Declaration

We declare that this is our own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor Date

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Abstract

At present most people spend half of their lifetime seated. The daily routine of a person, irrelevant of the profession as well as when, where and what, followed by sedentary behavior. Most of the professionals solve tedious matters while seated the tendency of a person to be stressed while seated due to following a tedious matter, is high. Therefore, most of the companies, spend considerable amount of money for the chairs to make the employees comfortable, as the sustainability of the company depends on the wellbeing of the employees. However, even such expensive chairs are not capable of detecting the seating abnormalities and suggesting correct seating postures to make a healthier life.

While focusing the variations of seating postures of persons, the abnormal postures can be certainly harmful for a healthier life. In fact, such abnormal seating patterns will lead for serious health issues such as coronal cancers, nervous diseases related to stress and heart strokes. Among the aforementioned health issues stress is playing a vital role in person's life. When a person is stressed it is found out that the heart rate is rapidly increased. However, persistence of high stress levels can be harmful to people which is occurred as a result of being stressed [10].

The smart chair proposed is known as the "iChair", and has the ability of determining the stress levels of people considering the seating posture and the heart rate of a person who is seated and suggesting actions that can ease stress of the person seated. Additionally, it includes a functionality of informing the person regarding the bad postures followed during the sedentary action.

By the implementation of the solution which complies of a web application and a mobile application which views the data retrieved by the device implemented on the seat pan of the chair the users will be able to view and track the behavior which would result to follow a healthier lifestyle. By use of the iChair in a workplace, it would increase the productivity and the health of the workforce involved. iChair can be utilized in many professional environments in order to create a healthy society.

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1 Introduction

1.1 Background & Literature survey

The smart chair concepts have been growing globally [11] to extract important data that can be used to help the occupant to lead a healthy life amidst of the busy schedule. The stressful lives that is being followed, results in unhealthy life styles being practiced. Many lead stressful and busy lives where time, which is an important factor, becomes a constraint to focus on themselves is degraded.

Nowadays people are using technology to transform their community in positive ways. That is called as a "smart community". Most of the people understand the potential of information technology and form successful alliances to work together to use technology to make residents' lives easier, healthier, and more productive.

Chair is a mandatory equipment that is used on daily basis irrespective when, where, and what the task persons are involved in. As shown in Figure 1.1 which depicts the data retrieved by the survey implemented it is validated that the chair is a mandatory equipment. However, general purpose chairs are not used to provide smart services except providing a comfortable support to sit. Thus, chairs can be used for the capturing many vital information of the occupant, since it's a known fact that a person utilizes a chair for 6 to 8 hours per day as shown in Figure 1.2. Yet existing chairs are incapable of capturing sensory details because it cannot sense the actions of its occupant and therefore there is no ability to interpret the user's intentions. On the other hand, with the bloom of the Internet and IT technologies, professions related to computing is becoming more ubiquitous and distributed [13]. Such industries playing a vital role in global economy and the sustenance of the global wellbeing. However, need for human–computer interfaces of the IT industry is still questionable. The chair that is available today is, therefore a passive object that does not resend to its user's needs.

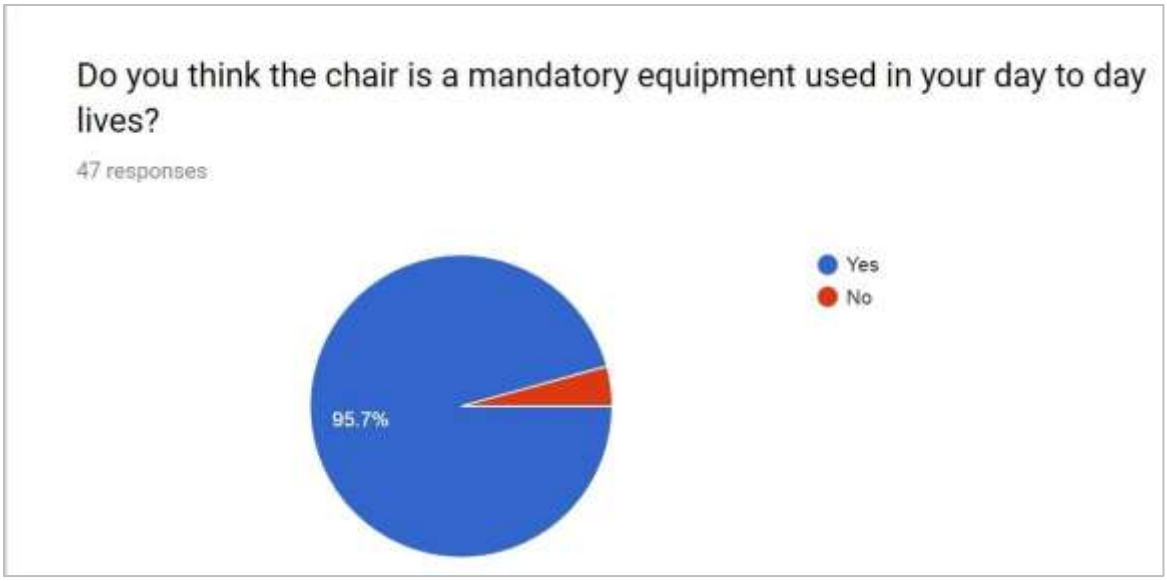

Figure 1.1- Summary of responses for what people think about a chair

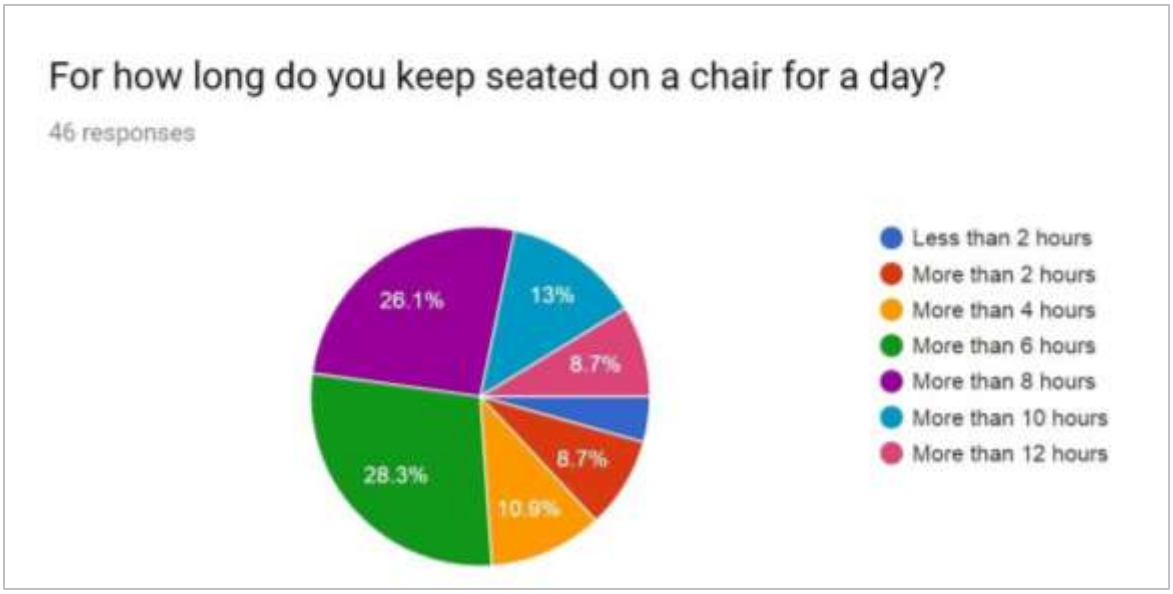

Figure 1.2- Summary of responses for how long people keep seated on a chair for a day

Employee comfort is an essential for creating a productive working environment. Most companies spend a lot of money on a chair, to get a high-quality ergonomic chair is an investment in employees' comfort and productivity. Even though furniture designers are creating ever more comfortable, ergonomic chairs, sitting in the same seat in the same place for hours on end is a struggle for all employees, not just for their bodies but for their minds too.

Many researches have been implemented in order to monitor the heart rate, the stress levels and the posture of the occupant. According to many authors it is said that health has important factor in human activities. The energy contained in the human body depends on the health condition [8]. If the human condition is of a healthy state, that implies that the energy available will be sufficient to carry out daily activities, vice versa, if the person's health condition has decreased, so then the level of productivity of the person will be decreased. Based on data obtained from heart foundation, heart disease is one cause of death in the United States [8]. This is further exacerbated by exposure to data reported by online media from Indonesia association cardiologist, who said the victims died from heart disease reached 7.6 million individual persons who were 325 thousand cases occur due to delays in treatment before arriving at the hospital [8]. It's a known fact that the cardiology involved diseases occurs due to activities that evolves stress [2].

In predicting the stress levels the authors have considered the heart rate using the RR intervals from locating a stethoscope device which is needed to be worn by the occupant in order to detect the HRV and conclude the stress level [8]. The authors also mention that the heart rate has a very close relationship with 13 different health factors which is mentioned below.

1. HRV and autonomous nervous system
2. HRV and blood pressure
3. HRV and myocardial infarction
4. HRV and nervous system,

5. HRV and cardiac arrhythmia
6. HRV and diabetes
7. HRV and renal failure
8. HRV and gender, age
9. HRV and drugs
10. HRV and smoking
11. HRV and alcohol
12. HRV and sleep
13. HRV and infants

The low value of HRV is related to diseases such as hypertension, diabetes and chronic obstructive pulmonary and other diseases [8]. The authors have considered the HRV by categorizing the RR intervals and by the use of SDNN index the stress level is predicted [8].

In another research the authors have collected data of 33 subjects that underwent a laboratory test of stress intervention while a set of physiological signals was collected [14]. In this work the authors have investigated whether affective information related to stress can be found in the posture channel during office work [14]. Following more recent work in this field directly associate features which are derived from the pressure distribution on a chair [14]. The authors have found that nervous subjects reveal higher variance of movements under stress [14].

One of the research authors have mentioned that by focusing on a chair—an object that is involved in virtually all human–computer interactions, the sensing chair project enables an ordinary office chair to become aware of its occupant's actions and needs [15]. The authors have mounted pressure distribution sensors over the seat pan and backrest of the chair for real time capturing of contact information between the chair and its occupant [15]. Given the similarity between a pressure distribution map and a grayscale image, pattern recognition techniques the authors have arrived into conclusions on the posture maintained on the chair. The Authors have categorized the posture into two different

categories namely as, static and dynamic. The Authors Future work is aimed at a dynamic posture tracking system that continuously tracks not only steady-state (static) but transitional (dynamic) sitting postures. Results reported here form important stepping stones toward an intelligent chair that can find applications in many areas including multimodal interfaces, intelligent environment, and safety of automobile operations.

It is also believed by the authors of one of the researches implemented that there is a possibility in measuring an visualization of the pressure data applied on the seat pan, and the sitting habits and increase in efficacy in posture through feedback is possible [7].

As per the above-mentioned readings it was crystal clear that the intelligent chair concept will be of many advantages and that many issues will be addressed, and an efficient solution would be provided. Although there are researches prevailing in the area of the smart chair concept but there are no researches prevalent regarding the dynamic change of posture. Also there are no researches prevailing that can predict the stress level of the occupant by extracting the heart rate and the data regarding to the posture thus which suggest the methodologies to ease stress.

1.2 Research Gap

There are many informative data which can be grabbed from a person who is involved in the sedentary behavior on a chair. From the information that we can extract from the occupant of a chair many researches have considered the following metabolic variables,

- Heart rate
- Posture

Many of the researches conducted includes the,

- Monitoring of the heart rate from the chair
- Monitoring of the posture
- Monitoring of the posture and determining the stress level

According to the available research papers [7]-[10] and resources there are several researches developed on the Smart Chair concept for monitoring posture and physical health. Many researches are mainly concerned with the health problems related with the posture and the stress levels (table 1.2.1). Research A [8] has concerned about posture and stress level where the authors have focused on obtaining a heat map of the surface of the seat pan and predicting the stress level through image processing of the image, and the research B [11] has concerned only about posture. Finally, research C [7] has concerned about posture and heart rate only. There are no products that would provide suggestions to ease stress, where the stress level is obtained by considering the heart rate and the posture.

The table 1.1 shows a tabularized format of the explanation.

Product	Posture	Heart Rate	Stress	Suggestions to ease stress
Research A	✓	X	✓	X
Research B	✓	X	X	X
Research C	✓	X	X	X
iChair	✓	✓	✓	✓

Table 1.1- Comparison of former researches

The smart chair concept which is proposed, is designed with many more functionalities than other researches which are currently prevailing. By the proposed solution the chair would suggest probable solutions to the health problems due to prolonged seated positions and to create a healthy society, to detect stress levels and suggest a solution in order to reduce the stress level of people, to track activities of the person who is seated, and Increase productivity of the person seated by enforcing healthy seated postures.

1.3 Research Problem

In day to day activities, a chair is used as a mandatory equipment. From the survey conducted it was validated that averagely a person keeps seated for at least or more than 6 hours per day.

Incorrect seated postures result in back pains and muscle strains [3]. Bad posture may cause postural scoliosis [1]. It is incurred that many have to go through surgeries and medical assistance in order to maintain a healthy body due to their posture of seating. However, limited number of devices can be found that are capable of detecting the seated posture [4]. Also, [1] [2] conclude that being seated for a long-time also results in several other health problems, i.e. Colon cancers, weak bones, brain damage, in fact, it is also provided that organ damages can also be occurred due to the fact that people being seated for a long time [2]. Sedentary behavior can make a human sick (Figure 1.3), since the muscle movements are very less the body becomes weak, which can be linked to the risk of developing obesity, type 2 diabetes, cardiovascular diseases, metabolic syndrome or premature death [4]. Given a fact that a person is seated mostly during their lifetime, the seated position can be harmful enough, that it creates defects in the body.

It is a known fact that when a person is stressed, a hormone called adrenaline is produced, the pulse rate and rate of change in posture dramatically increase [5]. Currently there are devices that are used to measure the pulse rate using the mobile apps and other electronic devices [5]. However, in order to retrieve the pulse rate, we have to hold the equipment in such a manner that it is able to detect the pulse rate. Thus, as human beings, people tend to be seated while stressed, hence some people seek medical help since they are unable to control and manage their stress levels. People believe that being stressed or pressurized can make a human fall sick.

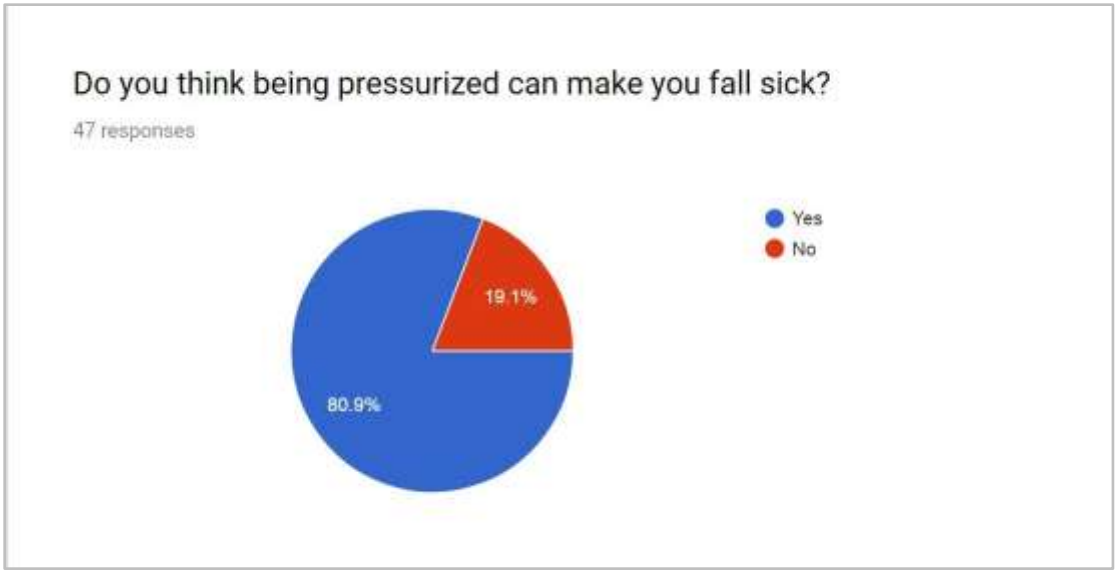

Figure 1.3- Summary of responses regarding being pressurized

Sitting has become the sensation of the young generation since of their busy lifestyle which involves activities involved with the use of computers. Thus, many lead stressful lifestyle which would need to be addressed so that the harmful activities are no longer practiced by humans. Consequently, this study proposes "iChair" as a companion that supports the people to increase the life condition by aiding to control stress.

2 Objectives

2.1 Main Objectives

The main objective of implementing the iChair is to make use of a chair, by making the chair a companion. Given a fact that a chair is a tool used in daily activities the objective mentioned above can be achieved easily. However, as pointed out previously, it is also considered that a long time sedentary behavior is a health issue. Therefore, the introduction of iChair has the main objective of finding and recommending solutions to improve the health of people who use chairs in their activities irrespective when, where and what purpose the person uses the chair for.

Since the prolonged sedentary behavior can lead to an unhealthy life; thus, the solution will ease the need of providing solutions to the health problems which can occur due to the activities which involves continuous seated position. The solution iChair has the mechanism of monitoring the variation of the posture of the occupant, therefore the activities will be tracked by the device which will be depicted using the web application and the mobile application, which helps the occupant to improve the style of the behavior on the chair.

However, it is also incurred that many of us perform mundane and strenuous tasks while seated [2]. The level of stress will be measured by the use of data retrieved from the sensors and solutions will be suggested to the occupant, so that the stress will be controlled up to a certain level. The methodology of detecting stress is explained further in the document.

2.2 Specific Objectives

In order to reach the main objectives, the specific objectives that needs to be attained is as follows,

1. To optimize the data capturing and processing.

   Initially the authors have to decide the location of the heart rate sensor which should be placed in order to get accurate data with minimal effort. Also the placement of buttons in the button mesh have to be decided to get the actual position of the person seated with minimum errors.

   The optimal time frequency of intervals where data should be obtained will also be decided by authors depending on a proper hypothesis. The data retrieved from the sensors will be analyzed, and the data that is needed in order to use as inputs of algorithms will be stored in the database.

2. To analyze stress using time-frequency distribution of heart rate variability (HRV) signals.

   The heart rate data which is grabbed from the data sources and are used to analyze stress level of the person seated using an algorithm. This prediction is performed according to the logged user of which the user will be identified by the fingerprint. This process includes of considering the history related to the cardiovascular data of the person. The mobile App provided, will have the facility of providing a graphical view of the heart rate and the notifications regarding the predicted stress level.

3. To analyze stress by identifying the change of behavioral patterns using the seated posture.

   A button mesh will be implemented on the seat pan of the chair. The data will be stored on the database showing the change of buttons pressed on the seat. The posture data which is grabbed from the data sources and are used to analyze stress level of the person seated using an algorithm. This prediction is performed according to the logged user of which the user will be identified by the fingerprint. This process includes of considering the history related to the posture data of the person. The mobile App provided, will have the facility of providing a graphical view of the posture the occupant is in and the notifications regarding the predicted stress level.

4. To provide recommendations to ease stress, by the analysis of day-to-day activities which causes stress and the prediction of stress by analyzing posture and heart rate data

   The prediction of the stress level achieved by the data related to the heart rate and the posture will be considered, and suggestions will be provided to the user regarding the methodologies which can ease stress. A rule based algorithm will be used in order to suggest methods to ease stress. The history of the occupant, Details collected through doctor consultation and published research papers will be considered when the algorithm is built to suggest methods are to ease stress.

3 Methodology

The proposed "iChair" is a smart chair that has the capability of,

- Measuring the heart rate of the person seated.
- Identifying the posture person is in.
- Predicting the stress level by analyzing the heart rate and the posture.
- Suggesting methodologies to ease stress.

Moreover, "iChair" is capable of notifying the seated person regarding the sedentary behavior and is capable of suggesting an exercise that should be performed to avoid any disease caused due to prolong seated position. The software algorithms can predict the stress levels [6] of the seated person by analyzing the data retrieved from sensors and the previous records of that particular person. The chair provides predictions regarding as to what can happen in the future due to the stress level that is faced by analyzing the previous data of that particular person. The chair will be developed to suggest probable solutions to colon cancer, Obesity, Weak bones, and Brain damages.

The sedentary behavior may not response in a bad manner at once. Thus, this can take several times. Therefore, the mandatory regular medical checkups that is persistently avoided can be solved since the "iChair" has the capability of analyzing the data retrieved and predicting the future scenarios that can be faced by the person who owns the "iChair".

The chairs that were just used only to sit will be gaining a new meaning through iChair concept, and thus “iChair" will redefine the companionship given by the regular chairs. The "iChair" will be the next generation of chairs which would solve many issues apart from focused, as mentioned above.

3.1 System Architecture

The system architecture is shown in the figure 3.1.

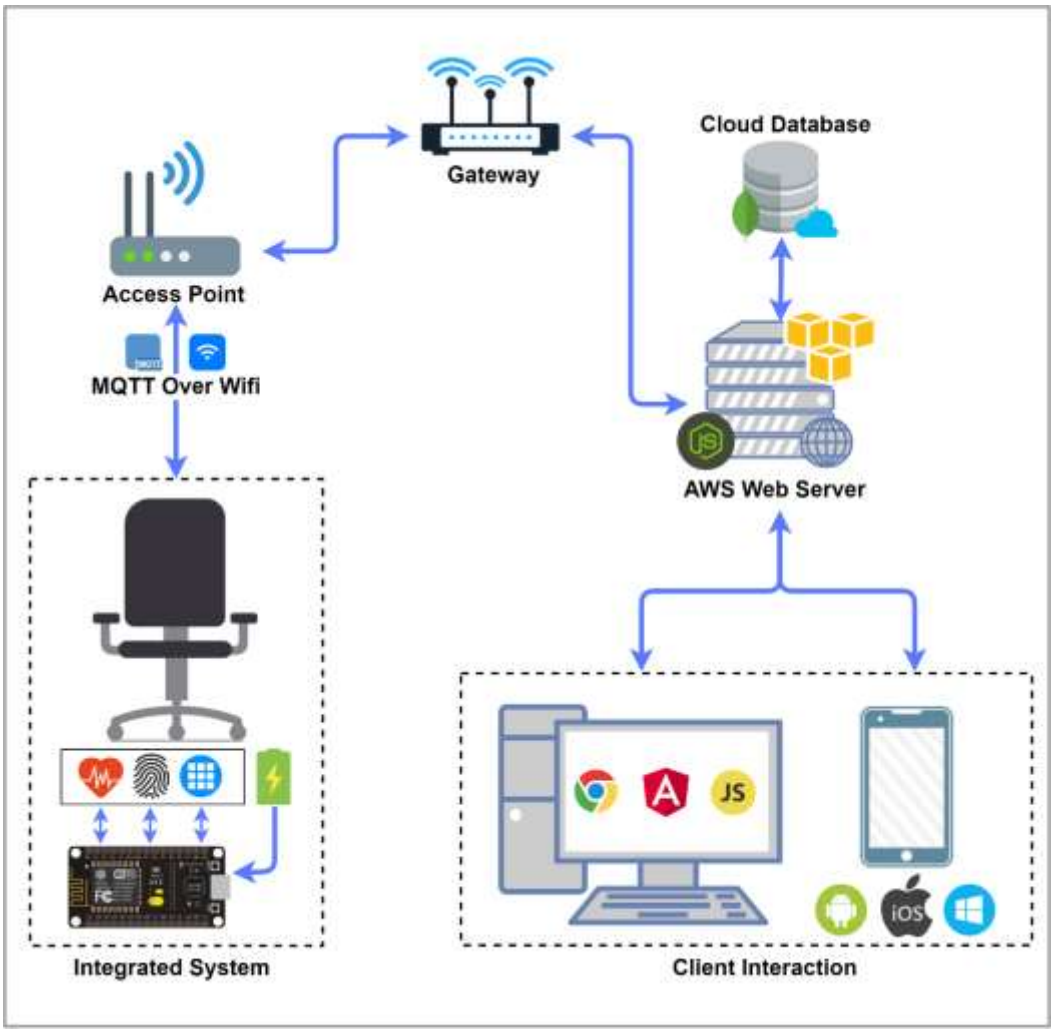

Figure 3.1- High Level Architectural Diagram

3.1.1 Hardware Solution

The hardware architecture is shown in the figure 3.2.

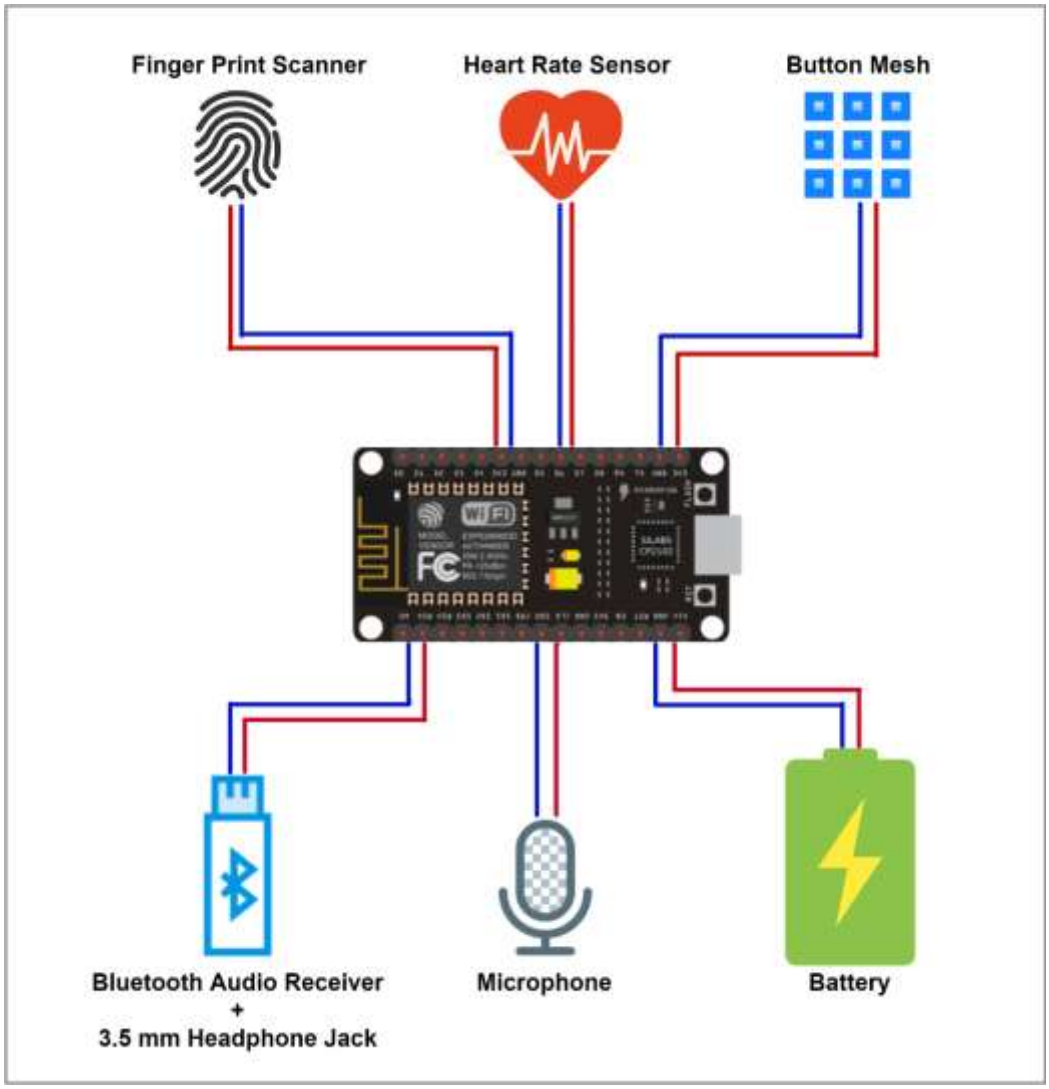

Figure 3.2- Hardware Architecture Diagram

- **Connectivity**

  The chair should collect data from the sensors and the collected data should be sent to a centralized server in order to proceed with the following processes. The server is located remotely in the cloud and all the data should be directed to the cloud. The collected data can be transferred to the server using an existing Wi-Fi network of the user. Instead the chair can be isolated from the existing network using a GSM module fixed in the chair. When comparing the above two methods mentioned, few drawbacks of using a GSM network exists than using an existing data network in the area, such as monthly subscription charges, high latency of connection establishment, requires a more expensive module. Thus, Wi-Fi network will be used as the communication method from chairs.

- **Microcontroller**

  After comparing the available microcontrollers in the industry, NodeMCU development board was proposed to be used as the microcontroller unit for the chair sensing subsystem. The main reason for selecting NodeMCU was the enabled Wi-Fi function in the board. The most popular development board for this kind of projects is Arduino. In the Arduino development platform coding, debugging and compiling is not much complex with the Arduino IDE. NodeMCU development board can be programmed by the same Arduino IDE importing the NodeMCU board manager plugin. ESP 12e module is acting as the heart of the development board and it has the capability of acting as a Wi-Fi host and as an access point as well.

- **User Identification.**

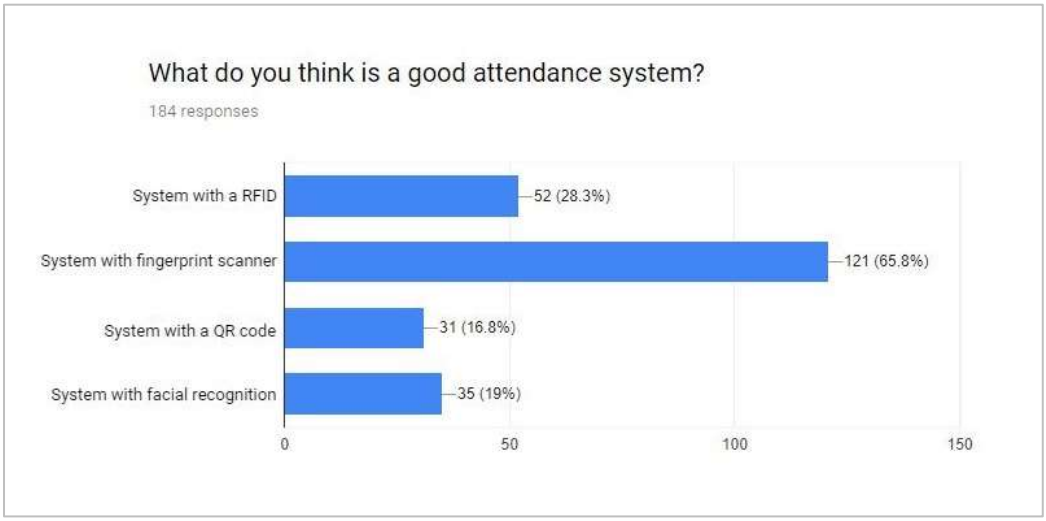

Figure 3.3-User Identification Methods

The user unique identification number is used to identify the user in the system. The chair needs to have the capability of identifying the user from something user has or from something user is. RFID tags or NFC tags can be issued to all the users and the user can be recognized by the card swaps. Fingerprint method can also be used as the user identification method and the main advantage of using fingerprint is the users don't need to carry a card or a tag with them. After considering the survey results, as shown in Figure 3.3, that was conducted to support the decisions that authors make, it was confirmed that the fingerprint method is the most suitable and the feasible method that would satisfy users or the customers.

3.1.2 Software Solution

The software development life cycle which would be considered will be the agile methodology. And Scrum will be the methodology that will be followed under the agile methodology. Scrum is a lightweight agile project management framework with broad applicability for managing and controlling iterative and incremental projects of all types [15]. Since scrum has the capability of inspecting and adapting to the change in requirements (Figure - 3.4), thus the solution the authors will implement is based on the hypothesis that was done by the literature survey and the survey implemented, constant changes

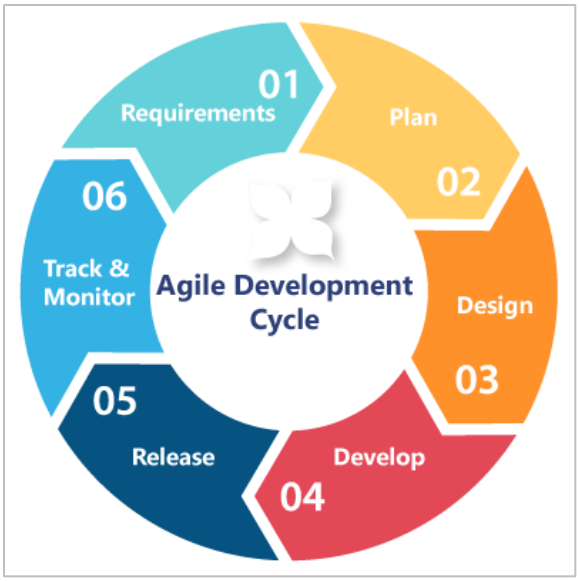

Figure 3.4- Agile methodology [16]

- **Requirement Gathering and Analysis**

  The First phase will be the requirements gathering process.

  - **Survey Results**

    Investing time in a requirement gathering questionnaire has helped us the authors to get an idea about what people think about a chair and making a the chair a companion. The authors have organized the questions to full fill the project objectives.

- **Feasibility study**
  - **Schedule feasibility**

    The proposed project should be finalized in the defined time limits completing each phase with credible outputs while maintaining timeline. And present with the final outcome product on the planned due date.

  - **Economy feasibility**

    A solution wouldn't be a real solution unless the troubled subjects use the solution, even though the final outcome of the project, the proposed project works perfectly as expected providing preferred correct outputs without any errors or misses, it cannot identify as a success if it costs high The components which will be used should be less expensive and more reliable. So, the resources and needed components cornered into a limitation of cost.

- **Technical Feasibility (Skills)**
    - Basic Electronic knowledge

      To successfully complete the proposed project, the project members should have some expert level of knowledge in basic electronics, current laws and equations and hands on experience on using basic electronic components. PCB designing, and soldering experiences will add more advantage when designing the prototype of the proposed project.

- **Implementation**

  The implementation phase complies with the development of the functionalities below,

    - Optimal data capturing and processing
    - Analysis of stress using time-frequency distribution of heart rate variability (HRV) signals
    - Analysis of stress and identify behavioral patterns using sitting posture
    - Providing recommendations to ease stress, by the analysis of day-to-day activities which causes stress and the prediction of stress by analyzing posture and heart rate data

  The above functionalities will be implemented so that a view will be provided to the user using a web application and a mobile application.

- **Android Application development**

  The final product contains an android mobile application to increase the usability and user friendliness. IONIC is free and open source platform and easier to market and generate popularity. It is easier to develop, saves time, money and enables faster release. Developers can use Angular, which is promoted by google as programming language. To develop the application authors should have a good knowledge in Android application development (IONIC) and Android studio.

- **Web Application development**

  The final product contains a web application to analysis output of all the output details. Angular is a platform that makes it easy to build single page application with the web. Angular combines declarative templates, dependency injection, end to end tooling and integrated best practices to solve development challenges. To develop the application authors should have a good knowledge of web application developing (Angular) and visual studio code.

- **Database Handling**

  The device will generate thousands of data to the server. So, the best way to store these type of sensor data is to use NoSQL database. MongoDB database will be used as the main data storing location. MongoDB is a document oriented, free and open source, highly scalable database program. Having the knowledge in inserting, updating, deleting, securing the data using encryption methods and filtering data with mongoose will be important to handle the database.

- **Microcontroller Programming**

  NodeMCU development board was proposed to use as the microcontroller unit of the project. ESP8266 12e module is integrated with this module and the authors should have a clear knowledge on using ESP modules and its firmware. All The algorithms will be developed in Arduino IDE and all the authors should have a good experience in working with the Arduino libraries and the Arduino IDE.

- **Server maintaining**

  The final product contains a web server to handle communication between server and the device, handle client server communication, handle all the incoming and outgoing data, analyze data and apply necessary algorithms, save necessary data for later use, apply proper data structure to store data, handle incoming and outgoing traffic of the network, always keeping the server communications secure with outsiders. Authors should have a good knowledge and experience of server-side development (NodeJS) and database management (NoSQL) techniques.

- **Data Communication Protocols**

  Sensors pass the data to the microcontroller via serial communication. The button mesh sends the data to PCF8574 microcontroller and it sends data to the ESP8266 via Inter Integrated Circuit (I2C) Protocol. MQTT protocol is used to build the connectivity between the ESP chip and the server. MQTT transfers data as a byte array which in comparison to HTTP is lightweight and uses less bandwidth as later supports MIME standard to define the content type and constrained devices like sensors, low energy powered devices. The authors should have a clear understanding in using the above-mentioned protocols.

- **Deployment**
  - **Amazon Web Services**

    Amazon Elastic Compute Cloud (EC2) is a web service that provides secure, resizable compute capacity in the cloud. It is designed to make web-scale cloud computing easier for developers. Amazon EC2's simple web service interface allows developers to obtain and configure capacity with minimal friction. EC2 run command let users remotely and securely manage the configuration of your EC2 instances, virtual machines and servers in hybrid environments.

  - **Node Package Manager (npm)**

    Node Package Manager is package manager for the Node JavaScript platform. It puts modules in place so that node can find them, manages dependency conflicts intelligently. It is extremely configurable to support a wide variety of use cases. Most commonly, it is used to publish, discover, install and develop node programs.

  - **NodeJS Process Manager (pm2)**

    PM2 is General Purpose Process Manager and a production runtime for NodeJS apps with a built-in load balancer. It allows to keep applications alive forever, to reload them without downtime and facilitate common system admin tasks.

  - **NGINX**

    NGINX is open source software for web serving, reverse proxying, caching, load balancing, media streaming, and more. In addition to its HTTP server capabilities, NGINX can also function as a proxy server for email and a reserve proxy and load balancer for HTTP, TCP and UDP servers.

4 Description of Personal and Facilities

4.1 Optimal data capturing and processing

1. Deciding the best way to communicate with the server in a low bandwidth network
2. The sensor data should be captured efficiently
    - There will be a pulse rate sensor used to capture the HRV, and a custom-made button mesh to detect the posture of the seated person.
3. Decide the time frequency of data capturing and feeding the database
    - According to the seated position of the person, the data capturing frequency should be decided.
4. Which kind of sensor data should be stored in the database
    - The data retrieved from the sensors will be analyzed, and the data that is needed in order to use as inputs of algorithms will be stored in the database.
5. Utilizing the optimal data capturing algorithms
    - The data which provides the optimal solution will be utilized.

The diagram below (Figure 4.1) shows the method followed and the technologies used in developing the optimal data capturing and processing.

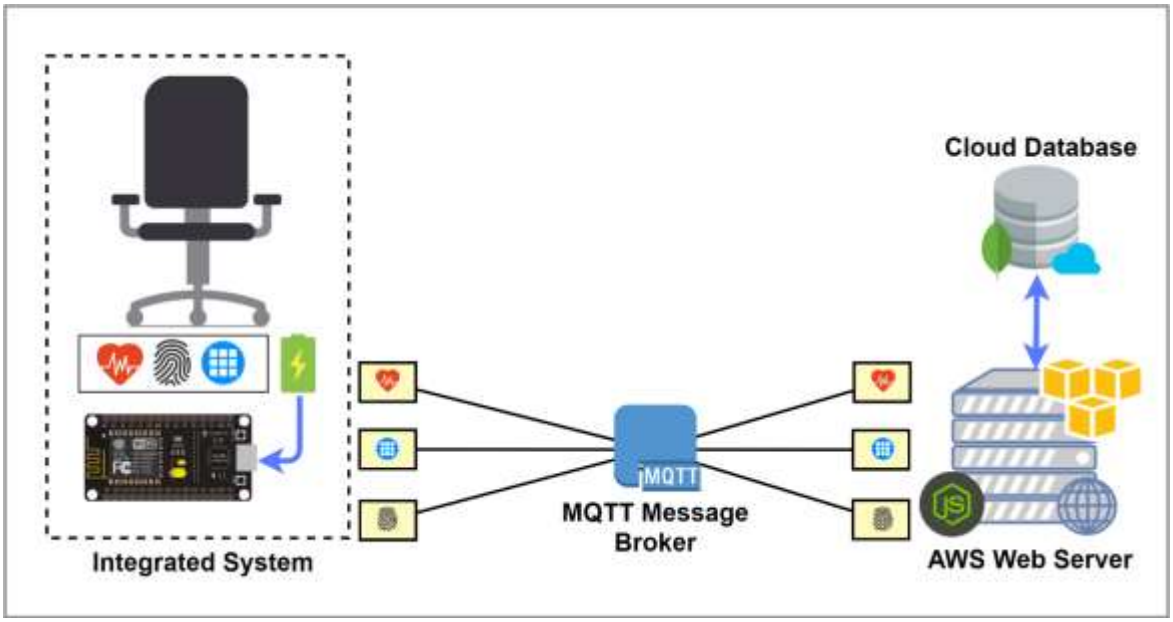

Figure 4.1- *Optimal data capturing and transmitting methods*

4.2 Analysis of stress using time-frequency distribution of heart rate variability (HRV) signals

1. Grab the necessary sensor data from the data sources
    - Grab heart rate data from the server to analyze according to the logged user.
2. Analyze and identify changes of the HRV of the user.
    - The data retrieved from data sources will be analyzed in order to detect the stress level of the person seated.
3. This process (2) is real time and users can see their heart rate using their mobile application
    - The mobile App provided, will have the facility of providing a graphical view of the heart rate.
4. According to the current heart rate and the historical data of the user, algorithm will analyze the stress level of the user
    - The HRV retrieved by the data source is analyzed by algorithms, that is capable of analyzing whether the person seated is stressed or not.

The diagram below (Figure 4.2) shows the method followed and the technologies used in developing the mechanism of analysis of the stress level using the heart rate variable.

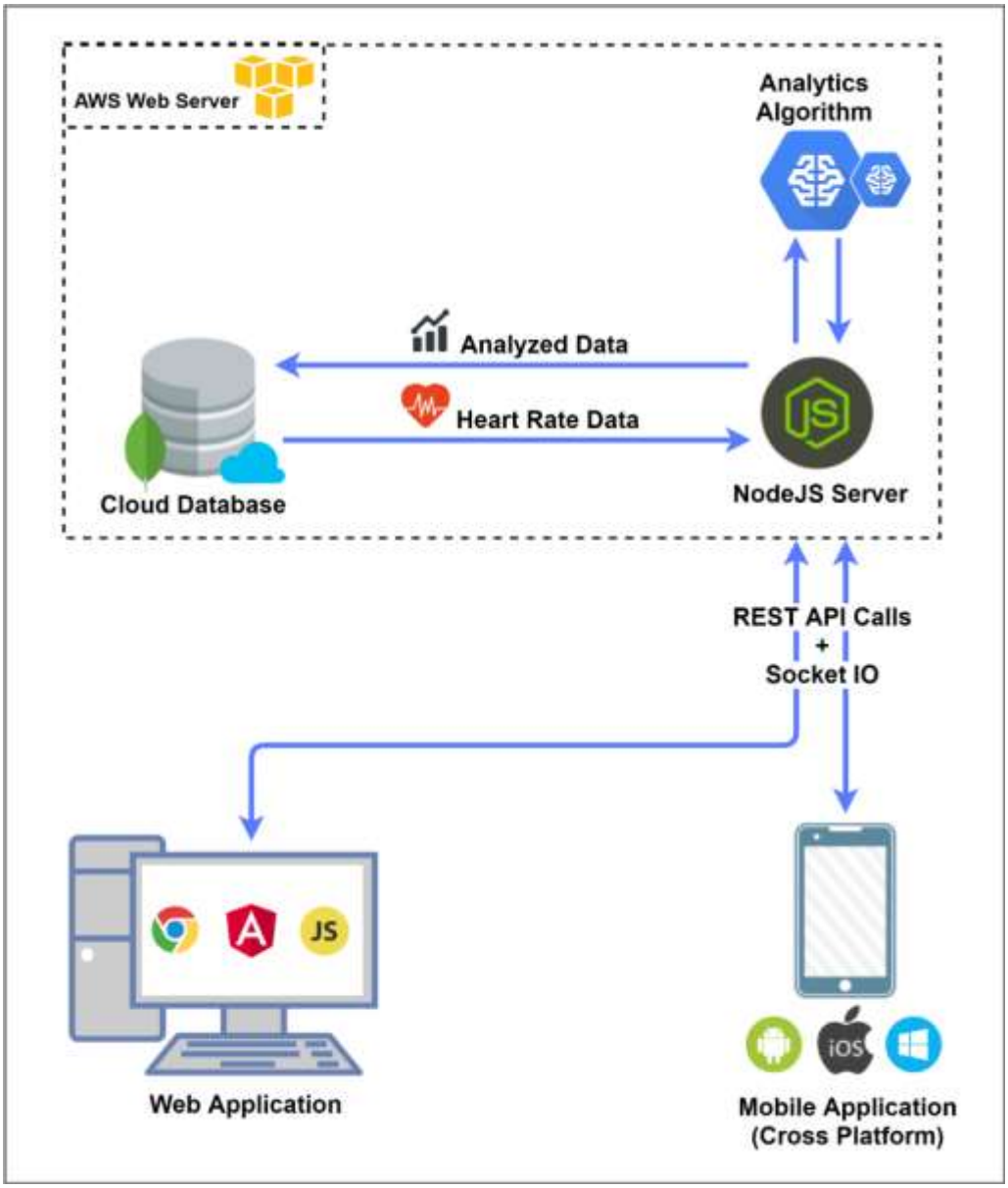

Figure 4.2- Obtaining and the analysis heart rate

4.3 Analysis of stress and identify behavioral patterns using sitting posture

1. Grab the necessary sensor data from the data sources
    - Grab posture data from the server to analyze according to the logged user.
2. Analyze and identify behavioral patterns of the user.
    - The data retrieved from the data sources will be analyzed in order to detect the posture, the person is in.
3. This process (2) is real time and users can see their sitting posture using their mobile application
    - The mobile App provided will have the facility of providing a graphical view of the posture.
4. According to the current behavioral pattern and the historical data of the user, algorithm will analyze the stress level of the user
    - The posture and the fidgety behavioral patterns which can retrieved by the data source, is analyzed by algorithms that is capable of analyzing whether the person seated is stressed or not.

The diagram (Figure 4.3) shows the method followed and the technologies used in developing the mechanism of analysis of the stress level using the posture.

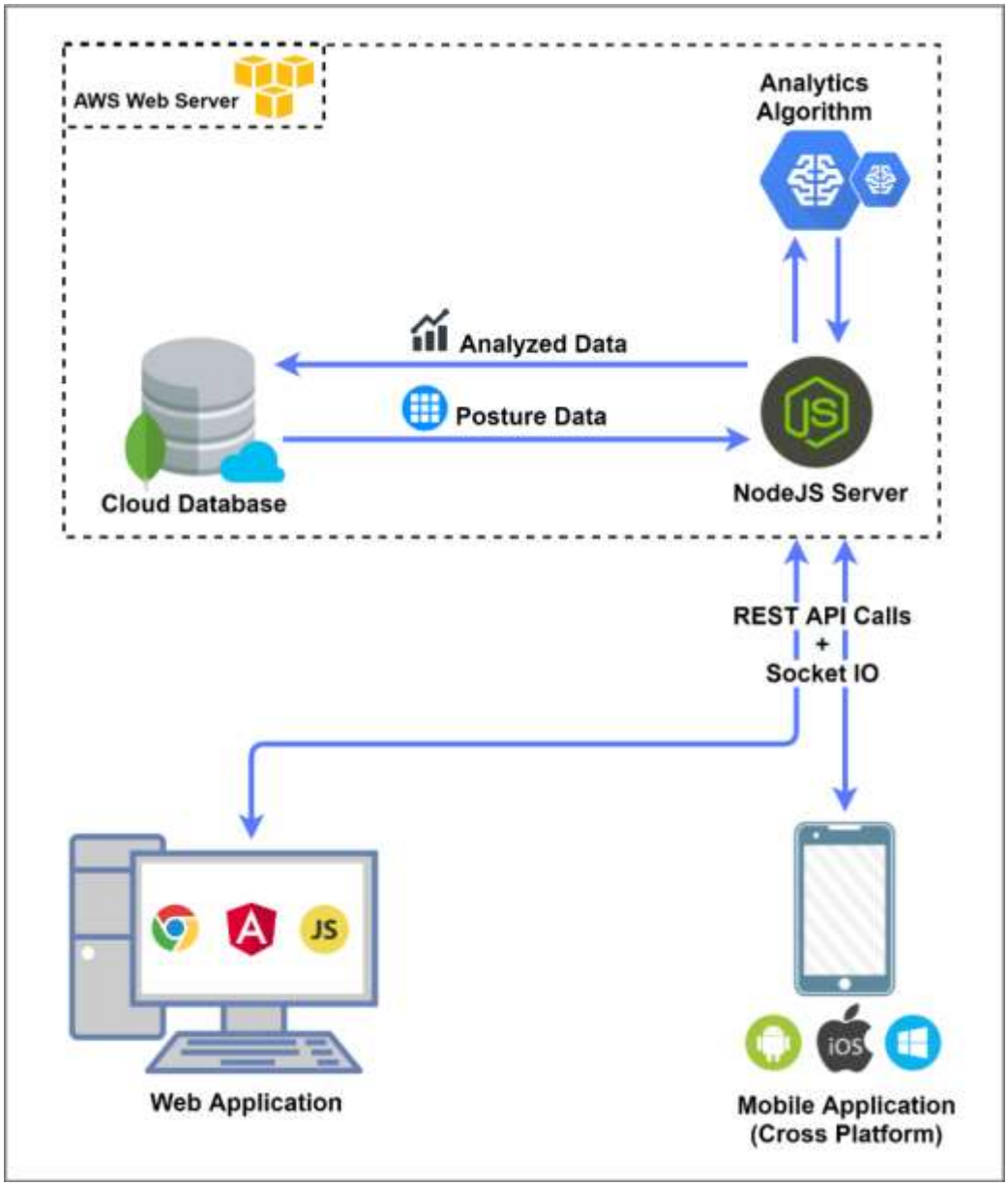

Figure 4.3- Obtaining and the analysis of the *Changes of posture*

4.4 Providing recommendations to ease stress, by the analysis of day-to-day activities which causes stress and the prediction of stress by analyzing posture and heart rate data

1. Make a comparison with the data analyzed from heart rate and posture using an algorithm.
    - Suggestions will be provided for the person seated to perform activities which can ease stress using analytic algorithm.

2. The Program will analyze user's data automatically and notify user whenever there is an anomaly detected

    - Analyzes the current and past sedentary behavior and suggest mechanisms to avoid health problems that can arouse due being seated consistently. (This includes sleeping while seated and prolonged seated behavior which involves less muscle behavior)
    - Vibrator alert when there are less movements of the person seated for a long time

The diagram (4.4) shows the method followed and the technologies used in developing the mechanism of suggesting methodologies to ease stress with the use of rule-based algorithms which is derived using the history of the user, medical assistance and researches published.

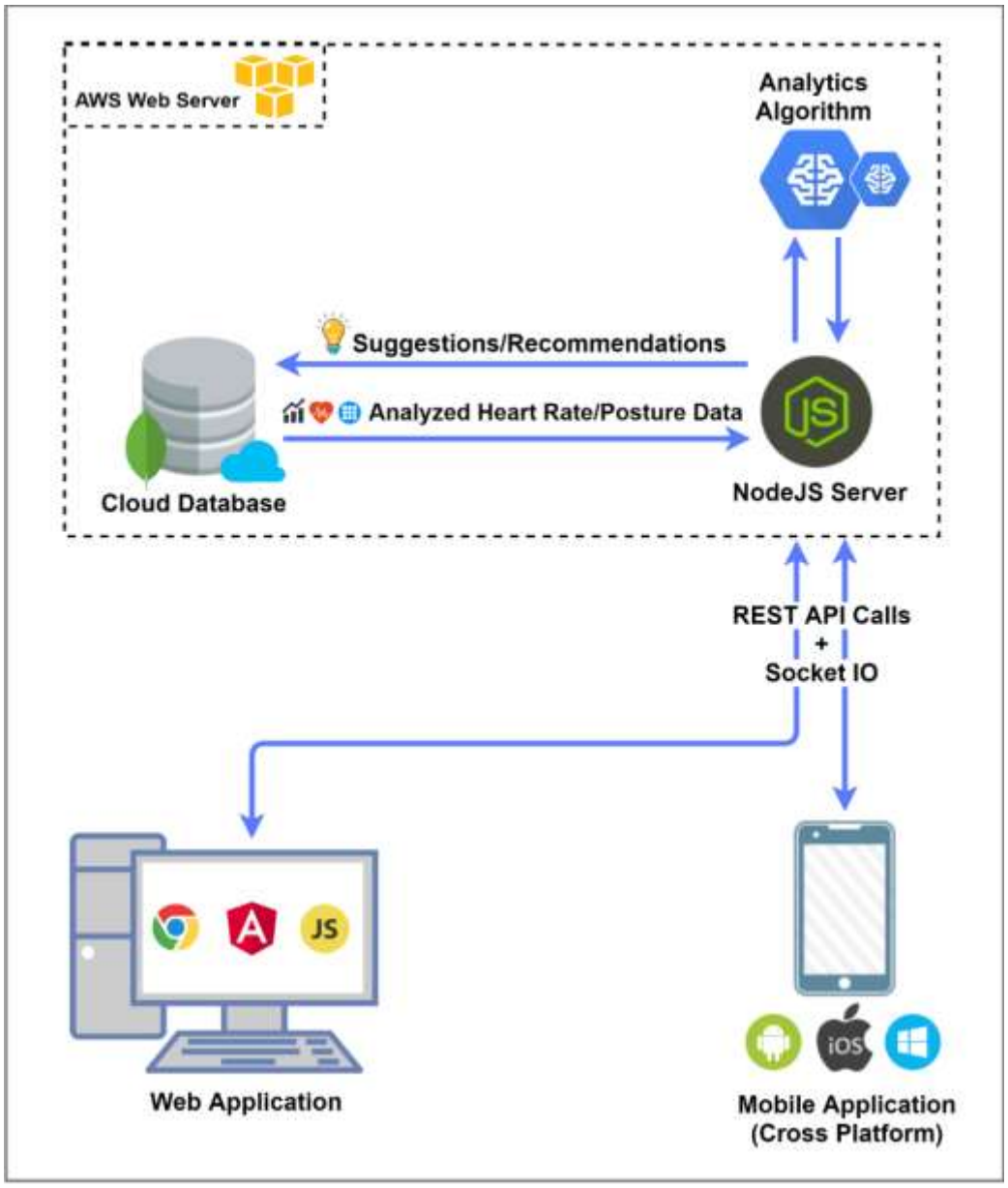

Figure 4.4- Providing recommendation to ease stress

4.5 Other functions

1. Fingerprint authentication
2. If the domain is company, Managers can monitor availability of the employees. (Manager's app contains additional function for this part)
3. Voice command support for operate mobile phone.
4. Listen to music feature.
   Chair has 3.5mm headphone port for connect hands free or headphone – Bluetooth audio transmission. And users can turn on off this feature through the mobile app.
5. Calendar is synced with the chair and notify events.
6. Vibration alarm.
7. Get the user's suggestions and opinions. (feedbacks and user reviews)
8. Share user experience to public timeline. (Provide public timeline to all users to publish their **iChair** experiences)

5 Gantt chart

The Gantt chart of the development process is as depicted in Figure 4.1.

Figure 5.1-Gantt Chart

6 Budget and Budget Justification

The survey conducted shows (Figure 6.1) the amount a person is willing to spend on a smart chair. And the cost incurred in the process of development of the ichair is as shown in the table 6.1.

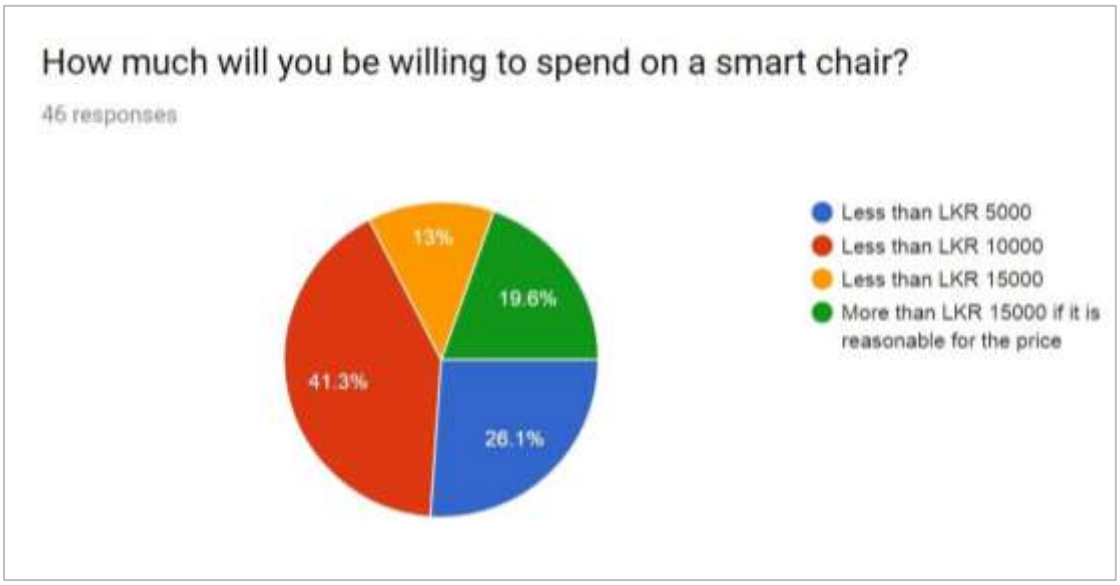

Figure 6.1- Summary of responses of the cost

Component	Amount (USD)	Amount (LKR)
Variable Cost (per chair)		
NodeMCU	5.00	750.00
Pulse Sensor	5.34	800.00
Fingerprint Sensor	38.6	5800.00
Button Mesh	2.34	350.00
Battery + Charging circuit	4.00	600.00
Total	**55.34**	**8300.00**
Fixed Cost (annual)		
Domain Name Registration	5.00	750.00
Hosting	60.00	9000.00
Total	**65 .00**	**9750.00**

Table 6.1-Budget

Reference list

[1] scoliosis?, D. (2018). Does sitting slouched and slanted cause scoliosis? - Physiotherapy Articles. [online] Physiotherapy & Functional Wellness. Available at: https://www.coreconcepts.com.sg/article/does-sitting-slouched-and-slanted-cause-scoliosis/ [Accessed 18 Feb. 2018].

[2] Healthline. (2018). 10 Things That Happen When You Sit Down All Day. [online] Available at: https://www.healthline.com/health/workplace-health/things-that-happen-when-you-sit-down-all-day#4 [Accessed 18 Feb. 2018].

[3] Anon,(2018).[online]Available at : https://fitness.mercola.com/sites/fitness/archive/2015/05/08/sitting-too-long.aspx [Accessed 18 Feb. 2018].

[4] Adams, D., Allison, C., Adams, D. and Allison, C. (2018). Sit up straight: Best smart posture trainers to save your back. [online] Ware able. Available at: https://www.wareable.com/wearable-tech/the-best-wearables-for-improving-your-posture [Accessed 20 Feb. 2018].

[5] Yourhormones.info. (2018). Adrenaline | You and Your Hormones from the Society for Endocrinology. [online] Available at: http://www.yourhormones.info/Hormones/Adrenaline.aspx [Accessed 20 Feb. 2018].

[6] J. A. Healey and R. W. Picard, “Detecting Stress During Real-World Driving Tasks Using Physiological Sensors.”

[7] M. Park, “Design and Implementation of a smart chair system for IoT - IEEE Xplore Document,” pp. 1200–1203, 2016.

[8] A. S. Iskandar, A. S. Prihatmanto, and Y. Priyana, “Design and implementation electronic stethoscope on smart chair for monitoring heart rate and stress levels driver,”

Proceedings of the 2015 4th International Conference on Interactive Digital Media, ICIDM 2015, no. Icidm, 2016.

[9] B. G. Ahn, Y. H. Noh, and D. U. Jeong, “Smart chair based on multi heart rate detection system,” 2015 IEEE SENSORS - Proceedings, pp. 6–9, 2015.

[10] Heart.org. (2018). Stress and Heart Health. [online] Available at: http://www.heart.org/HEARTORG/HealthyLiving/StressManagement/HowDoesStressAffectYou/Stress-and-Heart-Health_UCM_437370_Article.jsp#.WrpZKi5ubDc%20nzc [Accessed 14 Mar. 2018].

[11] BMA Ergonomics UK. (2018). Axia Smart Chair – your personal posture coach - BMA Ergonomics UK. [online] Available at: https://www.bma-ergonomics.com/en/product/axia-smart-chair/#ad-image-0 [Accessed 24 Mar. 2018].

[12] Anon, (2018). [online] Available at: https://www.researchgate.net/publication/228371789_Smart_communities_initiative [Accessed 26 Apr. 2018].

[13] H. Z. Tan, L. A. Slivovsky, S. Member, and A. Pentland, “A Sensing Chair Using Pressure Distribution Sensors,” vol. 6, no. 3, pp. 261–268, 2012

[14] B. Arnrich, C. Setz, R. La Marca, G. Tröster, and U. Ehlert, “What does your chair know about your stress level?,” IEEE Transactions on Information Technology in Biomedicine, vol. 14, no. 2, pp. 207–214, 2010.

[15] VersionOne. (2018). Agile Methodologies for Software Development. [online] Available at: https://www.versionone.com/agile-101/agile-methodologies/ [Accessed 1 Apr. 2018].

[16] https://online.husson.edu/software-development-cycle. (2018). [image].

[17] C. Ma, W. Li, R. Gravina, J. Cao, Q. Li, and G. Fortino, “Activity Level Assessment Using a Smart Cushion for People with a Sedentary Lifestyle,” Sensors, vol. 17, no. 10, p. 2269, 2017.

[18] R. Zemp et al., “Application of Machine Learning Approaches for Classifying Sitting Posture Based on Force and Acceleration Sensors,” BioMed Research International, vol. 2016, 2016.

[19] S. Furugori, N. Yoshizawa, and C. Iname, “Measurement of Driver ’ s Fatigue Based on Driver ’ s Postural Change,” pp. 264–269, 2003.

[20] J. Pan and W. J. Tompkins, “A Real-Time QRS Detection Algorithm,” IEEE Transactions on Biomedical Engineering, vol. BME-32, no. 3, pp. 230–236, 1985.

[21] M. Salai, I. Vassányi, and I. Kósa, “Stress detection using low cost heart rate sensors,” Journal of Healthcare Engineering, vol. 2016, no. i, 2016.

[22] H. M. Seong, J. S. Lee, T. M. Shin, W. S. Kim, Y. R. Yoon, and Y. R. Yoon, “The analysis of mental stress using time-frequency distribution of heart rate variability signal.,” Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference, vol. 1, pp. 283–285, 2004.

[23] J. Choi and G. O. Ricardo, “Using heart rate monitors to detect mental stress,” Proceedings - 2009 6th International Workshop on Wearable and Implantable Body Sensor Networks, BSN 2009, pp. 219–223, 2009.

[24] M. Kumar, M. Weippert, R. Vilbrandt, S. Kreuzfeld, and R. Stoll, “Fuzzy evaluation of heart rate signals for mental stress assessment,” IEEE Transactions on Fuzzy Systems, vol. 15, no. 5, pp. 791–808, 2007.