design Tutorials, User Examples and Concepts	Project Description	25	Yes
Yes	Email, MSN Messenger, Facebook, Skype	No	No	Design Tutorials, FAQs, Future of Open Source Product Design, New and Innovative Medical Devices	Project Files	25	No
Yes	Email, MSN Messenger	No	No	New and Innovative Medical Devices, New Member Introductions, FAQs, New Project Introductions	Project Description	50	No

As a coordinator of a project would you consent to disclosing information about a project to members outside the project community?	As a coordinator of a project would you like the option to add/remove members from a project?	If you have a Facebook account, would you like to be able to register and login with it?	If any, which other social networking sites do you use to communicate with friends or colleagues?	If Other, please specify?	What information would you like to have direct access to when visiting Cranfield OPD3?	What theme would you suggest be used for Cranfield OPD3, please stipulate colours, font and layout?	Would you like the theme to be consistent?
Yes	Yes	Yes	MySpace		Latest Projects, Project Updates	I dont think there should be a set Cranfield colour scheme, Let the project managers choose colours/logos for their own projects as it is open source, allow groups to at least staple themselves as a collective	No
No	Yes	Yes	MySpace, Bebo		Recent Projects, Latest in Open Source, Recommended Projects	Light and suttle colours, adjustable font size, clear navigation, light animation	Yes
No	Yes	Yes	None		Recent Projects, Associated Projects, Member List, Recent Site Updates		Yes

If No, please suggest an alternate theme?	Do you consider Real Simple Syndication (RSS) to be valuable in providing news updates?	If Yes, please specify information you would like to recieve?	Additional Comments/Requirer
see above.	Yes	Project(s) Progress	
	No		It would interesting to a semantic approach, projects suggested on the basis of profile data.
	No		The site needs to contain more information about the initiative to appeal to a wider audience

9.3   Appendix B: Primary Joomla Extensions Used Within Development

Developer	Extension	Version
Joomlapolis	Community Builder	1.2.1
Kunena	Fireboard Forum	1.0.4
Accueil	FlashiTool	0.902
Gavick	PhotoSlide	GK2
Sourcecoast	JBF Connect	2.1.2
Azrul	JomComment	3.0.1 Build 562
Azrul	MyBlog	2.0.1 Build 286
AlexRed	OzioGallery2	2.1
Fiji Web Design	PHP Pages	

9.4   Appendix C: Stakeholder Experience Questionnaire

Cranfield OPD3 Experience Questionnaire

The Cranfield OPD3 Team aims to provide its users with a highly exceptional and responsive experience, in order to achieve this we welcome all your comments. Your feedback will help the team to improve the culture, contents and containment of the site to meet your expectations.

* Required

Username *

[   ]

General Aspects of the Site

How did you find out about the site? *

[Search Engine ▼]

What was your reason for visiting the site? *

☐ Information On Projects
☐ Consular Information
☐ Education/Commercial Information
☐ Project Involvement

Did you successfully complete the registration process? *

○ Yes
○ No

Content and Layout

Is there sufficient information (on the homepage) with regard to the sites initiative? *

○ Yes
○ No

What do you think of the design of the site? *

	1	2	3	4	5	
Poor	○	○	○	○	○	Very Good

Did you find the contents and layout of the site to be clear in finding the required information? *

| Yes, Without Any Problems ▾ |

Site Attributes

Rank: Clarity of Navigation *

	1	2	3	4	5	
Very Poor	○	○	○	○	○	Very Good

Rank: Aesthetic Appeal *

	1	2	3	4	5	
Very Poor	○	○	○	○	○	Very Good

Rank: Qualiy of Information *

	1	2	3	4	5	
Very Poor	○	○	○	○	○	Very Good

Rank: Ease of Uploading Images/Files *

	1	2	3	4	5	
Very Poor	○	○	○	○	○	Very Good

Rank: Ease of Downloading Images/Files *

	1	2	3	4	5	
Very Poor	○	○	○	○	○	Very Good

Rank: Ease of Communicating with Members *

	1	2	3	4	5	
Very Poor	○	○	○	○	○	Very Good

Rank: Conflict Handling *

	1	2	3	4	5	
Very Poor	○	○	○	○	○	Very Good

Rank: Creating and Managing a Project *

	1	2	3	4	5	
Very Poor	○	○	○	○	○	Very Good

Recommendations

8. What would you like to see on the site that is currently not available?

```
[                                                          ]
[                                                          ]
[                                                          ]
[                                                          ]
[                                                          ]
```

10. If you have any other comments or messages related to the site, please list them here:

```
[                                                          ]
[                                                          ]
[                                                          ]
[                                                          ]
```

[Submit]

9.5 Appendix D: Additional System Features

9.5.1 Appendix D1: System Feature: Discussion Forum

9.5.2 Appendix D2: System Feature: Weblog
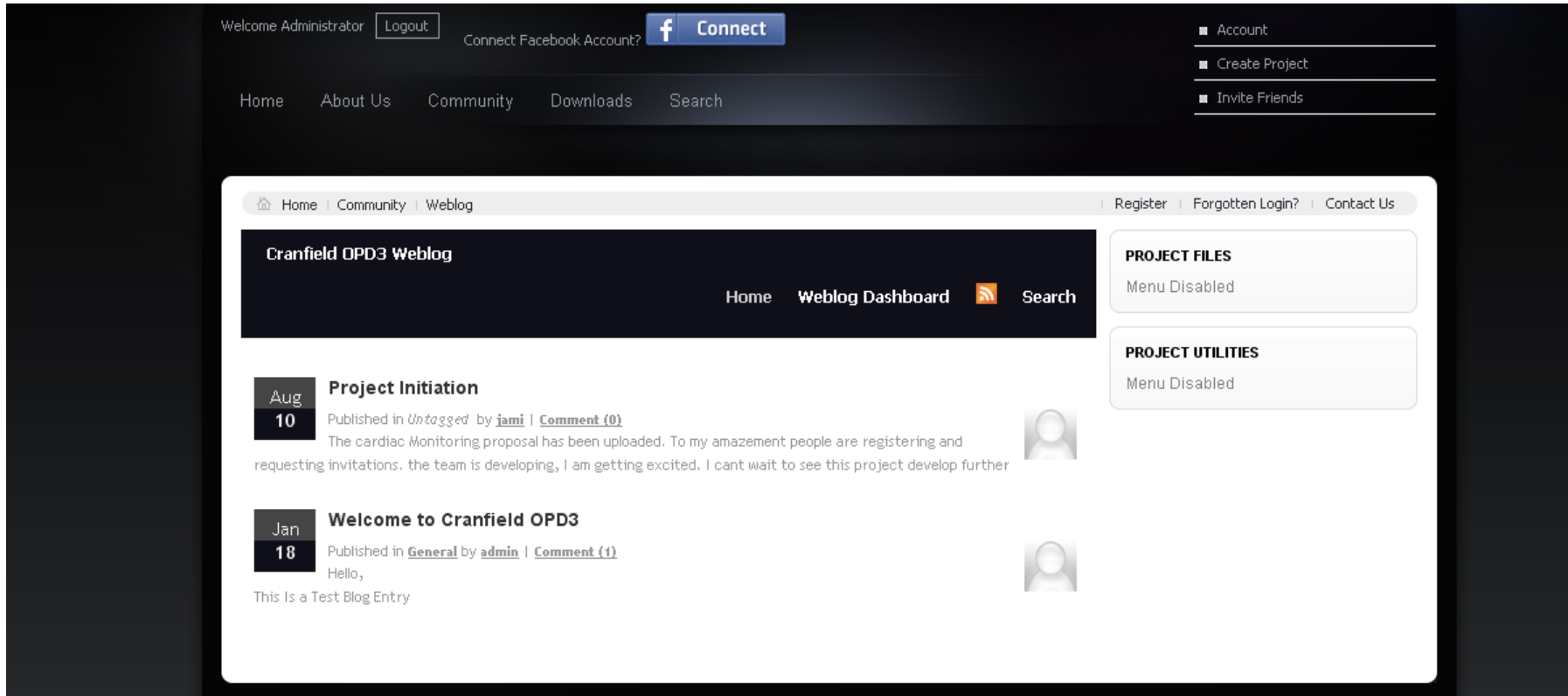
9.5.3 Appendix D3: System Feature: Project Comments

Comments (36)

Subscribe to this comment's feed

Show/hide comments

Write comment

Show/hide comment form

Name

Administrator

Email

k.g.f.mortimer@cranfield.ac.uk

Title

Comment

B *I* U -S-

smaller | bigger

☐ Subscribe via email (registered users only)

☐ I have read and agree to the Terms of Usage.

Add Comment

9.5.4   Appendix D4: System Feature: Invite Friends
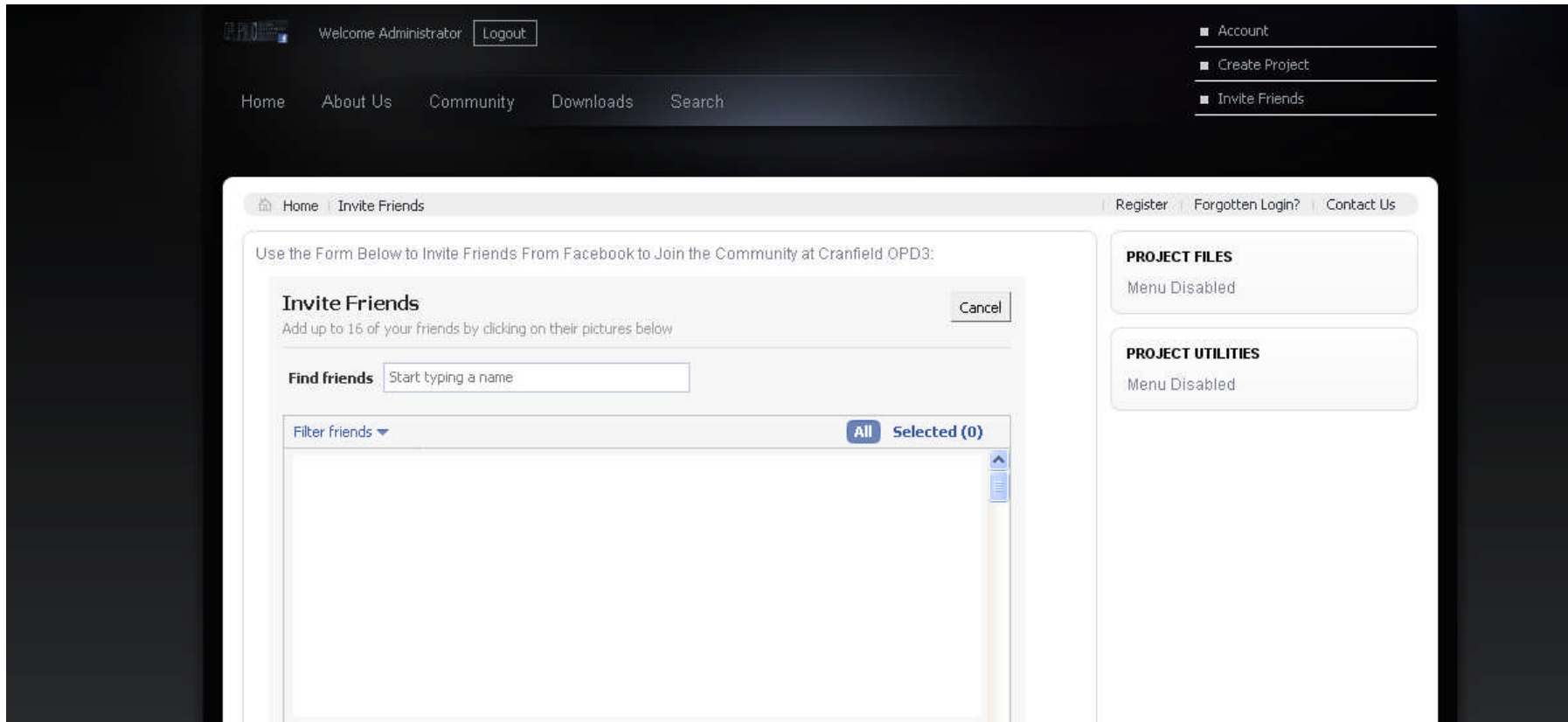
9.5.5 Appendix D5: System Feature: View Project Images
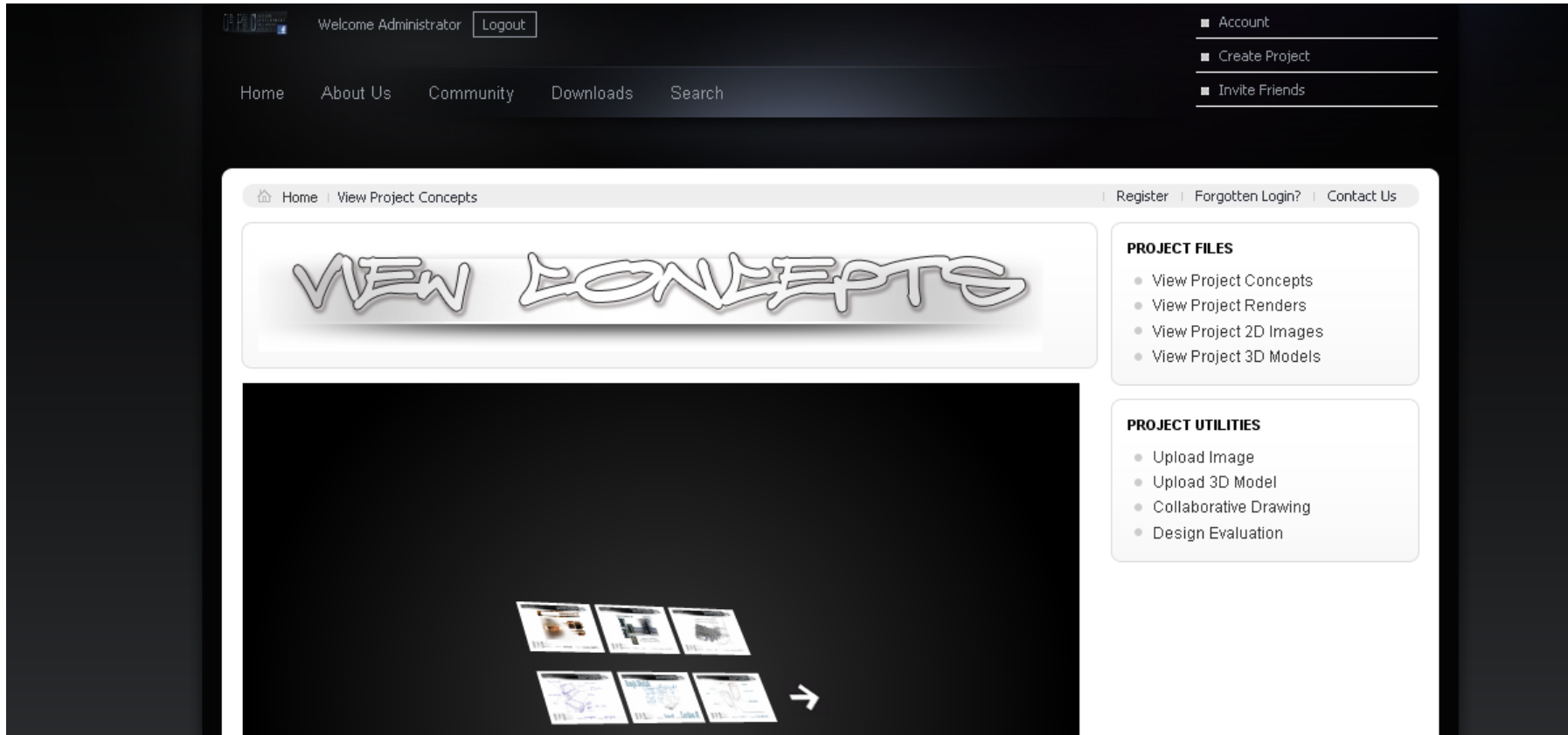
9.5.6 Appendix D5: System Feature: Collaborative Drawing
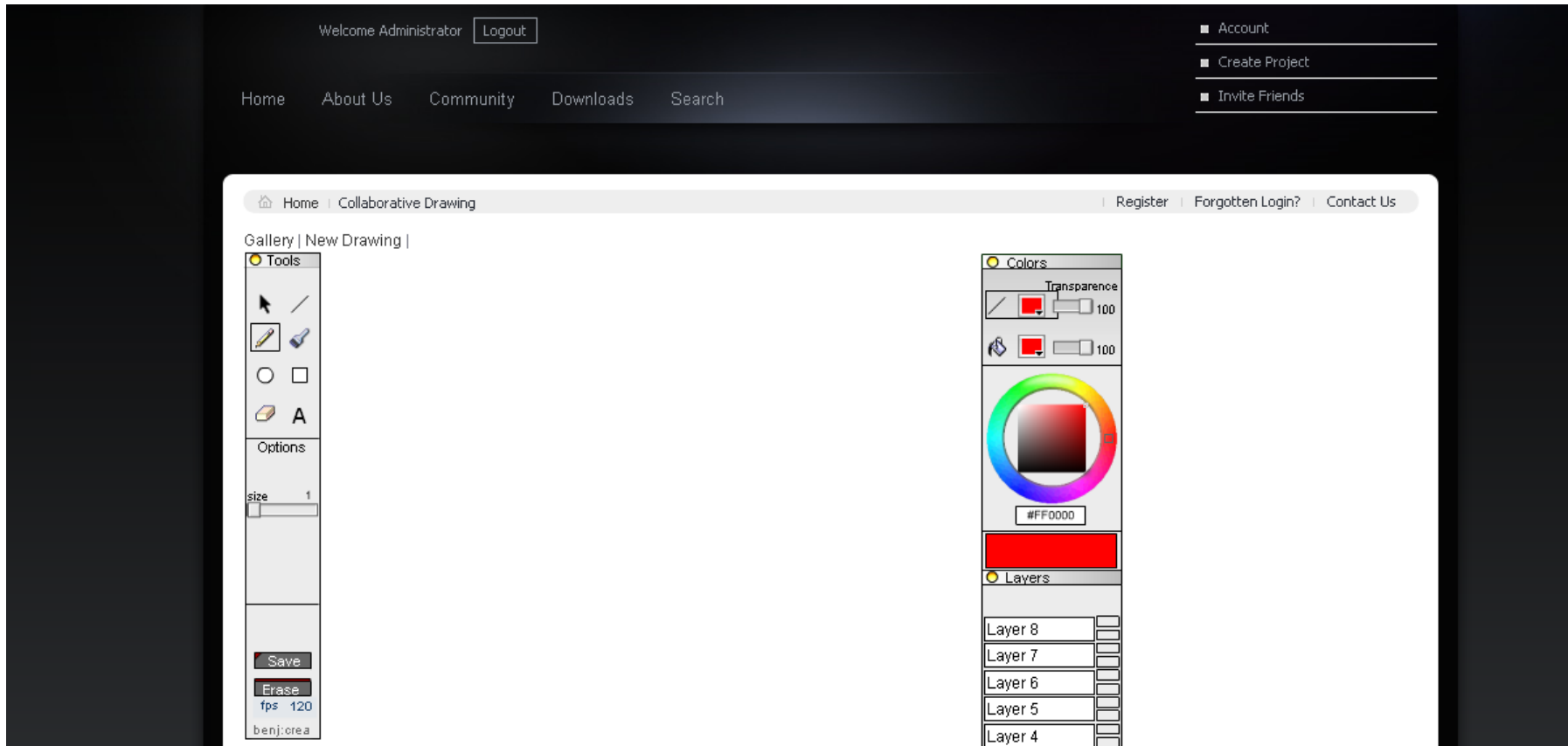
9.6 Appendix E: Source Code for Open Source Web Based Infrastructure

9.6.1 Appendix E1: Source Code – Get Page URL

```php
function cur_page_url()
        {
                $pageurl = 'http';
                if($_SERVER["HTTPS"] == "on")
                {
                        $pageurl .= "s";
                }
                $pageurl .= "://";
                if($_SERVER["SERVER_PORT"] != "80")
                {
                $pageurl .=
$_SERVER["SERVER_NAME"].":".$_SERVER["SERVER_PORT"].$_SERVER["REQ
UEST_URI"];
                }
                else
                {
                $pageurl .=
$_SERVER["SERVER_NAME"].$_SERVER["REQUEST_URI"];
                }
                return $pageurl;
                }
```

9.6.2 Appendix E2: Source Code – Get Current Date/Time and User ID

```php
$getuser =& JFactory::getUser();
$setuser = $getuser->id;
$datetime = date("Y-m-d H:i:s");
```

9.6.3 Appendix E3: Source Code – Input Form

```
<body id="public">
        <div id="container">
                <div style="height:30px"></div>
                        <form method="post" action="<?php echo
cur_page_url();?>" onSubmit="return validForm();">
                        <?php if(!empty($message))
                                {
                                echo "<p class=\"message\"><b>" . $message
."</b></p>";
                                }
                        ?>
                        <?php include("includes/formproj.php");?>
                                <ul>
                                        <li id="foli15" class=""></li>
                                        <li class="buttons">
                                                <input type="submit"
value="Create Project" style=" background:#000000; color:#FFFFFF; font-
size:14px;"/>
                                        </li>
                                </ul>
                        </form>
                <div style="height:30px"></div>
        </div>
</body>
```

9.6.4 Appendix E4: Source Code – Prepare Form Fields for Database

```
foreach($prepvalue as $key => $value)
                {
                        switch($key)
                        {
                        case 'title':
                                $title = strip_tags($value);
                        break;
                        case 'purpose':
                                $introtext = '<span style="text-align:justify"><img
src="images/stories/defaultproject.jpg" border="0" alt="Project Image"
title="'.$prepvalue['title'].'"
                                                        hspace="10" vspace="5"
align="left" />'.$value.'</span>';
                        break;
                        case 'class':
                                $class = strip_tags($value);
                        break;
                        default:
                                $fulltext .= '<span style="text-
align:justify">'.$value.'</span>';
                        }
                }
```

9.6.5 Appendix E5: Source Code – Check and Generate Random Folder Title

```
do
{
$randval = mt_rand();
$set_imgdir = check_multi_folders($randval);
}
while($set_imgdir);
```

9.6.6 Appendix E6: Source Code – Retrieving Multiple Fields from a Table Join

```
$mailinfo = get_multi_db_fields($_GET['contid']);

$to      = $mailinfo['email'];
$from    = 'admin@opensource-cranfield.org';
$subject = 'Authorise Member';
$recipientname = $mailinfo['name'];
```

9.6.7 Appendix E7: Source Code – Retrieving Multiple Fields from a Table Join Continued

```
function get_multi_db_fields($contid){
$db_query = "SELECT ju.email AS email, ju.name AS name,
jc.title AS title FROM (jos_users";
        $db_query .= " AS ju INNER JOIN jos_project_groups";
        $db_query .= " AS jpg ON ju.id = jpg.coordinator)";
        $db_query .= " INNER JOIN jos_content";
        $db_query .= " AS jc ON jpg.contentid = jc.id";
        $db_query .= " WHERE jc.id = '{$contid}'";
        $result_set = mysql_query($db_query);
        confirm_query($result_set);
        if($results = mysql_fetch_array($result_set))
        {
        return $results;
        }
        else
        {
        $results = NULL;
        }
}
```

9.6.8   Appendix E8: Source Code – Generating an Email Using the MIME Email Extension

```
$semi_rand = md5(time());
 $mime_boundary = "==Multipart_Boundary_x{$semi_rand}x";

 $headers .= "\nMIME-Version: 1.0\n" .
                        "Content-Type: multipart/mixed;\n" .
                        " boundary=\"{$mime_boundary}\"";

 $message = "This is a multi-part message in MIME format.\n\n" .
                        "--{$mime_boundary}\n" .
                        "Content-Type: text/html; charset=\"iso-8859-1\"\n" .
                        "Content-Transfer-Encoding: 7bit\n\n" .
                        $message . "\n\n";
```

9.6.9   Appendix E9: Source Code – Resizing an Image Prior to Upload

```
if($image){
        $imagepath = "/" . $imagename;
        $save = $setdir . $imagepath;
        $file = $setdir . $imagepath;

        list($width, $height) = getimagesize($file);

        $modwidth = 640;
        $modheight = 480;
        $tn = imagecreatetruecolor($modwidth, $modheight);
        $image = imagecreatefromjpeg($file);
        imagecopyresampled($tn, $image, 0, 0, 0, 0, $modwidth, $modheight, $width,
$height);
        imagejpeg($tn, $save, 100);
        }
```

9.6.10 Appendix E10: Source Code – Uploading Multiple Files

```
    foreach ($file_ary as $file){
                    $tmp_imagename = $file['name'];
                    $ext = find_file_extension($tmp_imagename);
                    $imagename = $randval . "." . $ext;
  $source = $file['tmp_name'];
  $target = $setdir . "/" . $imagename;
                    if(move_uploaded_file($source, $target)){
                    $file_path[] = $target;
                    }
                    else
                    {
                    $file_path[] = NULL;
        }
}
```

9.7   Appendix F: Communicative Facilities Activity Diagrams

9.7.1   Appendix F1: Forum Activity Diagram
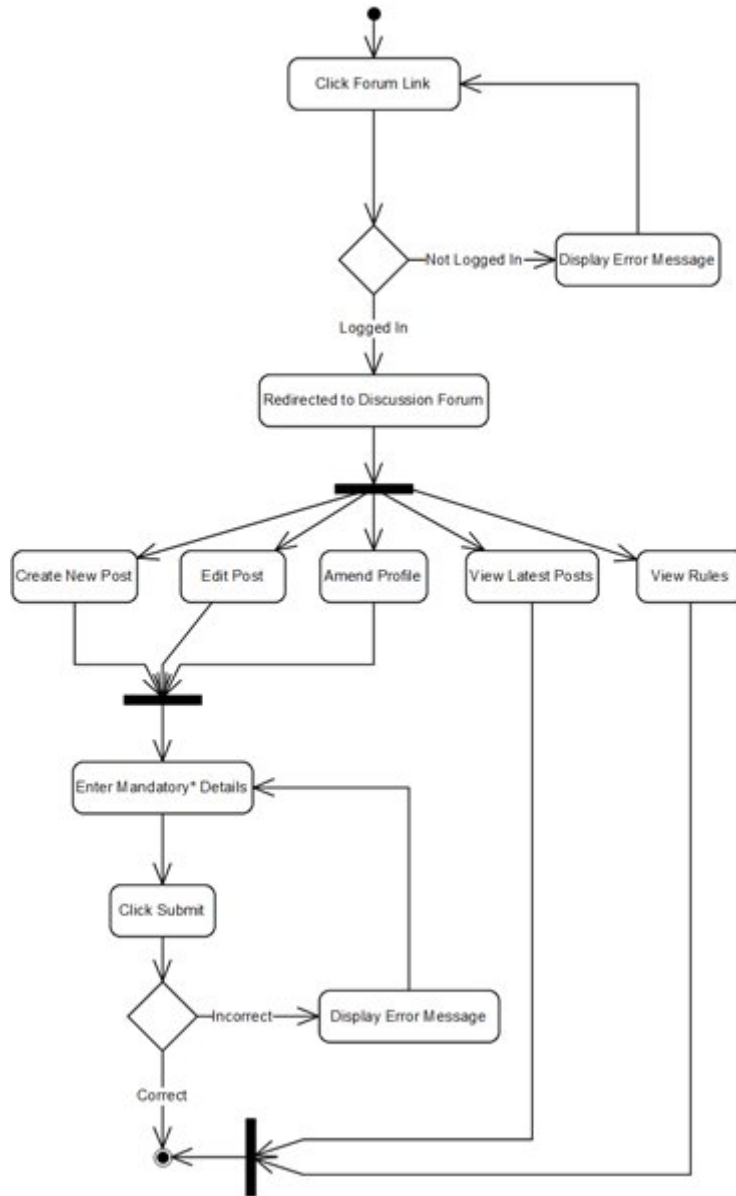
9.7.2 Appendix F2: Weblog Activity Diagram
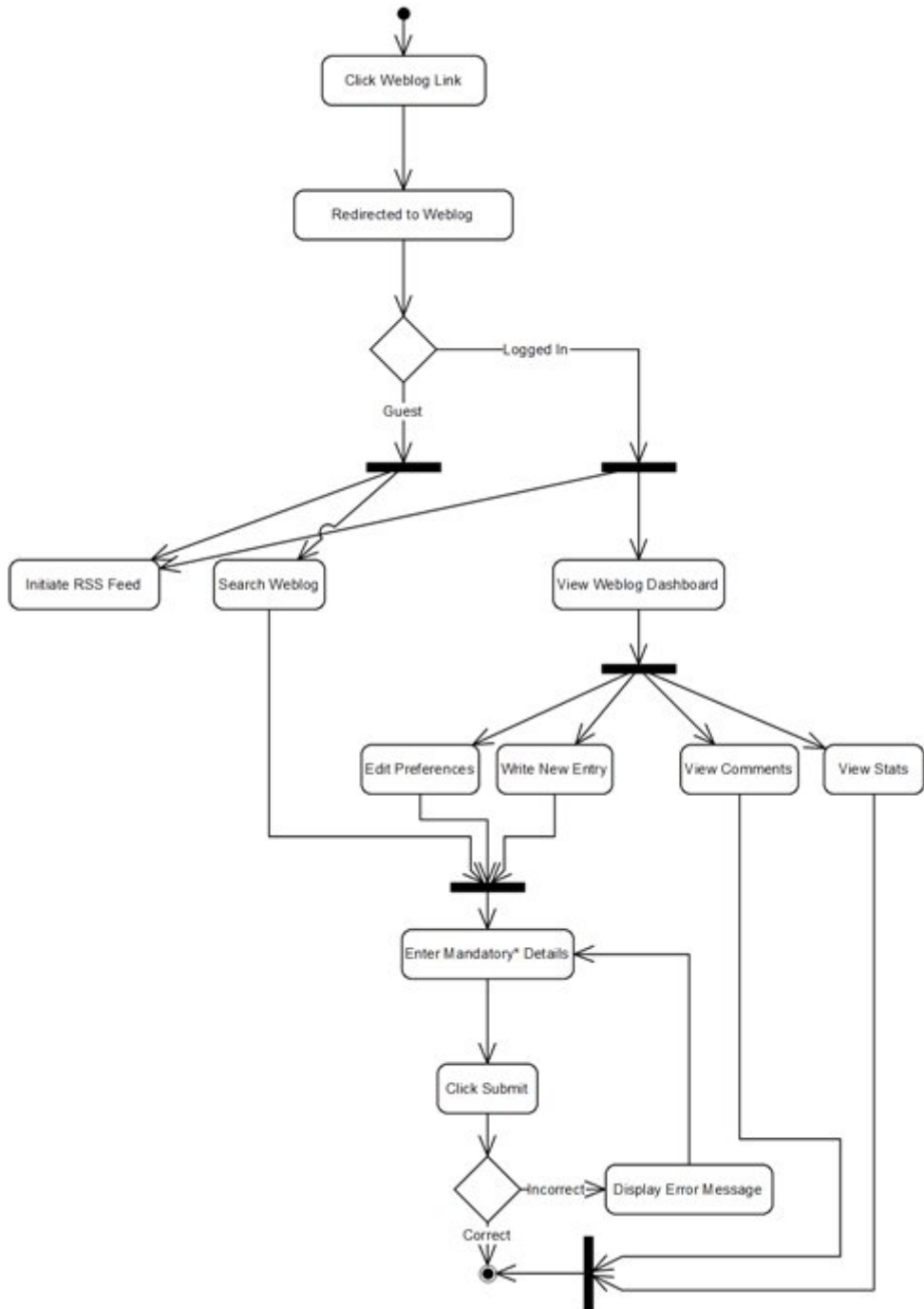
9.8   Appendix G: Open Source Web Based Infrastructure User Guide for Part Two of the Project

Instructions:

Preparation

Open your preferred web browser and navigate to:
http://www.opensource-cranfield.org

Part 1: User Interface

It is essential that you understand the various elements of the system including its layout and navigation to ensure anomalies are avoided, please review the following figure prior to proceeding with further instructions:

Troubleshoot: If for any reason the proceeding instructions appear differently or fail to execute, please consult the troubleshooting section located at the end of this user guide.

Part 2: Registration

1. To access the registration page, please left click the far left option 'Register' located in the secondary navigation. The following figure illustrates the 'registration' form that should appear.

Registration Key:

- ![icon] This field is required (mandatory)
- ![icon] This field is **not** visible on your profile
- ![icon] This field **is** visible on your profile
- ![icon] If you have any queries regarding the entry of information, e.g. format or validity, please hover over the information icon.

2. Please complete all 'required' fields and left click the 'Register' button, located bottom left of the registration form to create an account;

  - If successful, you will redirected to a confirmation page notifying you that your registration is complete and that you may now login.
  - If the registration failed with errors, please check all fields to ensure that you have entered the information correctly and re-submit.

1. If you have an 'existing' Facebook account you are able to utilise these credentials to register on Cranfield OPD[3], left click the Facebook Connect button located far right of the primary navigation. The following figure illustrates the Facebook login pane that should appear.

2. Please enter your Facebook login credentials into the designated fields and left click the 'Connect' button located far right to login.

   - If successful , you will redirected to a page where you will be presented with two options:

       i. If you have an existing account with Cranfield OPD[3] you may login, this option is for users who have an existing account and have opted 'not' to use their Facebook credentials.
       ii. If you do not have an existing account with Cranfield OPD[3] you may register, this option is for users who do not have an existing account and have opted to use their Facebook credentials to register.

   - If successful, you will redirected to a confirmation page notifying you that your registration is complete and automatically logged in.
   - If the registration failed with errors, please check all fields to ensure that you have entered the information correctly and re-submit.

Part 3: Creating a 'New' Project

Prior to creating a project, you must first be logged in, please enter your login credentials into the designated fields located in the login panel, or if your accounted is connected to Facebook you may use your Facebook login credentials by left clicking the Facebook 'Connect' button.

The following figure illustrates the changes that will appear once you have logged in, notice the login panel change to reflect the users 'logged in' status and the additional user options that appear to the right.
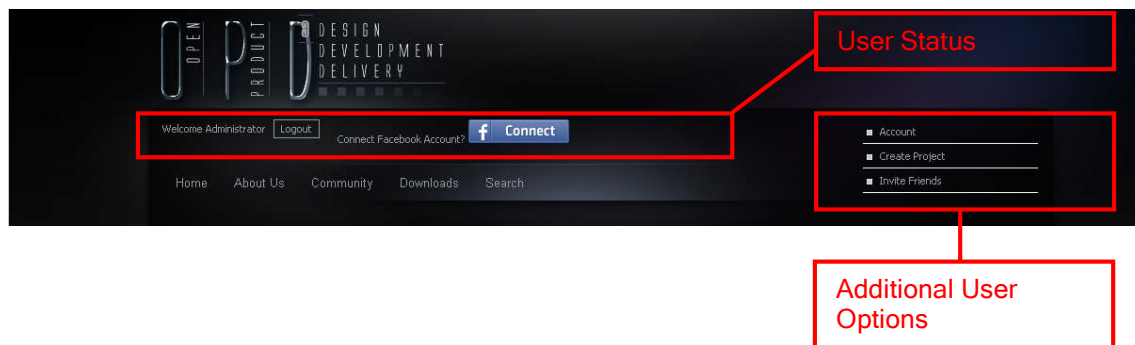
1. To create a project, left click the 'Create Project' option located second from the top in the additional user options.
2. If successful you will be redirected to a page requiring you to enter details about the project, initiating with its title, risk level followed by a group of text areas to structure the project description.

Note: All fields are mandatory; therefore please enter the required information as accurately as possible to aid its perception to others.

3. If you are satisfied with the details you have provided, please left click the 'Create Project' button located bottom left of the page to create your project and advertise it for other members to join.

Note: Prior to the project being advertised, the administrator will review the project to ensure it is viable, if satisfied the administrator will publish the project within a period of 30 days from its creation.

- If successful, you will be redirected to the same page and receive an automated response in the form of three messages as illustrated in the following figure:

Project Creation Successful, you have 30 days to publish the project before it is removed
Project Folders Created
Project Group Created
Title

If you have received messages that deviate from the above figure, please contact the administrator immediately, contact details are provided at the end of this user guide and on the website.

Part 4: Viewing Your Project and Others

To view the project(s) that you or others have created, you can either use the project navigation by category or the project navigation by category and project, the latter provides direct access to projects; however it does not provide the full list of projects available.

Note: The projects are sorted by date in ascending order and categorically by risk level; this applies to both options for accessing projects.

1. To view the full list of projects, please select the appropriate risk level from the 'Project Navigation by Category' menu.
2. If successful, you will be redirected to a page displaying the full list of projects for the selected risk level, the page will display three projects to every row, providing brief details about each project.

Note: The project display can be alternated to display the projects in a list view, to use this feature, left click the minus (-) option located at the bottom right of the page.

3. To view a project in detail, left click the 'Read More' button associated to the project, typically located below the project synopsis.
4. If successful, you will be redirected to a page containing the projects full details, the text on the page is segmented into three sections with an additional section dedicated to posting and responding to comments with respect to the project, as the following figure illustrates:

Project Options

Introduction to the Project

Stipulates Project Requirements

Additional Information

Post and Respond to Comments

Note: The 'Project Files' and 'Project Utilities' menu will be shown 'only' if you are a member of a project, otherwise they remain disabled until authorisation from the coordinator has been given. By default the creator of the project will have access to both menus, whilst to others who do not have authorisation the menus will appear as illustrated in the following figure:

Part 5: Request Creator Authorisation

1. To request authorisation, left click the 'only' option in the 'Project Files' menu located top right of the page titled 'Request Authorisation'.
2. If successful you will redirected to a page where you will have the opportunity to upload a file to support your request, it is important to note that the coordinator does not have to authorise your request, they also have to option to decline if they feel you are not suitable.

Note: It is suggested that you upload a zipped file, e.g. a portfolio of your work; however it is **not** mandatory that you provide supporting files.

3. To send the request, left click the option 'Send Request', located below the 'upload file' utility.

Note: The request is sent to the coordinator's external email address, therefore responses should be prompt. Once the coordinator has made a decision an automated email will be sent to you notifying you of whether you have been authorised or declined. If you do not receive a response with seven days, please contact the administrator immediately; contact details are provided at the end of this user guide and on the website.

Part 6: Other Facilities Available

Cranfield OPD[3] provides a subset of communicative Web 2.0 technologies including a forum, weblog and facility for you to invite friends and/or family from Facebook to join the continuously growing and innovative community at Cranfield OPD[3]. This user guide is provided as an aid for you, streamlining the process of becoming established within our community and we anticipate that you have knowledge within the remaining facilities that we offer, however if you do have any questions that burden you please do not hesitate to contact us.