

**CARDIFF UNIVERSITY**  
**SCHOOL OF COMPUTER SCIENCE**



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**A requirements analysis and feasibility study  
for a design of a pervasive fitness centre  
designed specifically for its members**

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## Background

According to the 2014 State of the UK Fitness Industry Report, the UK's Health and fitness industry has more clubs, more members and a greater market value than ever before. The member numbers have exceeded 8 million, and young adults have become more determined to improve their health and fitness.

The availability and advance in technology has meant that there is more knowledge of individuals' health and fitness, and there is a large market for fitness companies to make the most of smaller embedded systems to improve the facilities for their customers and clients.

The high demand for incentives for members expresses that if companies do not utilise these new systems to their benefits, they will slip behind the vast competition that is currently taking place in this industry, and miss out on the intake of new members who are seeking the best services from the providers of this industry. <sup>[1]</sup>

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## **The intended project**

The aim of this project is to generate a design of a pervasive Gym and Leisure centre for its members. Requirements will be generated specific to solving problems addressed in the fitness environment focusing on the issues raised by members, along with the investigation as to how developed and rising technology will impact the design, and ways in which this could be implemented to further improve the connectivity of devices and embedded systems around a fitness centre.

The project will cover both the requirements needed in order to fulfil the member's needs along with researching into whether these may actually be fulfilled.

## Design Method (The design Phase)

The design of this project and the method behind the design is to provide a detailed specification to give a specific and defined solution to the problem that has been identified

It will be used to describe the technological needs of the user and how processes can be developed to enhance a user's experience. The design phase will aim to identify the entities that will be involved in the solution along with the relationships between the entities. The design phase will identify all constraints held on the project, and the facilities in which it will require.

The requirements produced will satisfy a solution to the problem through the means of qualitative and quantitative research, to highlight both the possibilities and the issues that may be raised with the success of the project. This will then roll onto the costs of undertaking the project along with the feasibility of future phases. [2]

## Undertaking the project

The project will begin with a full investigation into all areas surrounding the project, such as the stakeholders, and identifying a root definition of the project, and a conceptual model to explain the activities that are in place.

To enable the development of a full list of requirements, primary research and market research must be undertaken to identify the stakeholders and the views of those who would be affected by the completed design. From this, a set of requirements will be produced as an initial list.

When the first set of requirements has been listed, more market research will be produced, through a thorough investigation into the information retrieval methods possible. This will allow any changes that must be made to the requirements to be identified, to understand if the requirements that have been produced are relevant, and to generate views on further requirements that could be relevant for the project. The research from this will be for opinionated qualitative views, as opposed to the initial research, which will be quantitative and help to identify the scope and target audience.

After research methods have been investigated and an appropriate route is selected and undertaken, further research will be required to identify the technologies that are available to enable a complete design of the project, and potentially in the future develop the system further into the implementation phase. The research will enable me to see the processes that companies have in place to improve their systems and hardware to keep up with the ever growing technical industry. After this is completed, a requirements specification will be produced to identify all current problems faced in leisure centres and gyms.

A requirements analysis will then be undertaken to refine existing requirements to determine their impact on the current processes in place at the centre to determine the project's success. Finally, a feasibility study will be generated to analyse if the design generated will be feasible to be implemented, taking into account the costs of purchasing systems involved within the design.

## Design Milestones

After identifying the processes that will take place for design, the following milestones will be delivered:

1. Activity and action modelling (SSM)
2. Initial Research and results (quantitative)
3. Initial generation of requirements
4. Qualitative research and results
5. Investigation into technology
6. Requirements specification
7. Requirements analysis
8. Feasibility of design
9. Costs
10. Conclusion

## SSM Modelling

As stated in the brief of this project, an SSM model will help to ensure that the design that has been produced has been fully established. This will help to confirm that the design accomplishes the proposed objectives. An SSM model is “A simplified description or conception of a system, or a process, which is put forward as a basis for calculations, predictions or further investigation” [3].

### Root definition

A root definition will describe what the proposed system is, and the activities that are in place. The formulation of the root definition is represented using a CATWOE analysis, identifying clients; the customers of the project, Actors; those who carry out the activities in the project (turning inputs into outputs), Transformation; a process of what the system does to turn the inputs into outputs, Worldview; putting the system into its wider context, Owner; the owner of the system and finally, Environment; which involve external factors such as resource limitations and ethical considerations. [4]

Below is the CATWOE analysis of my proposed solution.

**Client:** Members

**Actors:** Me

**Transformation:** Identifying, improving and developing embedded systems

**Worldview:** Encouraging membership at fitness centres

**Owner:** Personal (me)

**Environment:** Emerging technologies, resource limitations, health and safety

From this the following root definition is developed:

“A personally owned pervasive computing design of a leisure centre/gym to encourage membership at fitness centres by identifying, improving and developing embedded systems while recognising emerging technologies, health and safety and resource limitations.”

## Conceptual Model

The second of the key SSM concepts is a conceptual model. This is a way of describing what the system will actually do. <sup>[4]</sup> It aims to contain the activities stated within the root definition and those required from it, along with the relationships between the activities.

The completed conceptual model can be found in Appendix 1 “Conceptual Model”

## **Stakeholders**

Stakeholders are those who have an interest in or are affected by the activities that take place within a business or a project. This may be an individual, a group of people or society as a whole. Stakeholders have a huge impact on the objectives that are set for a project or a business. Stakeholders must be engaged to enable a successful project. [5]

It is important from this, to identify the stakeholders of fitness centres, to enable me to develop an understanding as to where my investigation should follow up research from.

### **Owners**

The owners of the Gym/ Leisure centres are a very important stakeholder for this project. If the project is undertaken, the state of the owners business is changed on a large scale. If successful, the project undertaken could improve the owners profit and reputation. The owners will have responsibility for choosing to implement the new system within their organisation. They will have to analyse the system and decide whether it will be cost effective or not.

### **Employees**

The employees are involved in the under-go of the system if it was to be implemented. Employees would have responsibility to ensure that the system in place can work with the classes and duties they have to perform. They would have to have to be aware of the new processes in place to fix any minor problems that may arise mid-shift and to utilise the new system to its full potential.

### **Managers**

Managers would also have to have understanding of the system that is to be implemented. They would have to factor this into any relevant time planning that needs to take place and decide whether this is feasible for their company or not. Managers would also be responsible for arranging full training for the employees to become knowledgeable of the new system.

### **Suppliers**

If the system is to be implemented, there would have to be a change in suppliers, and technology companies available to provide the software needed would be responsible for providing both hardware and software for the system.

### **Customers**

Customers are the key stakeholder. The customers will pay money for the new system in place, and their experience will be affected by the new processes in place. The customers will use many aspects of the system during each visit, and the requirements will be based mainly on their needs and opinions. The customers are the people who can identify key issues with the current systems in place within their fitness centres and will be able to provide insight into the improvement of these.

The results generated from the investigation into this project will come from any one of the stakeholders who uses the facilities leisurely within the fitness centre. This may include employees of these companies, to enable an all-round highlight of problems that occur from both a working point of view and a customer point of view, to identify new opportunities to improve the service to its members. This would suggest that the two main stakeholders for this project would be the customers and the employees. Both of these stakeholders will be able to input their knowledge of existing systems. From this the most commonly identified problems will have to be highlighted and addressed so that the majority of the users concerns are satisfied. The aim of the project is to improve processes and experience, whilst attempting to eliminate existing problems as much as possible.

## Health and safety in a fitness environment

When undertaking a project such as this, and developing a pervasive environment which could potentially be implemented by companies providing a customer service, the health and safety methods in place must be of an acceptable standard to enable members to exercise in a safeguarded environment.

It is essential, during the design phase that the requirements that are suggested are used in such a manner to maintain or improve the health and safety standards that currently stand.

According to The fitness Industry Association Code of practice, “Clubs and centres must be committed to ensuring the health and safety of employees, members, guests and contractors. They must ensure full compliance with the Health and Safety at Work etc. Act 1974 and associated legislation and strive to exceed the standards set by law. Clubs and centres should comply with the legal requirements of the Disability Discrimination Act. It is the aim of the FIA’s Code of Practice to promote standards of safety and health that will minimise risks and avoid accidents and ill health.” [6]

Andy Epps’ “Health and safety in fitness” suggests various methods in which centres should be including in their practices to ensure customers are not at risk of danger.

## Temperature

“Maintain suitable temperature regulations” is mentioned as a key factor to ensure that customers do not overheat and cause serious damage to their bodies. Systems in place in my design must not affect this, and should be designed to improve this.

## Cleanliness

Designing for a public service means that the gym/leisure centre needs to be kept hygienic and tidy to a high standard. It must be ensured that the design does not include the use of products, machinery or systems that cause a polluted environment.

## Acknowledging complaints

As stated by the fitness Industry Association Code of practice “Acknowledge complaints by customers and maintain communication with them until the matter is resolved”. Once completed, the design should improve the complaints system or maintain it at its current standard.

### **Conduct Risk Assessments**

“Hazards to employees and customers are identified through a risk assessment process, whereby hazards are removed in the first instance or risks reduced to a safe level through the implementation of controls”. The risks of the systems that are to be implemented need to be considered carefully and if this would be an unsafe risk to impose on the customer.

### **Water Hygiene**

It is a requirement that “legionella bacteria must be controlled in the water systems. Systems that are included in the design must not damage the swimming facilities or cause an unhygienic pool. [7]

## Sampling

When undertaking initial research, a sample population must be identified so that there are enough results to generate a reasonable response. Sample population is an extremely important factor to consider when undertaking research for this project. Population sampling involves taking a subset of subjects to represent the entire population. It must be of a sufficient size for statistical analysis. Sample population is a useful tool for data gathering, as it would be impractical to obtain opinions from the entire population. For example, the number of gym members in the UK is 8.3 million, and it would be extremely difficult (or impossible) to collect data which would represent all of these individual thoughts. The population size used will be an estimation of the number of members of fitness sites in Cardiff. According to the latest fitness industry statistics from "leisuredb", there are 6112 fitness sites in the UK, with a total of 8.3 million members [8]. From this, on average there are a total of 1357 members per gym. From further research, it is approximated that there are 9 combined gym and leisure centres in Cardiff [9]. Due to this an approximation of 12221 fitness members in Cardiff has been generated. It is understood that this is an extreme approximation of the number of members in Cardiff, however from the mathematical estimations produced; this will be an appropriate sample size to use. From this, it is important to begin to generate the requirements from the stakeholders identified, in particular the customers.

## Opinion Collection Methods

In order to establish effective and useful requirements for the design of the pervasive environment, primary market research must be performed to generate users opinions and to ask questions about other relevant factors that must be considered. There are many different methods that can be used to generate opinions from the public which are listed below, and the ways in which these could be advantageous, if used. [10]

### Focus Group

A focus group is the most widely used qualitative tool. It involves a discussion of usually between 4 and 15 people, which is run by a moderator [11]. The aim of the focus group is

to develop an insight to customers' (or other stakeholders) opinions. Focus groups involve general discussion rather than individual responses to formal questions in the hope that free flowing ideas and opinions are generated, for the moderator to make note of and observe <sup>[12]</sup>. This method of market research allows groups to suggest potential solutions to problems that may be identified during discussion and allows the moderator to obtain detailed information about personal and group feelings, perceptions and opinions. It is found however that managing these groups can be difficult, especially including a large number of individuals. Disagreements and irrelevant discussion may distract from the main focus wasting the moderator's time and potentially slowing down the project. If this method were to be used, the group size would have to be manageable to enable a successful focus group. <sup>[13]</sup>

### Depth Interviews

A depth interview is a form of qualitative data collection, used in market research. A depth interview allows the interviewer freedom to explore additional points which may be brought up by the interviewee, which could change the direction of the interview and uncover answers which may not have been expected, yet still deemed very useful. A depth interview is face to face and delivers open questions for the interviewee to consider. <sup>[14]</sup> A major concern with interviews for market research is that one interview only generates one point of view. If the interviewee is not willing to widely discuss the project, then it may be deemed useless. If this method was to be used, a broad discussion about the topic would have to be encouraged, whilst making sure that the conversation does not fall off-track.

### Think aloud analysis

A think aloud analysis is typically used throughout the testing stages of an implemented system. It usually involves an individual acting as a user of the system, whilst "thinking aloud" to identify any problems that they may occur or any aspects which they feel has improved. Research proves that the use of a think aloud analysis during the research stages of the project will allow the users to identify problems with existing systems before the design is produced. For example, in a supermarket, a think aloud would be used to analyse the current customer experience as they shop before deciding what needs changing <sup>[15]</sup>. This enables the observer to further develop potential

requirements. If this method is used, it would involve attending one of the centres and engaging with members asking them to think aloud during a workout.

## Surveys

Surveys are one of the cheapest market research methods that are used to retrieve quantitative data. As surveys allow a large number of people to participate, this can represent the view of the public very well. There is little to no subjectivity, as they provide all participants with a “standardised stimulus” meaning that the results are unbiased. <sup>[16]</sup> This proposed method could however introduce problems such as the use of inappropriate questions, which could hinder the relevance of results found. If this method were to be used for this project, the questions could have to be thoroughly planned. The survey would have to be executed as a test first, to deem if the questions are appropriate.

## Observation

The method of observation allows the researcher to watch an individual and observe and record how they would react in a particular situation. Using observation rules out the problems regarding self-report, where a researcher would record thoughts about a situation, which may not be complete or correct. This method can however be a time consuming process and it is also suggested, that the presence of an observer may change the behaviour of the observed. The observer would have to therefore be as unobtrusive as possible if this were to be undertaken. <sup>[17]</sup>

## Suitable Research Method

Through the thorough research into relevant stakeholders of the new system design, the most appropriate method to retrieve high quality research would be a questionnaire or survey. A survey will help me to identify the key users of the gyms/ leisure centres through the use of age range questions and reasons behind their membership. Surveys will allow the collection of data from a large scale of the public in a quick manner, as particular constraints for this project gives only a small amount of time to generate results. <sup>[16]</sup>

## The science of surveying

When choosing to develop a survey as the primary method of research, there must be a correct or substantial number of responses to enable an accurate representation of the public views. As a result of this, taking into account margin of error, confidence level and the size of the sample population is essential. [18]

Margin of error, can be defined as “a bound that we can confidently place on the difference between an estimate of something and the true value.”

The margin of error for this project will depend on the sample size which will be estimated. [19]

Level of confidence, can be defined as “a measure of how confident we are in a given margin of error.” [20]

An example of this in its context provided by “isixsigma” is as follows:

“A survey may have a margin of error of plus or minus 3 percent at a 95 percent level of confidence. This means that if the survey were conducted 100 times, the data would be within a certain number of percentage points above or below the percentage reported in 95 of the 100 surveys.” [21]

A mathematical equation used to calculate the recommended sample size is

$$x = Z(c/100)^2 r(100-r)$$
$$n = N x / ((N-1)E^2 + x)$$
$$E = \text{Sqrt}[(N - n)x / n(N-1)]$$

$N$  is the population size

$r$  is the amount of responses of interest

$Z(c/100)$  is the critical value for the confidence level  $c$  [22]

The margin of error for this project will be 10%. This is due to the fact that it will be difficult to reach out to over 200 individuals to participate in the survey, which could consequently reduce the size of the margin of error. There is only a small amount of time to collect results and so collecting any more surveys would not be feasible.

From the calculations and estimations made earlier, of the number of members as 12221, and with a margin of error as 10%, and a confidence interval of 95%, it is calculated that there should be at least 96 individuals needed to fill in the survey to ensure that the results are viable.

Having more participants will be an added bonus to the results, however due to the time constraints that this project is working under; this number is an acceptable and achievable solution.

## Survey

The survey was generated using SurveyMonkey. Unlike other survey building sites, where the maximum number of questions allowed to generate a free template was 10, SurveyMonkey enabled all questions that needed to be included to fit within the survey, with no fees.

The reason behind generating the survey was to develop an understanding of the current issues that members of fitness sites have during their stay. The survey consisted of 13 questions for individuals to choose from a range of options along with one question for members to comment on their own unique views, to highlight maybe problems which had not been covered within the questions. The survey consisted of the following topics:

- Purpose for attending gym
- Technical problems
- Performance
- Age & Gender

The survey was shared through various methods including email, public posting to Facebook and word of mouth. The survey was shared via a link to directly access the questionnaire prompting for members only to participate. After this, to enable a broad age range of results, the survey was pushed further to email contacts, and their contacts, and so on, to enable a range of responses highlighting all potential problems that individuals face.

The front end of the design consisted of the look that participants would see as they clicked the URL. This was the list of questions (one question to each page) along with various options for the individual to either choose one or many. The back end of the survey consisted of the questions that had been built, along with the number of responses, and their answers. This was updated each time a new survey was submitted by a participant and these responses were added to the results automatically. This made it a very simple process to have access to all of the data retrieved in one place. Answers

that were given within the survey were presented in a pie chart making it visible to identify the main problems addressed.

Many survey generating websites were selected and tested before choosing Surveyplanet. Websites such as “FreeOnlineSurveys” and “SurveyTool” only allowed a small number of questions to include, and did not allow additional comments to be made by participants. As this would have restricted the findings for primary research, more searching was undertaken to successfully find “Survey Planet”, which was much more suitable for the sample size and range of questions needed. Exporting of results was not required as results graphs and charts had already been automatically generated.

The comments that were made by individuals were displayed as a list to be read through thoroughly.

From initial research it was stated that 96 participants would be required to ensure an accurate response. The total number of responses was 110, exceeding the requirement by 14, and therefore enabling a confident and viable set of results.

After the results had been generated, it was then necessary to develop an understanding of the data retrieved to begin to build a set of requirements from these.

## Survey Results

The survey was able to gather 110 participants. From the 110, there were 4 people who filled out the survey who did not attend the gym and therefore these responses were deemed useless. This was indicated by the question “How often do you attend the gym?” The 4 participants selected “Never” which indicated that they would not be able to generate valid opinions for this project.

With only 4 participants providing comments that would not be relevant to the project, 106 useful responses remained, and as the number of participants exceeded the sample size recommendation, this still left 10 results over 96 in order to achieve the 10% margin of error.

The choice of developing the survey results as a graph, will allow the results to be displayed in an easy to follow manner, allowing high quality analysis of the results. The Colour coordination allows distinction between the different options available, and the colour coded format avoids too much information being written in the chart itself.

Further questions other than multiple choices were added to enable the participant to add any extra information that they may deem necessary, to enable broad research into the problem.

Particular questions in the survey provided example problems which the participant could choose. For example, question 4 asked “what problems concern you most with your membership?” this was explained with multiple options such as “safe storage” or “poor/old machinery” for the member to identify, or leave blank if necessary.

The results of the survey were able to demonstrate the need for change in the Fitness Industry, and the potential improvements that customers of this industry are looking for. The points which were identified as the most important issues which needed solving were:

- Slow experience
- Lack of incentives
- Lack of temperature regulation
- Lack of fitness monitoring
- Poor staff response
- Insecure storage
- Insecure membership
- Poor machine conditions
- Lack of fitness knowledge
- Lack of health and safety knowledge
- Lack of technology
- General quality of service

The full results of the survey have been reported in Appendix 2 “Survey Results”, where all figures and participant data can be found.

## Proposed requirements

A requirement is a feature of the system or a description of something the system is capable of doing in order to fulfil the system's purpose. In respect of this project, it will indicate the processes of the system and its components to enable a pervasive environment, satisfying the members.

The three categories of requirement are as follows:

- Absolutely must be met
- Highly desirable but not necessary
- Possible but could be eliminated <sup>[23]</sup>

It is important to identify all requirements, for further research to then establish which requirements may not be necessary, and which are essential towards the development of the pervasive environment.

Requirements are essential to validate that the system once built satisfies the needs of the users. Without well-defined requirements, projects cannot be planned correctly, developers do not know what to build and customers do not know what to expect. The requirements are drawn from the results of initial research, as a solution to identified problems. <sup>[24]</sup>

The initial set of requirements was generated as a result of the survey which was undertaken. This initial set of requirements will then need further research and individual opinion, and this could generate a huge change in highlighted issues, and so have been presented as a list, instead of a detailed description. The list explained a minor solution to the problem, awaiting further details within a requirements specification, once confirmed by individuals as need for change.

The initial requirements were separated into a set of broad topics such as "Membership Requirements" and "Machinery Requirements" to enable the understanding of each requirement, assuming the reader is unaware of the problem as a whole.

The initial set of requirements were drawn with the intention for it to be understandable by readers who are not fully aware of what pervasive technology is, as this list will be used during interview stages. This means that the initial requirements do not go into descriptive detail about the functions of the embedded systems.

An example of a set of requirements from the initial list is as follows:

### **Machinery Requirements**

1. *Touch pad interface*
2. *User detection (scanner)*
3. *Personalised settings*
4. *Wireless headphone feature*
5. *Built in webcam & video chat*
6. *Built in staff contact call*
7. *Auto adjust machinery based on profile*
8. *Voice controlled commands*
9. *Weight machine with built in performance review*
10. *Ability to notify members when machine is free*

The complete list is reported in Appendix 3 “Initial Requirements”

## Interviewing

Qualitative research was the next important process to ensure that the initial research and requirements that had been drawn together are an appropriate and accurate response to the problems that have been identified by the members of the fitness sites.

From this, and using the list of potential secondary research methods developed, it was decided that interviewing would be the most appropriate method, to ensure that qualitative information is derived from the initial requirements and appropriate changes are made to satisfy the users (members).

The number of recommended interviews to conduct for research depends significantly on the timescale and the size of a project. Although there is not specific mathematics to prove an appropriate size, many research papers have been developed as a response to this question, and ongoing problem. In a “research methods review” paper written by Sarah Elsie Baker, Middlesex University and Rosalind Edwards, NCRM, University of Southampton, it states that Adler and Adler advise graduate students to sample from as little as 12 to as many as 60, for qualitative research. This paper also provides many other recommendations such as research expert Harry Wolcott who says the number of participants is dependent on how many are enough to satisfy the person undertaking the project. [25]

Based on the number of participants that took place in the survey, which took a number of weeks to complete, it is understandable that conducting a large number of interviews would just not be feasible, however conducting approximately 12 would give a broad reaction from members, and should fit within the given timescale of the project. This was estimated in the hope that the 12 interviews would provide an in depth response. If this was unsuccessful, for example if not enough information about the requirements were generated, more interviews would have to be conducted.

Interviews were arranged in advance prior to meeting with each participant, and were structured in an informal manner to enable a wide discussion of the project. It was hoped that the interviews would highlight the following points:

- Which requirements held the most valid solutions
- Specific issues or concerns relating to the addressed requirements
- Additional requirements to input
- Requirements which may not be relevant
- Changes which must be made to the initial requirements
- Enthusiasm for the project from participants

Each interview began with determining what understanding the individual had (if any) of the term “pervasive computing” along with a description of the intentions of this project. If the participant required more information, this was provided. The depth of responses was determined by the knowledge of the participant, and their understanding of the concept of the project. Once explained, a printed list of requirements was handed to the interviewee for them to read over. Interviewees were given the chance to ask questions about the requirements themselves and give their opinions on whether they felt these were substantial or not. Questions were asked to the interviewees regarding any changes that should be made to any of the requirements produced, or any further requirements that could be included.

Here is an example of one of the interviews that took place. All interviews have been provided in a separate Appendix 4 “Interview Results”:

***Ben Windebank- Member***

***Interview held 6<sup>th</sup> March 2015***

*Ben is 21 years old. He is a full time student and attends the gym/leisure centre at peak times in the day. He particularly enjoys using the swimming facilities available.*

*As an engineering student at university, Ben understood the idea of pervasive computing as some of his modules have briefly covered this. He has a personal interest in technology himself and so understood the requirements fully.*

*Ben read through the list of requirements and was impressed with the ideas generated. He identified that improving the way in which he swims. Ben still likes to be aware of his speed whilst swimming leisurely and has suggested for a way in which this can be monitored. Upon a detailed discussion about this, ben also went on to explain how it is a shame she cannot listen to music whilst she swims, but he had always just ruled this out and presumed that there is no technology available for this. I explained to Ben the possibility of new advanced systems being out there and he was excited at the prospects of this.*

*Ben highlighted the requirement about data being displayed on the interface. He expressed a concern about the amount of data that was being displayed, and that it should be placed across a few pages so it is not confusing to some members. This was later added as a very relevant requirement.*

*Having read through all of the requirements, ben was pleased that he could have an input and from this was satisfied with the final list.*

## Interview results

The interviews conducted were able to demonstrate a drastic need for change with the current situation for fitness sites. All main issues that currently stand the interviewees felt were highlighted in the requirements and each of the participants felt that the project had great potential to address various problems that could easily be resolved.

There were some participants who didn't show an interest in some of the requirements that were included within the list. These individuals did however understand that different preferences of different members make all of the requirements listed as useful, and understood that the requirements listed would help improve the experience for members as a whole. There were a few requirements that addressed concern, which could be changed slightly or have new requirements designed in link with the original. For example, requirement "touch pad interface" raised concerns from interviewee Janet Jackson, who said although this was useful, there could be another requirement available to use the machinery without the interface, and so requirements like these were added at the requests of the interviewees.

The interview results reported show the particular interest individuals expressed towards specific requirements, to highlight which may be the most important to implement. It was assumed, that requirements that were not brought up as a concern during interview, were accepted as appropriate by the interviewee. The number of interviews held remained at 12. Accurate responses and valid points were brought up during these, and all requirements were covered on a number of interviews held, and so it felt that this number was appropriate to finalise the qualitative research collection.

To conclude, the interviews demonstrated that all of the requirements have addressed the problems accurately and appropriately. There were no extreme concerns raised about any of the requirements, and any minor concerns were discussed thoroughly and were resolved at interview. All individuals expressed an interest in the potential of the project, and were satisfied that the requirements would help to solve all problems that currently stand in fitness centres.

## Improved requirements

Below is a list of the requirements which participants at interview showed interest or concern during the interview process and the comments or changes that have been made. Any additional comments made by participants have been added to the requirements list accordingly.

- Lockers will enable a one touch open and one touch close system with fingerprint scanner (SA01)
  - *Agreed a useful requirement due to the concern of possession safety in the fitness centres*
- Lock on machinery for 15 minutes
  - *15 minutes added to allow other members access if unused*
- The system will send Bluetooth alert to user device when machinery is free (HI02)
  - *Agreed a useful requirement due to problems accessing machinery*
- There will be built in balance monitors within the fitness class suites
  - *Agreed a useful fitting*
- System to send signals to air conditioning to adjust temperature in accordance to heat radiance (TC02)
  - *Agreed a useful process due to the current problems with temperature regulation*
- Personal performance data monitored by machinery will be pushed to the smart device of the fitness instructor
  - *Included as a requirement after discussion with concerned interviewee*
- Room light sensors will automatically adjust the fitted light intensity in the room (TC05)
  - *Agreed a useful function for energy saving*
- Weight machines will automatically measure the lifting exercise and assess the quality of the lift. (FC02)
  - *Agreed a useful feature due to safety risks when weightlifting*
- Hardware and fitness machinery will automatically adjust its settings based on the individual member preferences. (AM01)
  - *Included as a requirement after discussion with concerned interviewee*

- Machinery and fitness suites will have wireless headphone capability (E03)
  - *Agreed a useful feature for entertainment*
- All hardware will have built in voice recognition to control the interface hands free (SC02)
  - *Included as a requirement after discussion with interviewee*
- Room access interface into wall with built in fingerprint scanner for membership detection (M01)
  - *Agreed a useful feature due to concerns regarding unauthorised access of facilities*
- A membership code will be an alternative protection for accessing of personal data (M04)
  - *Included as a requirement after discussion with interviewee*
- Interface will allow an alert sending function to the reception staff interface (MI09)
  - *Agreed a useful feature due to current technical difficulties*
- There will be an information page displaying the weight gains and losses of an individual throughout membership.
  - *Agreed as a useful feature due to users being unaware of their weight*
- Heart rate monitors will retrieve real time data about the members' heart rate. (HS02)
  - *Agreed as a useful feature to improve health and safety*
- Embedded sensors in hand sanitizers (AM07)
  - *Included as a requirement after discussion at interview*
- Swimming Lap counter device will push lap data to main database (AM03)
  - *Included as a requirement after discussion at interview*
- Each Machinery Interface will have separate pages for different pieces of information and performance (MI01)
  - *Included as a requirement after concerns raised with too much content for a user to read*
- Smart device tennis racket will push performance data to member interface
  - *Included as a requirement after discussion at interview*
- When exiting sleep mode, or re-entering the system, the system will remember the most recent activities and re-load these (SC01)
  - *Included as a requirement after discussion at interview*

- Tap water
  - *Requirement removed as breached health and safety\**
- System will provide the ability for warning alerts to be muted where needed
  - *Included as a requirement after discussion at interview*
- Interface will allow an alert sending function to the reception staff interface (MI09)
  - *Agreed a useful feature at interview.*

\*The health and safety of individuals in a public fitness environment must be adhered to at all times. This includes the provision of clean tap water. The requirement that enabled an automatic dispense of water meant that water could be standing in an open space for a long period of time. This therefore had to be removed as the water could become contaminated and be a risk to the members at the fitness centre.

## Technological Solutions

### Forthcoming Technology

Here is a detailed description of the technology that is currently in the development stages, or has not yet been released, and is hoped to be introduced in the near future. Some of these technologies are a replacement of the other existing technologies which could be used in a pervasive environment of a fitness centre, but with better functionality or additional useful features, or products which have been further developed to help with the signalling and storing of data. Additional technologies with links to the fitness centre have been provided; however these are very new developments and would take a very long time before being introduced into an environment such as this.

### Automatic Brightness Adjustment

All of the latest smart technology, including android and apple devices, consists of the automatic brightness adjustment feature. The feature itself has a general design involving light sensors which are located directly next to the screen of the device. This measures the ambient light. The control software that is linked to this then adjusts the screen brightness accordingly. When in the dark, the screen should dim, and when the ambient light level is brighter, the screen gets brighter accordingly.

Although this is an existing technology, it is found that current designs implementing this technology are incorrect, and provide higher screen brightness than necessary, using greater battery consumption and also causing the health and safety problem of eyestrain. Current implementations can use more than 50% of the total power of the phone. Improper brightness output is also causing high internal heat and temperature issues, causing a lot of damage to the devices. With such expensive machinery in use, a fitness centre would have to ensure that this feature is safe enough to use within the interfaces.

Dr. Raymond M. Soneira explains that the standing technology indicates issues with the location of the light sensor and where it is actually incorrectly measuring the

brightness. For example, in smartphones, the lighting that is measured is the brightness of the users face, rather than the brightness behind, or around the sides of the individual. This then causes an incorrect adjustment of the brightness causing further technological problems elsewhere. [26].

Although this technology currently seems to be an issue, there are designs that are emerging as solutions to these problems, meaning this could be resolved in a matter of months, for the latest hardware that is being developed.

The designs in place could very easily be embedded within the interfaces and devices within the pervasive fitness centre. This could be used to control the machinery interface against the lighting in the room, or the daylight intensity.

### **Waterproof fitness tracking**

Fitness tracking has changed significantly based on the preferences of the user. Brands are aiming to make performance monitoring as easy as possible by embedding systems within the sport equipment.

“Instabeat” [27], is a company who have who are in the later phases of developing a waterproof heads up monitor, for professional and training swimmers. The design consists of a unit which is attachable to the front of goggles, providing real time results through the monitoring of heart rate, calories, laps and turns whilst swimming.

The design, as it currently stands, consists of an optical sensor and an on-board microprocessor which is used to read the heart rate of an individual from the temporal artery, located within distance of the goggles. [28]

When attached to the head, the device is automatically powered on and coloured writing is projected onto the lenses of the goggles to produce real time information about how close you are to your target zone. The design consists of a colour coordinated projection telling the user which level of the zone they are in (beginning, middle, or upper limit). The display also monitors calories burned, along with the “flip turns” and the number of laps that have been counted during the swim.

Currently the data is transmitted via a USB port, however as the model is still in development, this is being attended to with the hope that the next model will sync the data wirelessly to smart devices and a separate dashboard. [29]

Although there are existing products with similar designs, these do not currently provide the ability to store the performances that have been measured and so would not add much value to a pervasive system, however the improvement and development of “Instabeat” could become an interesting contribution to this project.

This could be an interesting possibility as a replacement to the smart watch that currently exist, providing more opportunities for the user.

These devices are simplistic and small, and could become a property of many fitness sites, whilst connecting wirelessly to store data to a fitness centres central database, an extremely useful tool for professional swimmers.

Instabeat is currently taking pre-orders for the new design, which is hoping to be released within the next few weeks, where it will be available publicly, after the final tests are complete.

### **Brain – Computer interface and the Neurotoy**

A Brain-Computer interface is the idea of direct communication with the mind of a user and their brain and an external device such as an interface.

Although the brain commanding technology has been available for a number of years, there is continual development for this to be a more connective usage allowing individuals to use it for entertainment, along with for medical assistance.

Researches at brown university have had a breakthrough in the development of a wireless brain-computer interface in 2010, using a device which is attached to the skull of the user, using radio thought commands, which are collected from a brain implant. [30]

The new development is currently being used for medical purposes, to aid those with paralysis; however the idea has further developed to provide even more advanced technology for entertainment and user control. This is a broad aspect for now, but could change the way in which a public environment controls its devices, such as a fitness centre.

The latest advancement and development of this idea is known to be called a "Neurotoy". The Neurotoy, developed by SXSW, Canadian neuroscientist and artist Ariel Garten, contains headbands with embedded sensors which can connect to various computers to enable a user to control a separate device or a game using their thoughts directly from the brain.

Currently, the design consists of the headband with associated applications, turning the brainwaves from the user wearing the equipment into real time data using the sensors which are within the headband, known as "electroencephalograph", or EEG, sensors.

Not only are these new devices used for the controlling during basic games, this idea has also been developed by different companies, such as Neurowar, to prototype a headset dragging music from the users lists to load onto a separate playlist, based on the mood of the users.

The technology detects the changes in the brainwaves, using electrodes. The change in voltage is recorded several hundred times / s and this is then transformed into digital signals which are then wirelessly transmitted to a computer via a Bluetooth connection.

[31]

This development would be extremely useful to provide entertainment to a member whilst exercising.

Although research has indicated that the Neurotoy would be available to customers in 2013, there is no evidence found of this being a completed product as of yet, and so may still be in the development stages.

## Wireless charging

Wireless charging is a new development that is currently being implemented into new systems. The idea is that an individual can charge a device whilst in range of a charging unit, without the need of an attached wire.

Wireless charging relies on electromagnetic induction. Magnetic fields are generated using the coil wires within the charging plate. Without the need to be in contact with the adjacent coil, an electrical current can be generated. When in contact with a coil which is a part of a battery charging unit, then wireless charging commences. [32]

The wireless charging capability is being developed currently to improve efficiency, as this currently stands that it is only between 60% and 70% efficient.

This new emerging development is an extremely useful tool for wireless devices in need of a constant charge. As this is available to charge many battery charging units, this would be particularly useful for wireless equipment fitted in fitness sites.

IKEA is one of the latest stores to be introducing the wireless charging products, which are soon to be available by the end of April. [33]

## Peer to peer networking

Although P2P has existed for many years, it is continually developing to aim to become the next generation of networking. It involves the transferring of files over a connected network. [36]

Peer to peer networking is the process where computers, who are named the “peers”, are connected to one another, without the need of a central server, allowing for various different processes to take place between these peers. [34]

As opposed to using the internet, this process involves using software to find which computers have the file which is needed. A request is sent out to find the file and the software queries each computer to find the file. Once located the file is downloaded. [35]

Peer to peer would be useful when an individual needs access to different files from different areas of the fitness centre.

### Screenless Displays – visual image

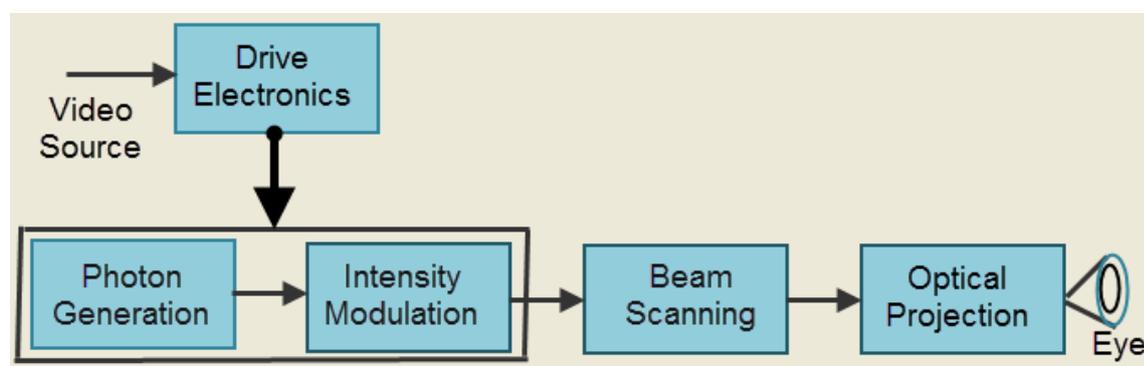
The technologies that currently appear to be the trend at present are touch sensitive devices. Soon enough this technology will become out of date and will be replaced with a more practical design. The screenless display is the latest advance in display technology, overcoming space issues that screen displays currently have. There are 3 types of screenless display; Visual Image Display, Retinal Display and Synaptic Interface. [37]

#### Visual Image

Portability and ease of use is an attractive factor for interfaces to be fitted in public environments, particularly fitness centres. The visual image is a form of screenless display which is currently in the development stages. This form of screenless display does not need an intervening medium to project the light. Examples of these include holographic images, which can display 3D images through the use of a helium neon laser and a lens.

#### Retinal Display

A retinal display is a design that aims to project the image directly into the retina. This gives the perception that the image is floating in space rather than on an object. The display consists of the following blocks:



This is a new and complex idea, which in the future has the potential to completely change the requirements of a pervasive design.

### *Synaptic Interface*

The synaptic interface is the idea of displaying a video without any use of light at all. The image does not pass the eye, but all visual data is sent to the brain. This is a very vague concept for now, as it has only been implemented into human use through the idea of braille reading for example. It would take a lot of extra work for this to be in use within a public leisure centre, although it would be a very useful tool. [38]

Screenless displays would be a particularly useful tool as a replacement for the physical screen of an interface on machinery. This would allow the display to be positioned at a more eyelevel view, for the member to be able to see safely whilst using machinery.

### *Integrated Fingerprint Detection Systems*

Christian Holz, a researcher in Human – Computer Interaction, is in the process of developing the idea of fingerprint detection system, embedded into the interface of a device, and has recently researched into a product called “Fiberio” which is a system that does just that. With each touch to the interface the Fiberio authenticates the user, verifying securely that the user has authority to be performing the particular activity. This frees the user from any other form of identification process.

The screen consists of a fibre optic plate which allows the activities to be displayed on the screen whilst simultaneously verifying the user. The screen works through the use of light whilst also diffusing light allowing the display projection.

When the user places their finger onto the fibre optic plate, the ridges from the finger appear dark on the screen, whilst the other surrounding areas appear light. [39]

Not only can the interface recognise fingerprints, but also fiducial markers.

The company behind this invention are currently raising money through investment and are hoping this will support their growth in the development of their systems, in the hope to release the product when the funding to continue is sufficient.

This technology would allow the member to have confidence that their data is safe. This process would also save time, as the member would not have to use any other proof of identify methods such as a username and password.

### **Performance monitoring – Adhesive Bandages**

Adhesive bandages have become a new interest in the development of health technologies.

The Ampstrip provides measurements during training, and also during recovery (the time spent resting after an exercise). This can be used to improve performance, and also as a safety precaution to ensure that a member is exercising correctly to avoid injury. The company claims that watches can be inaccurate, and chest straps, uncomfortable, however this device is fitted to the torso of the user and can be worn 24/7.

The Ampstrip has a substantial amount of storage to save data instantly, if it is not in range of a smart device or interface to store the information. Once in range, the data is sent straight away. <sup>[40]</sup>

The product is not currently available for purchase, however, once available it will cost in the region of \$149 per unit and is hoping to be released in August 2015. These devices are particularly useful for fitness centres to provide to their members for posture support, and to store their performance after workouts. <sup>[41]</sup>

### **Entertainment - Goji Play experience**

Fitness experience is becoming extremely competitive, and so the technology development is also improving in this sector, with companies trying to find new ways to enhance a customer's experience, particularly in the entertainment aspects. Blue Goji <sup>[42]</sup>, a fitness company with interactivity and entertainment as its motive, has developed Gogji play, their latest release. The Gogji play allows users to play games whilst they exercise. The product is attachable to treadmills, bikes, and elliptical in gyms and fitness centres. It works using an activity tracker which is attached to the users shorts and controllers that are attached to the machine in use. The individuals phone acts as the

screen and the user can select from a range of games to play. The aim of this is technology is to encourage those users who do not feel motivated to exercise, and to make a 30 minute exercise seem like 5 minutes. Running at different speeds controls the speed of the game and the controls add direction. Initial games have been produced and were released in 2013, however Blue Gogji is in the process of developing this further into fitness centres to improve the games and turn Gogji play into a “true platform” [43]

This would be an extremely helpful tool to give motivation to the newer members.

### **Pressure sensing floor**

Tracking people and pressure could make a huge difference in the way fitness classes such as yoga and balance exercise can be performed. There is evidence of performance measures that lacking in present fitness suites, which some members feel dissatisfied with.

Alan Branzel is a Human Computer Interaction researcher who has been looking into the development of tracking the location and poses of individuals using a high resolution pressure sensitive floor. The gravity pushing down on an object leaves imprints of pressure into the floor. The type of pressure applied and the force of each movement can then determine the position of an individual. This is a new development over camera based solutions, as it provides consistent coverage of a room. Should this be further developed, this measuring system could have the capability to monitor a human’s posture along with balance, to be a performance measure in many fitness classes. This is however a concept at the moment, as no further research has been produced as of yet. It could be many years before this would be released as a product.

[44]

Although some of these emerging technologies are rather broad as an addition in respect of this project, it gives a chance to see the possibilities of how new technology could immediately change a view of how things would work, particularly in a public centre.

## Existing technology

### Performance monitoring weight lifting

#### 1. *Beast Sensor*

“Beast Sensor”<sup>[45]</sup> is a new technology which has been developed to provide real time results of weight lifting performance, aimed to add motivation and avoid any wrong movements whilst lifting, to help with the fitness safety of the individual. The technology consists of a magnetic sensor and can be attached to many different pieces of equipment such as barbells, dumbbells, kettlebells or other gym machines. The sensor can also be attached to the body of the individual, enabling monitoring of performing free body exercise using the provided vest. The real time results generated from this is wirelessly linked to an application which can be accessible on smart devices. The sensors provide a range of performance monitors including the speed of lifts, along with the power and the strength of each lift, and can all be monitored during a workout. Results can be reviewed during exercise breaks with the app indicating ways to improve training methods and workouts.

Based on previous performance, advice is given to the individual for example the number of reps that should be performed or the best weight to choose to help reach training goals.

#### 2. *PushStrength*

The PushStrength arm and waist bands are attached directly to the individual in training. The Push Band aims specifically to avoid serious injury whilst speeding up improvements, providing real-actionable metrics. The power of the lift is measured in Watts, determining how much the individual has exerted themselves during a lift. PushStrength makes use of Velocity Based Training, which is a regulatory process of the load and volume of the lift prescribed, and if each load is appropriate for the individual in training. This helps to detect if a user is failing a lift, before a failure occurs and damage is done.

The advancements in technology has resulted in TW, also known as “Total Work”, which is a new metric which is becoming the new choice, in practice, to monitor the stress

imposed on an individual during a workout. TW is measured in Joules and is based on force produced, distance travelled and the velocity of each movement. [46]

The features of this technology are as follows:

*Height: 77.7mm, Width 53.3mm, Weight 32g* [47]

The equipment is fitted with an enhanced Bluetooth 2.1 wireless facility for the detected data to be sent to a device. It includes an Accelerometer sensor along with 1 gyroscope per band and is compatible with both Iphone and Android devices. Devices are rechargeable.

The use of the weight performance tracker will help members who are worried about the safety of weight lifting, and will provide guidance to beginner weight lifters, to learn the safest methods.

### Smart Rackets

“Babolat”, the oldest company specialising in racket sports [47], has developed a new tennis racket with an electronic handle with built in game performance measures. Named the “PlayPureDrive”, described by the CEO of the French tennis company as the first “Connected Racket”, Babolat insists that the invention of the smart racket handle does not hinder the swing of a shot in any way, and is able to provide useful measures to an individual’s play technique.

The Pure Drive Racket consists of a standard racket design on the outside. The handle has sensors integrated into it. The sensors react to power, through the detection of the vibration in the strings. It also responds to the number of strokes, whilst also indicating the type of stroke undertaken (forehand, backhand, serve and overhead smash) through swing and motion detection. [48]

It is expected that the device design will soon be able to be incorporated within existing racket designs, whilst existing as a standalone piece of equipment. [49]

With the memory capacity of 150 hours of tennis games, this device is durable, long lasting, and affordable invention added to the market.

The racket is available in a range of standard sizes, enabling usage from a broad range of players. It has the ability to transmit the data collected to smart devices, tablets and interfaces for further analysis of the data through a Bluetooth connection. . The handle integrates 2 buttons along with a USB port into the butt cap of the system for the ability to plug into a computer, without any performance change

The design has the ability to add further entertainment to play the game, by allowing competing against friends in a conventional game of tennis, comparing shots against each other adding enrichment to every game.

The design is as follows:

Composition: Graphite, Weight: 300g, Head size: 645cm<sup>2</sup> Balance point: 320mm. [50]

### **Automatic soap dispensers**

Automatic soap dispensers are designed to release a measured amount of soap on the palm of an individual's hand, aimed to reduce the amount of infectious disease that is transmitted.

The mechanism consists of a built in sensor within the bar of the dispenser, with the nozzle attached above. One a hand can be sensed the pump is activated, allowing a measured amount of antibacterial substance to be dispensed onto the hands of the individual.

Automatic soap dispensers come in a range of different brands, and have become a popular demand in many public areas over the last few years.

The dispensers can consist of many different types of sensor

#### ***Radar Based Sensor***

The radar based sensor uses ultrasounds energy or microwave energy. This energy is sent out in small bursts, and waits for a response of the energy reflecting back. If there are no hands placed in front of the sensors, the energy will reflect back in a normal manner. Once the hands are placed, the energy returns in an irregular pattern triggering the soap to be dispensed.

#### ***Photo Sensor***

A photo sensor can be used in these dispensers, and consist of two separate parts; a laser beam, and a light sensor. The light is disrupted by the disturbance of the hands being placed under the sensor. This then activates the pump to dispense the soap

### *Passive Infrared Sensor*

These sensors are able to detect infrared energy that is emitted from body heat. As hands are placed near the sensor, extra infrared is detected and so the energy fluctuates, alerting the pump to activate and dispense the antibacterial.

This would be used to maintain the hygiene within the fitness centre. Individuals would not have to come into contact with the facility to avoid the spread of harmful bacteria in a potentially humid environment. [51]

### **Automatic Light Sensors (Smart Lighting)**

The automatic light sensors, or “smart lighting” systems are designed to significantly save energy in particular environments. It is suggested that automatic lighting systems are specifically useful for open planned environments and can save over 30% of energy compared to standard lighting systems. [52]

“Finelight” offer products which provide integrated sensors in lighting systems, which automatically adjusts brightness based on the light intensity in the room, and switches off completely when there is zero occupancy. [53]

Another automatic light system product brand is the Osram Dulux Intelligent Sensor.

This design uses the detection of daylight through a process called spectral distribution. This is a measurement which describes the power per unit area per unit wavelength of an illumination. This system responds only to the daylight of the room, and no other lighting features which may be active.

As soon as the mains voltage is switched on, the system is initialised and ready to use straight away. [54]

This specific system has up to 500,000 switching cycles, meaning the light can be turned on and off up to 500,000 times before it loses its quality of light.

There are both closed loop systems and open loop systems available for light adjustment. The closed loop systems consist of measuring the light intensity from both daylight and electronic devices. It contains a photo sensor which measures the output of electric lighting systems. From this it develops results based on the adjustments made and makes further adjustments based on this, which is a closed loop. An open loop measures only the daylight. In this case the photo sensor would be placed outside the

building, or away from any electrical light contributors. The photo sensor measures this light, and a controller is signalled to dim the lighting in accordance with the daylight intensity measured. [55]

This would save energy for those members who are environmentally concerned, whilst also providing the perfect lighting conditions for a fitness classes.

### Smart Watches

“Garmin” a producer of navigational equipment, has designed a new smart watch which is specifically designed for swimmers. The watch itself is 100% waterproof and has the ability to monitor real time stroke counts. Not only this, but it also is able to measure the type of stroke being undertaken, along with the distance, the pace and further lap information.

The watch itself consists of a standard design including all of the basic features required of a general watch, with the performance material added to this. The watch can log “drills” or timed sets without having to rely on the clocks outside the pool.

“SWOLF” is a swim measurement based on the measurement of the time and stroked it would take to swim the length. A lower measurement of this indicates that the individual is a better swimmer. This device has the ability to measure and store the performance.

The Garmin watch contains wireless capability to the USB receiver for the sending and storing of the data, which can be accessed on tablets, interfaces and other smart devices.

[56]

### Heart Rate Monitors

A heart rate monitor has been an existing technology for some time however has been adapting into different shapes and forms over the years to give new unique processes and more simplistic and accurate designs.

Earlier heart rate monitor designs consisted of the transmission of a radio signal, once a heartbeat had been detected. The receiver would then measure the heart rate of the individual from this information. The signal came in different forms, from a coded signal in the form of Bluetooth or other radio links. [57]

Heart rate monitors have soon developed to more useful and technical pieces of equipment, including microprocessors, used to monitor the electrocardiogram (electric activity of the heart)<sup>[58]</sup>

Specific designs involve the use of accelerometers, detecting the speed and distance of the exercise as an additional feature.

Further additional features which have been introduced into the latest heart rate monitors include the following

- The average heart rate throughout a workout
- The number of calories burned
- The rate in which the individual is breathing

One of the most recent heart rate monitor designs is the Polar Wearlink monitor which includes plastic electrodes to detect the heart rate of the individual. From this, the connector sends the heart rate data via Bluetooth to a receiving device. <sup>[59]</sup>

Other additional heart rate monitors in watch form provide heart rate monitors sending the signals wirelessly to a smart interface or device.

Additional features included within recent technologies include “target zone alarm” which is an alert informing the user that the target heart rate zone has been achieved during that particular exercise.

Further features include the calories burned, along with the duration and the distance of a particular form of exercise. <sup>[60]</sup>

### **Smart scales and air/temperature monitors**

Over the last decade traditional scales have been transformed in to electrical monitors enabling the tracking of various performance measures of an individual. Technological advancements has led to the ability of the storing and transmitting of data which is monitored

Electronic scales work using a load cell, which is a form of transducer, enabling the mechanical energy which is conducted from the weight of the individual on the scales, into electrical effect. <sup>[61]</sup>

“Withings”, a company that builds smart devices around health, has developed a smart body analyser. The device, not only measures weight, but it also includes additional

features such as body composition and air quality, useful for regulating air conditions within fitness centres.

Poor air quality in fitness rooms can lead to problems occurring in the body such as headaches, respiratory problems, sore throat or stinging of the eyes. The air quality monitoring system measures the temperature and the carbon dioxide levels in the room. This data can be pushed to a smart device wirelessly and the CO<sub>2</sub> levels are presented in a graph, indicating when the air needs to be cleaned. [62]

The main disadvantage of this device is that it consists of an automatic user recognition system which is currently available for recognising only up to 8 users. Although there are other devices allowing more users, there are currently no known wireless scales with user recognition of any more than 20 users per set of scales. This could be easily implemented in the near future. With micro SD memory cards enabling memory storage of up to 128GB there is potential for this to be further developed. [63]

More features involved with the smart body analyser involves a body mass index identifier and considers the change of the fat-lean ratio to identify trends and similarities of the weight fluctuations, to enable an individual to become more “weight aware”. The feature is a great way of targeting those who are unaware of their weight and BMI, an essential aspect of maintaining good fitness levels.

Finally, the scale monitors embedded into the device includes a “position control” feature in which the individual can be aware of where to place their body on the scales to ensure an accurate and correct weigh in.

The smart scales will be able to target those members who forget are unaware of their weight, and enable them to keep a regular record of their changes and improvements.

### **Built in interfaces**

“Discover” is a new tablet console that has been built as an interface specifically for treadmills, exercise bikes and cross-training machines. The tablet consists of a range of features available for individuals to personalise and monitor their workout. [64]

The interfaces are designed for individual profiles to be loaded with private access to data about the fitness of an individual. This works through the use of RFID (Radiofrequency Identification) tags which uses electromagnetic fields to wirelessly send data, with the tags containing the data that is to be stored.

The interface itself consists of a HD screen with easy navigation and with a range of additional features.

Discover also includes internet capabilities allowing individuals to access anything they wish whilst exercising. The interfaces also allow the use of “interactive courses” in which a user can select a hike or an exercise of their choice in many different locations all over the world, with the speed of the interactive course adjusting accordingly with the speed of the individual.

The analysis of the workout can provide advice to the member allowing them to have a better understanding of the goals that they are working towards.

The interface allows for separate management via an individual’s smartphone, and customisation of the interface means users are able to choose from applications which have been pre-programmed to their favourite TV channels.

This interface also allows password protective access meaning it would be perfect for public use with many individuals, and contains a protective top layer with internal shock mounts. [65]

### **Fingerprint lockers**

The fingerprint locker uses biometrics, technologies in place to detect a user’s fingerprint.

Fingerprint recognition works through the comparison of the patterns of an individual’s fingerprint against a previously stored template of an individual’s fingerprint.

Fingerprint scanners consist of fingerprint sensors. These sensors take a digital image of the fingerprint and the pattern of its ridges. This image is then processed into a template which is then used to compare with newer fingerprints that are scanned, to provide access to the correct users. [66]

Technology has advanced for these fingerprint scanners to be embedded in many everyday objects and tools, to improve the security of individuals, and is particularly useful in a public environment.

Gaungzhou Jijia IT &Co. is a china based company who develop specialised technology equipment, including biometric fingerprint safes, typically used in airports, hotels and other public places. With sound operative guidance, the lockers allow ease of use and

security for any large companies, where use of keys may add difficulty to the experience. [67]

### **Remote controlling technology**

DLNA is called a digital living network alliance. This is a guideline organisation which gives standards about the sharing of information and multimedia between multimedia devices. This includes TVs and laptops and other pieces of equipment. The DLNA provides a bridge between the different devices in a room or building, allowing control of one device through another, or streaming from day your mobile phone to be displayed on the television.

There are various different DLNA devices which allow this connectivity and control to occur, such as smart phones and printers. The DLNA relies on a network, which can be wired or wireless to enable the remote control capabilities.

The DLNA uses UPNP, also known as universal plug and play. This allows pervasive communication activity in various different pieces of equipment and wireless technology. [68]

### **Virtual reality headsets**

Visus VR is the latest affordable wireless virtual reality headset, currently built for gaming systems. The device consists of an “on board head tracking system” which eliminates the need for the use of a mouse. The user’s smart phone acts as the display which can be fitted to a cover, streaming visual gaming activity from a PC.

The device also includes an anti-fog system to avoid any issues that there may be with the display. [69]

This new form of entertainment would be perfect for use in fitness centres, providing runners with a new running track of their choice, fulfilling the needs of many members.

### **Water Level Sensors**

Water level sensors have originally been developed to signal an alarm when the levels reach a particular amount. Since this, there have been further developments to create a more practical device such as the “Wimoto” technology.

The Wimoto consists of a small set of devices measuring different factors via Bluetooth. This includes a climate sensor, able to monitor the humidity of a room along with its temperature, and a water sensor, used for the measurement of the presence of water. The measurements of these small devices provide data which is then sent to a smart phone or Bluetooth enabled device, containing the central interface. [70]

This technology would be perfect for the measurement of water levels within the fresh water tanks available in many fitness centres.

The Wimoto would also be useful for the monitoring of temperatures within the fitness rooms, with the ability of an alert to be sent to the reception interface if it gets too hot.

### **Smart Air Conditioning**

“Tado Cooling” Is a new technology which allows the control of air conditioning from a remote device.

The technology consists of a small wall mounted device, with 6 infrared emitting diodes, aimed to give a range of 180 degrees to act as a replacement to the original remote control of the air conditioning, with a smart device taking control through a WIFI connection.

The system contains further features which detects when the room is unoccupied, turning the air conditioning off and saving energy. With multiple units fitted around a building, the system is capable of changing the temperature in relation to where an individual is in the room, creating a perfect temperature throughout the site for all. Similar to the google “nest” application for humidity, temperature can be monitored and controlled over a smart device. [71]

This could be a useful implementation to wirelessly monitor the temperature in many different rooms in the fitness centre.

### **Voice Control**

Voice control works through a “speech to data” process. This involves converting the vibrations of the voice into digital data through the use of an analog to digital converter. The digital data can then be understood by the computer and can then turn this into a command. Measurements of the waves are taken in samples, and removes irrelevant noise or “background noise”. The speech is normalized to generate a constant level of

volume. The speed can also be adjusted to align all voices recognised so that they match the same template on the device which is already stored.

The speech is split up into segments, so that the computer program can recognise a language. A statistical model is used to research all the segments and its surrounding segments, against a library of words to determine what the individual is trying to say.

[72]

Technology software is widely available for this process and is compatible with many devices and interfaces with a microphone such as a tablet or smartphone. Currently speech recognition in smart devices is used to undertake simple commands such as accessing the internet, or writing out a text message.

Voice recognition has the capability of performing many commands depending on the device in which the software is installed.

The google glass powered treadmill has voice activation capability, accepting voice commands for the adjustment of speed or to view the latest statistics. [73]

### **Television Capabilities**

Some exercise machines and televisions consist of their own internet capabilities; however this does not apply to all. Further technology development had led to a breakthrough of this issue allowing the steaming of on line material through the use of a separate connected device.

The google Chromecast is a video streaming device that is extremely small and can be fitted to a TV using a HDMI cable. The Chromecast allows users to find material on their phones such as TV programmes or films and stream them to the larger screen through a wireless connection. The Chromecast device allows the TV to mirror the video being played on the smartphone for a better view. [74]

A problem that faces the Chromecast device is security. There is no password protection capability, and so anyone within range of the device has access to it. This could be a problem within a public environment such as a fitness centre, unless the device is situated in a place where only the members can access this.

## Fitwall

Fitwall is a very new arrival in the fitness industry. It separates itself from any typical machinery and allows the user to perform various workouts on a wall, whilst maintaining their performance and monitoring their work level through the use of a mounted interface. The Fitwall works using the heart rate of individuals along with their speed of progression to provide a healthy motivation for the member to continue. The interface allows members to track how they are performing in comparison to the other trainers, through the use of a colour coordinated scheme.

In the future, the Fitwall Company is hoping to develop its application to overlay workouts over a period of time, for a better performance review for each member. [75]

## Requirements Specification

After identifying the existing technology that is available, and furthermore the emerging technology that is expected to be implemented in the near future, it is clear that all of the requirements are acceptable and technology is available for these requirements to be fulfilled. From this, a requirements specification was produced.

The requirements specification was an in depth description of the solutions identified to solve the problems. This not only included a description of the requirements for the system, but also how this would be performed in a pervasive manner, with justification referring to the initial research undertaken.

## Quality of requirements

There are various different characteristics that must be fulfilled to ensure good quality requirements. Different companies have contrasting views as to what the most appropriate characteristics are. Attributes of good quality requirements that are recommended by company "Coley Consulting" will be used, which splits the characteristic attributes into 3 sections; communication, control and construction characteristics. [76]

If a requirement is unable to fulfil the characteristics given below, it may be deemed as unsuitable for use in a requirements specification.

### Communication characteristics

The three characteristics that are key to satisfy the achievement of good communication of the requirements are Complete, Clear and Consistent.

#### *Complete, Clear and Consistent*

Every requirement must be complete. This is to ensure that all of the functionality which the users are expecting from the system is expressed, and so fulfilling all of the needs identified by the members. This involves providing all of the functional requirements, explaining the details of the processes of each subsystem, non-functional requirements identifying performance parameters which the system must meet, and a finished design for the system to progress.

Requirements must be specific so that the reader can understand what is intended of the system. The requirements must be reviewed to make sure that all users have the same understanding of a function being described. Requirements should be detailed and include specifics including figures. For example, “the system must not be too slow” is not detailed enough. “The system should execute commands in <1 second” would be a more reasonable requirement.

Consistency is the idea of ensuring that the system fulfils tasks in a similar manner, and ensuring that there are not a number of different methods in place to fulfil one task.

Functional requirements in place must not contradict statements made in non-functional requirements. For example, if a non-functional requirement states that “the layout of the machinery must remain the same”, but the processes in place within the functional requirements means this is not possible, then this is a contradiction and the requirements would not be deemed as consistent.

### **Control Characteristics**

The characteristics in place that are key to ensure control is applied within the requirements are certifiable, chosen and chaseable.

#### ***Certifiable, Chosen and Chaseable (Traceable)***

This is the idea that a characteristic must be verified and validated. Coley Consulting explain that “If no way can be found to show that a requirement has been built into a system; then it is not one.”

The requirements must be chosen based on their importance. If the time scope and available resources of the project means that all requirements cannot be managed, then this means that the most important and most useful requirements are chosen first, leaving further optional requirements last.

The requirements must be able to be traced back to the project purpose, and documented to see if the requirement has been implemented. If a requirement cannot be traced, then it would not be possible to determine what effect a fault would cause to the project or the company in which it is implemented in.

## Construction characteristics

The characteristics in place that are key to ensure construction is applied within the requirements are credible and clean

### *Credible, Clean*

The credibility of the project is determining the feasibility of the requirements based on the aims of the project. It is much better to determine the feasibility at this stage, rather than to realise that it is not possible at later stages. It is essential to make sure that the requirements which are developed are possible to be fulfilled at this time, considering the state of technology. Having a clean set of requirements is about concentrating on the functions that are to take place in the system, rather than its design. This means that there is a full set of requirements which satisfies the needs of the user.

To fully understand the requirements specification, the header explanations are as follows:

- **Interfaces**

*The Oxford English dictionary defines an interface, in terms of computing as “A device or program enabling a user to communicate with a computer” [75]*

- **Member Interface Management**

*Member Interface management refers to the processes that are related to the interfaces used directly by the members. This includes Interface contents, functionality and additional features.*

- **Software Interfaces**

*Software interfaces refers to software, along with its front interface, and its features and uses. In terms of this project the software interface requirements will be about additional required for the system to function correctly.*

- **Hardware /Machinery Interfaces**

*This is the requirements and the features of the interfaces fitted within the equipment within the fitness centre, along with their uses.*

- **Membership**

*Membership requirements identify the security features and processes that are put in place aimed to fulfil health and safety standards of the members.*

- **Additional Hardware/ Machinery**

*This describes the additional settings or abilities of the hardware fittings, and smaller pieces of equipment, and how the data is used and processed.*

- **Connectivity**

*This describes the settings and needs of the connections in place to ensure efficient and effective data transfer between machinery and devices.*

- **System Control**

*System control refers to those processes in place which allow the system to work appropriately in a public fitness environment, along with further system features put in place as a request from the primary research.*

- **Temperature and lighting control**

*These requirements identify the monitoring of external environmental conditions and the processes in place to control these.*

- **Fitness Control**

*This section describes the performance measures in place for each individual during exercise, and the processes in place to handle the data gathered.*

- **Health and Safety**

*In terms of the project, this refers to the activities of the system needed to provide high quality standards for the protection of a member during a workout.*

- **Entertainment**

*Entertainment refers to subsystems in place to enhance user experience through the use of gaming, video streaming and other media.*

- **One-Off/User Processes**

*This is a miscellaneous category covering any other final features of the system.*

The requirements were then produced based on the characteristics that have been identified. To make sure that all of the relevant characteristics are considered for all of the requirements, a basic template was to be produced, including sections where each and every aspect of the requirement can be explained.

### Template

Below is an empty template that is to be used as the base for the requirements. This was developed with the help of looking through older projects similar to this. Along with this is an explanation of what information is to be expected in each column of the template.

<b>ID</b>		<b>Requirement type</b>	
<b>Requirement</b>			
<b>Explanations and Justifications</b>			
<b>Requirement Change</b>			
<b>References</b>			
<b>Date Created</b>		<b>Level of Significance</b>	
<b>Test Criteria</b>			

### ID

The ID is a form of unique key used to identify each requirement separately. The requirements will be split up into the different categories as mentioned above, for

different functionalities of the system. The ID will be an abbreviation of the category title it is listed under, along with a unique number. For example, the category titled “Health and Safety” will have IDs starting in HS along with a listed number, and so in the format HS##. The first requirement for this category will have ID key HS01. The ID of each of the requirements will be defined and explained at the top of the requirements appendix stating the ID abbreviation of each category. This will allow for the requirements to be easily identified if they need to be referred to in the testing stages for example.

### **Requirement**

The requirement title is a short description of the function that is to take place and how. These are based in the initial requirements that were drawn together before interview stages, however may have a more in depth description of the sub-systems and their features, after researching into the existing and forthcoming technology.

### **Explanations and justifications**

This is an explanation as to why the requirement is needed for this project, linking to the research produced or other processes in place within the system.

### **Requirement change**

The requirement change refers to any adjustments that have been made to the initial requirements, after the interviews had taken place. This may be if the requirement is deemed useless in its current state, or to add further usability to the system.

### **References**

This section is to define where the requirement has come from. This may link to the surveys that were produced, the individual interviews of the technology that has been found available for this project. This is providing a direction locating the reader as to where the “explanations and justifications” has come from.

### **Date Created**

This provides documented evidence as to when the requirement was created.

### **Level of significance**

The level of significance enables each requirement to be ranked in an order of importance. This is useful to fulfil the “chosen” characteristic, and shows an order of

which requirements should be completed first, and are of most importance, and which, if not implemented would hinder the system as a whole. The Scale is from 1 to 5, with 1 being least important and 5 being essential.

### **Test Criteria**

The test criteria are the tests in place to ensure that if a requirement has performance measures that it must meet, then it is met within the timescale that is stated. This confirms that the requirement is functioning correctly.

### **Requirement Type & Defining Functional and Non-Functional Requirements**

This defines whether the requirement is functional or non-functional. A definition of a functional or non-functional requirement can be found below. A functional requirement describes something that the system should do. An example of this would be “The information of membership details and equipment information will be stored on a central database”. Non-functional requirements define the way in which a system should behave, or how the system works. An example of this would be “Machinery and fitness suites will have wireless headphone capability”

### **Requirements Produced**

The requirements were produced through entering the information that was specified on the template, to ensure that the characteristics are fulfilled. These requirements were added from confirmation during the interview and survey research that they were relevant. The interviews which identified any changes that needed to be made, were added into the “requirement change” column, stating what the change was and why. The requirements level of significance was calculated through the reactions of the participants of the interview. After this the requirements were placed into their categories, and given a suitable unique ID matching the requirement to the specific category.

An example of a set of the requirements produced under category “Entertainment” can be seen below:

## Entertainment

<b>ID</b>	E01	<b>Requirement type</b>	Non-Functional
<b>Requirement</b>	Machinery interfaces will have interactive gaming application available		
<b>Explanations and Justifications</b>	Secondary research indicated that members feel that exercising is boring and there should be new ways to encourage fun workouts. Exercise based interactive games will allow members to do something fun whilst they get fit.		
<b>Requirement Change</b>	N/A		
<b>References</b>	Appendix- Interview 5		
<b>Date Created</b>	20/03/15	<b>Level of Significance</b>	2
<b>Test Criteria</b>	Alert arrives at device in <1 second		

<b>ID</b>	E02	<b>Requirement type</b>	Non-Functional
<b>Requirement</b>	Machinery interfaces will have live TV interfaces.		
<b>Explanations and Justifications</b>	Secondary research indicated that members feel that exercising is boring and there should be new entertainment systems that can be specific to each member..		
<b>Requirement Change</b>	N/A		
<b>References</b>	Appendix- Interview 5		
<b>Date Created</b>	20/03/15	<b>Level of Significance</b>	2
<b>Test Criteria</b>	TV signal will be good strength and interfaces will display current channel guide		

<b>ID</b>	E03	<b>Requirement type</b>	Non -Functional
<b>Requirement</b>	Machinery and fitness suites will have wireless headphone capability		
<b>Explanations and Justifications</b>	Secondary research indicated that members feel that exercising is boring and there should be new entertainment systems that can be specific to each member. Wired headphone systems could be a danger to those who are in humid areas or are moving very quickly.		
<b>Requirement Change</b>	N/A		
<b>References</b>	Appendix- Interview 9		
<b>Date Created</b>	20/03/15	<b>Level of Significance</b>	2
<b>Test Criteria</b>	Headphones will respond in <1 second after sound selection.		

<b>ID</b>	E04	<b>Requirement type</b>	Non-Functional
<b>Requirement</b>	Machinery and fitness suites will have skype/ video call capability		
<b>Explanations and Justifications</b>	Secondary research indicated that members feel that exercising is boring and there should be new entertainment systems that can be specific to each member. Members can use this facility to get in touch with not only family and friends but also personal trainers and fitness instructors.		
<b>Requirement Change</b>	N/A		
<b>References</b>	Appendix – Interview 5		
<b>Date Created</b>	20/03/15	<b>Level of Significance</b>	1
<b>Test Criteria</b>	Video call signal will be good strength and interfaces will display video call.		

The complete requirement specification can be found in Appendix 5 “Requirements Specification”

#### **Drawbacks of the requirements specification**

The requirements specification that has been provided was able to give a detailed and clear list and description of the functional requirements that would be required to ensure a complete and high quality project. It is however an issue that not many non-functional requirements could be added to the specification. This is due to the fact that as the advancements in technology are forever changing, there would always be continual improvement and adjustments made, and as there is only a short period of time to complete this project, there would not be substantial time for full extensive research to take place to develop these non-functional requirements further.

## Requirements analysis

The requirements analysis is used to test that all requirements satisfy the characteristics that should be fulfilled. This is to ensure that an appropriate set of actions has been identified. As we have already found that all of the requirements suggested fulfil the needs of the members, through the use of surveys and interviews, all that is left is to ensure that the standards of the documentation are high quality, through the comparison of each characteristic against the requirements specification.

### Complete, Clear, Consistent

The list of requirements is complete as much as possible considering the time-scale of the project. The entire initial list of requirements has been considered and there is a complete finish throughout each individual table. All requirements have been read through thoroughly, and re-checked by one of the previous interview participants. Each participant clearly understood all the requirements produced. There was no confusion as to what a requirement was there for or how it would work as a part of the system. The same set up has been used for each requirement. All of the requirements are filled out using an identical template, to ensure consistency.

### Certifiable, Chosen, Chaseable (Traceable)

The use of testing criteria ensures that there is proof that the requirement has been built into the system. The rating of level of importance is able to which requirements are the most important to be implemented out of the list. The referencing that has been provided to explain where the information and requirement has come from enables the requirement to be traced back to the research and results.

### Credible & Clean

The referencing and changes made are able to show why these requirements are relevant, and the use of the technology research is able to indicate that these requirements are feasible. There is a complete set of requirements where all of the functionality satisfies the need of the user.

As all of the characteristics have been satisfied, this shows correct use of a requirements specification, which can be used in future to further develop the project.

As no implementation is taking place on the system as of yet, it is not possible to further analyse the requirements produced. Further analysis could be produced after implementation, highlighting problems that the testers have encountered from the requirements after completing a test.

### **Conclusion of analysis**

The requirements specification that has been produced has an in depth and informative description of the solution requirements produced in aid of solving the problem identified. A large amount of the issues that members identified during primary research have been tackled, and so satisfies large aspects of the problem. The requirements that have been produced are a significant contribution of the development of a pervasive environment within fitness centres.

The requirements that were in need of change have been appropriately altered within the specification, adding further functionality to the design of the system.

The requirements identified took into account the initial health and safety guidelines identified at the beginning of the research process, to ensure that, if developed, the system could be implemented into a professional fitness environment which is suitable for public use.

All of the recommended characteristics to use have been fulfilled through the use of a structured template that is easy to follow.

## Feasibility analysis

The feasibility analysis is used to highlight many issues that may arise with the project at its current state. It will be able to narrow down the alternatives that are available if any problems were to arise and to identify newer opportunities that may be available as the investigation has progressed. The feasibility study will improve the success chances by analysing the project early on before implementation through addressing factors which may have an impact on the project's completion.

From the initial research that was produced, and through the investigation into existing and forthcoming technology which is available to assist with a pervasive fitness centre, it is clear that there is potential for this design to be implemented in the future, however for now it may not be feasible as some of this technology is in its very early stages of development and may take some time to be publicly available. As the idea of a pervasive environment still requires further work, the feasibility will concentrate on a broad idea of implementing the project.

The main idea behind this project is to provide members of fitness centres with a solution to the current problems that stand, through the use of technology to simplify these processes, and improve the quality of the experience. For this to become an accepted idea for a fitness centre to use, gyms worldwide should begin to utilise the idea of a pervasive environment, increasing the competition between the different fitness companies. All companies would therefore have to adopt this new idea in order to maintain its custom. This design would be originally implemented by those fitness centres with larger budgets, and a larger site to host, and as the technology progresses and becomes less expensive, the smaller companies with tighter budgets will then follow. With this in mind, the feasibility analysis will be related to adding pervasive technology into an average sized fitness centre.

The feasibility study will also cover the following:

**Costings** – Determining if the system can be implemented at an affordable cost.

**Technology and system feasibility** – Determining whether there is technology available and expertise in the implementation of this technology for the project to be a success.

**Social feasibility** – Determining if the system is appropriate for people to use or not

**Security and privacy** - Determining if the current security for systems is substantial for the project to be undertaken.

**Operational feasibility** – Determining if all of the problems that were identified are solved with the use of the new system

## Cost

The cost of the devices needed to implement a pervasive environment could have a huge impact on the success of the project.

The smart technology that has become available has meant that things as small as hand sanitizers, to a larger scale such as cities can be used in a smart manner. More and more “things” are connecting to one another as technology improves.

The forthcoming technology that has been discussed in this report is all in the early stages of development and so would be very expensive to consider implementing right now. Estimates on the costs of these would not be feasible at this stage as funding is still being required to develop many of these systems further.

This means that at the moment, although the technology is available for this to become a complete project, this would be aimed at a more up market fitness centre, with the spare money to put towards what could currently be seen as unnecessary improvement at this stage.

The existing technology that is now available has shown that some aspects of the pervasive fitness centre are achievable at a relatively affordable cost. Taking a look at a water dispenser for example, costing approximately £160 <sup>[77]</sup>. Adding smart technology to this such as the Wimoto sensor would cost only an extra £25, <sup>[70]</sup> which is quite an affordable achievement.

At this current stage, there is some incentive for fitness companies to implement a pervasive environment as they must compete with other similar service providers, however as this is not something that has been fully implemented or is popular as of yet,

it is not seen as an essential for companies to move towards. This may well change in the future as the world is moving towards the “internet of everything” and companies will without a doubt be adding pervasiveness to their centres.

It would not be possible to estimate particular costs of implementing the completed system. This is due to the large range of different fitness centres that are available. As many concentrate on particular sports, and areas of exercise, the costs would be different and specific to each centre. For example, some centres may have hundreds of pieces of gym equipment which would be replaced, whereas others may not have so many. It is not possible to determine a budget for implementation within a centre such as this, as this will depend entirely on the location, size, number of memberships and other working processes in place. This section will be a very brief look into the financial position of an existing fitness centre company.

“The Gym Group” is a privately owned fitness company available in many cities across the UK. The company, as stated in its most recent financial report, has 40 gyms open and over 225,110 members. The Gym Group has a centre in Cardiff with a membership cost of £14.99 per month. [78]

	2013	2012	Growth	Growth
No. Gyms open	40	32	8	25%
No. Members	225k	166k	59k	36%
Visits	10.8m	6.9m	3.9m	57%
Turnover	£35.8m	£22.6m	£13.2m	58%
Gym EBITDAR*	£17.3m	£9.9m	£7.4m	75%
Gym EBITDA**	£14.3m	£8.0m	£6.3m	79%
Company EBITDA***	£10.9m	£5.9m	£5.0m	85%

Above shows the key performance figures from 2012 to 2013. It is clear that this is a company which is growing significantly fast. After Taxation, the profit for the year 2013 came to £4,198,675, which is a massive increase to the profit in 2012 of £237,850.

Splitting the profit between the 40 Fitness sites gives approximately a profit of £104,966 per site. [79]

With companies such as this growing so rapidly, profits would be expected to increase significantly each year, providing bigger maintenance and improvement budget,

however this would be entirely dependent on the company. Sites such as the gym group would have to decide how much money they would want to set aside to introducing new projects such as this, and the amount of equipment needed for its completion. This would involve determining what aspects of their current site would need changing to introduce the pervasive environment.

Although estimations for the full system is not possible, one of the main aspects of the pervasive environment is the collection the performance data into a central database. The database is an essential tool to ensure the project's success and is the method used to collect performance data of each member, a problem which many members hoped would be improved. All information gathered from each of the systems explained in the requirements specification will be stored here. Using The Gym Group as an appropriate example a cost benefit analysis will be used to estimate whether The Gym Group could afford its implementation, and if the benefits of doing such would outweigh the system expenditure.

### Cost Benefit Analysis

Implementing the new database will require the use of database software. Microsoft Access is reliable software used by many companies for the building and development of databases in many public environments. The cost of this software package is an affordable £109.99. It is assumed that the company would use software such as this for the databases implementation. <sup>[80]</sup>

Research has estimated that the salary for a database administrator is a medium of £29,436. This would be an essential investment to ensure that the database is built and maintained correctly. These would be the total costs required for the company to begin with the implementation of the system, for the storing and provision of performance information for each member. <sup>[81]</sup>

In order to estimate the impact of the new system, one must make the assumption that adding the new system would bring benefits to the company of more members, generating a higher income. It is approximated that at The Gym Group there are about 5625 members per fitness site. It is assumed that introducing the new system would

encourage at least a 5% increase in the number of members per year. With this assumption in mind, and using the current estimated member number per site of 5625, the following estimations have been made of the number of extra members per year due to the addition of the new system:

Year 0: It is assumed that there would be no increase in member numbers due to the new database system, this year would involve the creation and testing of the database, and benefits would occur once this is complete.

Year 1: 5625 members would rise to 5906 members: an increase of 281 members

Year 2: 5906 members would rise to 6201 members: an increase of 295 members

Year 3: 6201 members would rise to 6511 members: an increase of 310 members

Year 4: 6511 members would rise to 6837 members: an increase of 326 members

Year 5: 6837 members would rise to 7179 members: an increase of 342 members

The standard membership cost of each new member along with the initial joining fee is the financial benefit considered with the implementation of the new system. This gives a financial benefit of 1 year of monthly payments at £14.99 plus the joining fee of £20, giving the company £199.88 for each new registered member. <sup>[82]</sup>

The discounted cash flow has been calculated with an interest rate of 5%.

The financial appraisal is able to show that the system has the potential to bring the company benefits after a short amount of time with a payback period of 1 year and 1 month for the addition of the new database.

As The Gym Group has a high profit margin to afford the addition of just this one feature, it is assumed that once the system begins to pay itself back through the benefits of new members, that soon the entire system would be affordable, potentially rising the percentage of new members each year.

Finally, although this is a very vague outlook of the possible costings for this project, it is able to show its possibly great potential.

The financial appraisal for this project can be found in Appendix 6 – “Financial Appraisal”.

## Risks

If a company were to use this method of implementing the database, there would be risks involved.

The first major risk would be that the implementation and addition of the new system would not be a significant incentive for members to join their fitness centre. This would mean that the cost to implement the system could be deemed useless. A company would have to decide whether the benefits of providing additional features its members outweighed the risk of no additional income.

The second major risk could be that the database administrator hired is not qualified enough to build the intended database, or may spend longer time than anticipated on its creation. This could mean that the company may not see the benefits of the system for a number of years, and the payback period may be a lot later than expected. The company would have to decide if they could afford to continue running the business alongside funding the administrator for a prolonged time.

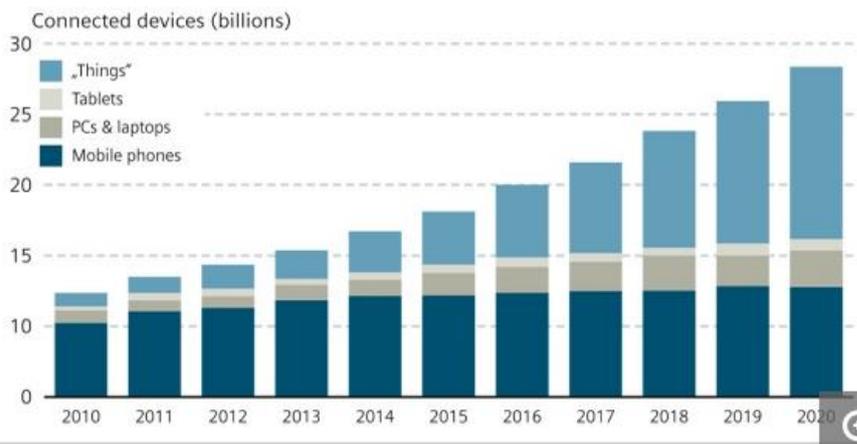
These risks are serious factors to consider, and decisions made based on these risks will depend on various factors including timescale and finance.

## Internet of Things

The term “Internet of Things” refers to the internet progressing in such a way that individual items and “things” are being provided with unique identifiers as to which they can now all be connected in a network across the internet. [83]

The “internet and things” and connectivity of devices has been vastly increasing in the last few years. According to Gartner Inc. the number of connected devices in use in 2015 is predicted to be about 4.9 billion, with a prediction of 26 billion connected devices over the internet by 2020. [84]

According to the MIT technology review, the number of everyday objects or other things, which are connected to the internet, will exceed PCs and smartphones by 2020. This shows that there is potential for the world to be adding connectivity to almost everything, making this project a particularly useful tool to the progression of the “Internet Of Everything”. [85]



With this in mind, the demand into the connectivity of these devices must be investigated with the capacity in which networks can hold as a vital concern. IPV4 is the 4<sup>th</sup> version that was developed of the internet protocol. This consisted of a large number of available addresses for the connectivity of devices. Computers need IP addresses to communicate with one another via the internet. [86]

The limits of IPV4 meant that there was limited availability for the connectivity of devices. IPV4 had only  $2^{32}$  addresses which were certainly not enough for the ever increasing amount of devices connected to one another. This problem has now been overcome through the use of IPV6. The development of IPV6 has enabled the increase in the connectivity of devices. IPV6 offers scalability, meaning that each square millimetre of the earth's surface has more than 2 billion of billions of addresses for connectivity. [87]

As IPV4 was designed when the development of computer devices was still in the early stages and mobility wasn't such a huge demand. Now, with IPV6, secure communications can be used to provide mobility for devices.

### Security and privacy

The Internet of Things brings big concerns in terms of security, particularly when in use in a public environment. A recent study by Hewlett Packard has suggested that

approximately 70% of devices connected over the internet are “plagued by security vulnerabilities”. This means that devices such as these are at great risk of a security breach by hacking. [88]

Companies are however becoming aware of the dangers of IOT devices if not secured properly, and the use of Cryptography has been implemented to avoid data being accessed by another party. Cryptographic technologies are currently being studied extensively, to develop new and advanced methods for the protection of data.

Lightweight cryptography is a new and advancing technology used for the Internet of Things. Lightweight cryptography provides security to devices through the use of a symmetric key algorithm, with a low energy consumption which is particularly useful for smart devices with a low battery power. [89]

### **Technology and system feasibility**

Through looking at the technology and systems that have already been created, it is clear that there is technological feasibility for this idea to be implemented. The current state of the technology means that a full completion of the project may not be possible at this moment in time however will most definitely be available in the near future. The technology that currently stands and the impressive new research and developments shows that soon there will be the potential for all aspects of the fitness centres to be controlled via pervasive connectivity.

Although this project may be deemed an expensive investment at the moment and some companies may be concerned that this may not be beneficial to them at this point, there is still a possibility for it to be used by extreme upmarket companies who have technology at the heart of their business.

### **Social Feasibility**

As it currently stands, the popularity and obsession with being physically fit and healthy, particularly in young adults, means that a system such as this is particularly useful. Individuals are continually trying to keep up to date with the latest trends, particularly technology, and many are constantly looking for newer ways of

improvement that defeat more traditional, manual methods. The more advanced performance monitoring means those individuals are improving at a quicker pace, resulting in happier customers and a better quality of life.

As the system aims to fulfil all of the requirements set out by members themselves, this will mean that those who use the system will be extremely satisfied with the outcome.

One concern with the system may be that individuals could be expected to come to terms with the new setup and adopt new skills to understand the system.

## Conclusion

Through looking at the availability and ever increasing connectivity of devices, it is clear that soon many fitness centres will be introducing pervasive environments. As the popularity of fitness centres and the technology available for building a system such as these increases, it is almost certain that soon fitness centres everywhere will become completely pervasive. With the current issues that may be in present such as the learning of new skills necessary to use the system, particularly with the older generation, it is not likely that it will be completed straight away. Individuals will have to naturally adapt to the new processes as time progresses.

Due to the current cost concerns that have been highlighted when investigating the potential for this project, it is unsure as to whether this could be a common implementation in the near future, however shows great potential in a few years.

## Continuing the project

The continuation of this project would consist of developing the system from the design into the implementation stages. This would begin through the further development of the requirements that have been produced.

The requirements currently stand as descriptions of processes of the proposed system, with its features. Although this covers all of the functions that would take place, this is very difficult to visualise in this current state. In order to have a better image of the system, UML would be used, a visual language use to specify, visualise, construct and document the systems and software of a project. This could be done through the use of use cases, which would show the behaviour, and the way in which an individual interacts with the system. Further visualisation of the system could be through the use of sequence diagrams, which would show the order in which the events take place within the subsystems, and class diagrams, which would be used to show the static structure of the systems in place, in terms of classes and their relationships. <sup>[90]</sup>

As currently the project does not have a system development process in place, it would be important to understand the method which would allow the system to be implemented.

The next step would be to produce a design of the interfaces which would be used to show the majority of the member information to the user. This would begin with the design of the database which would contain all of the records of information about a member. This would include designing the tables to be used and their relations.

The next step would be to develop the front end look of the interface. An initial prototype design of the interface would have to be developed first, using a software such as Balsamiq, which is a wireframing tool which focuses mainly on usability, allowing for a range of ideas to be produced using simple tools. <sup>[91]</sup>

This would conclude the design stages of this project. Once the design has been produced, the project would then be passed onto the implementation stage, where the software developers will turn the design into a functional interface.

In terms of estimating the costs for the implementation, once specific companies show interest in the system and their specific capacity and requirements have been measured, a further analysis into the costs and the benefits of the system would be investigated.

## **Evaluations and Conclusions**

### **Reviewing the initial plan**

The initial plan that had been produced included a large list of tasks to be completed within this project. There were a few tasks which were highlighted as not necessary once the project was underway, and so these were removed, without hindering the performance of the report. The initial plan stated within the aims and objectives that the report would include use cases of the system. It was later decided that the requirements specification was appropriate enough description into the different elements of the system and how it would work, and so this was disregarded. It was also suggested within the initial plan that a description would be provided of the pervasive fitness centre, however this was later also disregarded, as this would only be repeating the processes mentioned in the requirements specification. Apart from these minor adjustments, the final plan was followed through as stated in the initial plan.

### **Project Aims**

As the project was split into separate steps, there were various different aims involved. The first consisted of the full research into the problems that members are faced with in existing fitness environments, and their specific concerns relating to their experience with their membership. This step was completed as fully as possible, exceeding the recommended sample size and providing a thorough insight to the main issues. Had there been more time for this research to take place, there could have been more primary research conducted identifying further needs for change, however the research produced was seen as substantial considering the time frame and size of the project.

The primary research was then used to produce a requirements specification as a solution to the main issues addressed. The requirements identified cover the problems that could be solved with the use of technology. The requirements specification aim was fulfilled to a substantial level. Although all of the requirements that had been developed within the specification fulfilled the problems identified by the members, it would not be realistic to develop a full in depth system, as this would require extensive research, with potentially double the number of interviews, along with expert technical knowledge to ensure a full understanding of the subsystems required. A full design of the pervasive environment would need many more requirements than the 62 that have been developed in this project, as a system such as this would need hundreds. Although it was not possible to fully design a system with so many requirements, it was evident through the interviews that were conducted, that the requirements that had been identified were substantial for a solution that the members of these fitness centres would be looking for.

The next aim was to provide a feasibility study and analysis of the pervasive design. This was a difficult section to develop as it was hard to specify any financial restrictions that may be in place which would deem this infeasible in terms of costs. The feasibility study was able to identify that pervasive systems would be coming about in the near distant future, particularly in fitness centres, as there is rapid growth in the technology available for this sector and newer emerging technology to support this idea.

Finally, one of the most important aims of this project was to ensure that all of the design that have been produced met with the health and safety requirements of a fitness centre that is open to public. None of the research into existing and emerging technology identified any health and safety problems that could occur, as all equipment had been thoroughly tested in many environments to ensure safe use.

To conclude, it is evident that the aims of this project have been fulfilled to their best potential. The problems which were initially addressed have proposed technical solutions in the form of embedded systems within a pervasive environment, and the feasibility study was able to show that pervasive environments will soon be making a big impact on the functionality of public fitness centres.

## Reflection

I feel that through the use of this project I have been able to develop a thorough understanding of time keeping, and also the every changing and improving technological environment which we live in.

A main importance that I pretty much instantly came to terms with was the need to keep evidence of all of the research produced, along with where this research was found and how this could be used in the hope of developing a pervasive system. Not only would this add richness to my work, but it would also allow me to save some time. I created a folder with separate files for all of the documentation of my research, which I could then quickly and easily access when documenting my findings, to ensure that I didn't lose any interesting pieces of information that I came across during my research.

Timekeeping was an essential practice that I had to commit to, to ensure that I could produce a high quality report, complete to a good standard. Although I knew that as I progressed into the later stages of the report, time planning could change slightly, I aimed to keep to my initial time plan as strictly as possible. This worked fantastically for me as I had initially planned my report task to give me enough time to relax each week, whilst also completing a substantial amount of work. There were only a few weeks throughout the project where I steered away from the time plan, due to other university commitments, however this did not have a negative effect on the report, as I made up for lost time elsewhere.

Although I managed my time well, a lesson learnt for me would be to always consider other commitments during the beginning of the project. During my initial plan, I had given myself a particular length of time to work on a different project I was completing with the university. This took more than double the time of which I anticipated. Because of this, I had to spend my free time re-planning my work schedule for that week, which became rather difficult and could have had the potential to hinder the final outcome, which luckily, for me, it didn't.

My work pattern consisted of typical working hour days, with a few breaks in between. This worked very well for me, as It allowed me to fulfil large quantities of work in one go, which I could then review and feel satisfied with.

My meetings and progress reviews were all positive, with useful criticism provided by my supervisor, which I used to improve the report. I attended meetings on most weeks, allowing for continual feedback to make sure I was on track of the work I have set for myself.

I feel that the skills that I have been able to gain from this project have included the ability to document relevant material linked with the design to be produced. It took a very long time to read through various developments in technology and decide which could be useful for a pervasive fitness centre. I also learned new ways of understanding how a system would work through the use of SSM models, and finally how to build a structured and detailed requirements specification. I gained new confidence in the explanation of a pervasive environment and the different elements that it consists of, through the use of the interviews, and I am also confident that the design that I have produced would be a fantastic introduction to fitness centres today.

I feel extremely pleased with the report that has been produced. A lot of effort went into its development and I have learned a great deal

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