MASTER

Fit to perform
open API platform development based on agile user needs

Sadeque, A.

Award date:
2015

Technische Universiteit Eindhoven
University of Technology

Department of Mathematics and Computer Science

Architecture of Information Systems Research Group

Fit to Perform:

Open API Platform development based on Agile User Needs

Ahsan Sadeque

Aalto University PHILIPS eit Digital

Supervisors:

dr. Natalia Sidorova

Jos Brunner

Aalto University Supervisor:

prof. Dr. Heikki Saikonnen

Final Version

Eindhoven, October 2016

Abstract

Health-Care intelligent services are becoming an integral part of the professional work life. Fit to Perform, an EIT digital designed multi-stakeholder project, wants to introduce an open service innovation framework that intends to improve the health and wellbeing of the professional long-haul truck drivers by augmenting physiological sensor data to the existing Vehicle Intelligent Fleet Management Systems (FMS). Currently, organizations in the trucking sector adopt a closed system that cannot easily integrate physiological data. Moreover, the project aims to expose the physiological and vehicle sensor data locally, for developing innovative new services for trucking sector, to the independent third party. The project aims to introduce this open service innovation framework by creating an open API platform.

The open API platform can be developed in many ways yet the capability of the platform depends on the extent the platform provides the correlated information. Therefore, in the first part of this research we identify the required information the open API platform needs to provide to enable new innovative services (user needs) by identifying the problems of long-haul truck drivers. In this research, we conduct a review of physiological, vehicle and external parameters (location-awareness) that model Fit to Perform. Fit to Perform being an agile project aims to introduce an MVP in the market with a staged delivery of most important needs. The important user needs can be collected via interviews, observations, surveys and focus groups, however, they do not sufficiently capture the user expectation, critical for the success of the product or service in the market. Therefore, the challenge for identifying the importance lies in determining the user's satisfaction impact for a particular need. This study proposes a methodology for classification and prioritization of the user needs in an agile perspective while identifying the user satisfaction impact for a particular need.

Fit to Perform aims to provide cheap affordable services to the trucking sector. To provide the information required to deliver services in real-time environment data needs to be transferred over the mobile network. Since most of the time trucks are driving cross borders for deliveries, therefore, the roaming mobile data costs for data transfer could render the system infeasible. Hence, in the second part of the study we identify the infrastructure cost associated with the API platform and the services that are going to be provided to the truck drivers in a real-time environment. This study proposes a cost model, modeling the key infrastructure cost-influencers of the Fit to Perform solution. The cost analysis in this study analyses sustainable system configuration by analyzing the variation in the overall system costs of two system configurations.

The open service innovation framework in Fit to Perform requires that domain specific project stakeholder could independently provide specific information context (physiological, vehicle and external). While at the same time exposing this information to the third parties to realize new services both locally on the in-cabin device and over the cloud. Finally, in this study we propose an architecture of the open API platform identifying the data acquisition, data storage and data exposing components. Further, the study provides a design and describes the organization and interfacing between the components to realize the open API platform.

The thesis has been conducted during a six-month internship at Philips Research. The work presented in this thesis is evaluated and examined based on a case study from the industry.

Keywords: sensor, application program interface (API), infrastructure cost, service design, physiological data, vehicle data, location-awareness, model.

Acknowledgment

In the Name of Allāh, the Most Gracious, the Most Merciful

وَأَن لَّيْسَ لِلْإِنسَٰنِ إِلَّا مَا سَعَىٰ ﴿٣٩﴾ وَأَنَّ سَعْيَهُۥ سَوْفَ يُرَىٰ ﴿٤٠﴾ ثُمَّ يُجْزَىٰهُ ٱلْجَزَآءَ ٱلْأَوْفَىٰ ﴿٤١﴾

Al-Najm 53: 39-41

Translation: And that man can have nothing but what he strives for; That (the fruit of) his striving will soon come in sight; Then will he be rewarded with a reward complete.

This is my final milestone for completing my master's program at the Eindhoven University of Technology and Aalto University.

I start by thanking Allah for without His will and grace this would not have been possible.

First of all, I am much obliged and grateful to Natalia Sidorava and Jos Brunner whose guidance and feedback brought this to its fruition. Special thanks to my big brother Ahmed Sadeque and my friend Faizan Ahmed for the continuous help and valuable tips to support my work during thesis.

I would like to thank Harrie Bastianseen for his feedback and support specially.

Furthermore, I would like to thank my parents whose endless prayer and Skype chats motivated and encouraged me during my entire two-year master's program.

Last but not the least, I would like to thank Taha Abdul Aziz and the entire Fit to Perform team for joining, listening and having fun with me during the master's project.

Contents

List of Tables

List of Figures

Abbreviations and Definition

Abbreviations

API: Application Program Interface

App: Application (Mobile)

ECG: Electrocardiogram

ECU: Electronic Control Unit

EE: Electroencephalography

EOG: Electrooculography

FMS: Fleet Management System

GSR: Galvanic Skin Response

HRT: Heart Rate

MVP: Minimum Viable Product

PP: Photoplethysmogram

TC0: Total Cost of Ownership

Definitions

API: In computer programming, an application programming interface (API) is a set of routines, protocols, and tools for building software applications. An API expresses a software component in terms of its operations, inputs, outputs, and underlying types.

MVP: A minimum viable product has just those core features that allow the product to be deployed, and no more. The product is typically deployed to a subset of possible customers, such as early adopters that are thought to be more forgiving, more likely to give feedback, and able to grasp a product vision from an early prototype or marketing information.

FMS: Fleet Management System is a system which allows companies which rely on transportation in business to remove or minimize the risks associated with vehicle investment, improving efficiency,productivity and reducing their overall transportation and staff costs, providing 100% compliance with government legislation (duty of care) and many more.

TCO: Total cost of ownership is a financial estimate intended to help buyers and owners determine the direct and indirect costs of a product or system.

ECU: An Engine Control Unit (ECU) is a type of electronic control unit that controls a series of actuators on an internal combustion engine to ensure optimal engine performance.

Agile: software development is a group of software development methods in which solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development, early delivery, continuous improvement, and encourages rapid and flexible response to change.

Interface: is a shared boundary across which two separate components of a computer system exchange information.

1 Introduction

1.1 General Description

Agile project Fit to Perform (F2P) aims to improve pro-actively wellbeing and safety of the professional drivers and enable drivers to drive as long as they are fit. Healthcare wearable technology and services have become the frontier of both research and industry. This trend has thrived to an extent that it is now seamlessly augmented into the everyday life of the people. Various stakeholders of Fit to Perform project realizing this growing trend aspire to be the forerunners for introducing new health technologies and services to the truck transportation sector that has remained dormant in this growing trend. Primarily, because these healthcare wearable technologies and services are still a luxury item making them expensive and neglect the grueling needs of the truck drivers. Most of the time trucks are on the road; that increases the cost of providing e-services because of mobile data and roaming charges.

Fit to Perform is an evolutionary by-product of the digital innovation of the past decade that augments physiological intelligence, collected by unobtrusive sensors and wearables, with location-awareness and vehicle intelligence in an open service innovation framework. The Fit to Perform project wants to introduce this open innovation framework by providing an open API platform. The API platform enables third party app developers, cloud service providers, and cloud information providers to develop new innovative services for the trucking sector thereby opening new revenue streams and laying a foot on uncharted grounds. Another, important aspect of innovation framework is that it aims to develop a system that can support real-time critical services as well as deferred services both locally and over the cloud.

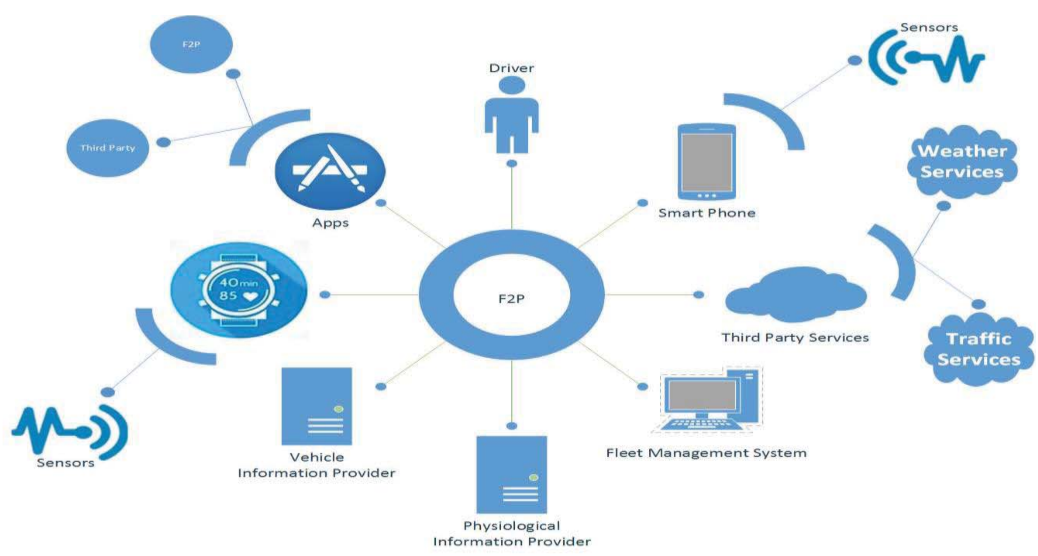


Figure 1 Fit to Perform: Key elements

The Fit to Perform services aim at providing a holistic driver coaching to the driver that improves the work life of the driver and motivates the professional driver to improve his health (sleep, stress, exercising and calorie expenditure). Eventually assessing whether a driver is healthy to perform for long hours of driving. The projects initial focus is therefore truck drivers, in particular, the long-haul drivers.

1.2 Technological Dependency

The success of the Fit to Perform project crucially depends on the development of Stress Algorithm that brings the unique value to the platform. Stress Algorithm could be developed using physiological parameters such as skin conductance or Heart Rate, F2P objective is to develop the algorithm using the heart rate (ECG) since they best describe the physiology of humans. Although there is substantial work on the development of this algorithm, they are not reliable yet. Apart from the development of crucial algorithm the correlation between stress and driving behavior needs to be proven. The paradox of Fit to Perform: the services aimed at the truck driver rely on these algorithms and correlations that are currently under research and development, while the API platform and services need to be defined and developed to illustrate a solid case for the research.

1.3 Project Organization

Fit to Perform is a 'High Impact Initiative' project from EIT ICT Digital that is collectively developed by multiple partners and stakeholders. These partners include MAN, Astrata, Telecom Italia, DFKI, Philips, Imperial College London, and Netherlands Organization for Applied Scientific Research (TNO). The Fit to Perform, an agile project is mainly organized into three teams 'Algorithm Development Team', 'User Acceptance Team', and 'Business Team'. The 'Algorithm Development Team' handles developing the algorithms and co-relation between the physiological and vehicle performance characteristics of the driver. The "User Acceptance Team" works on analyzing the user needs and need acceptance for designing and developing different features for Fit to Perform. A part of 'User Acceptance Team' is also responsible for designing the open API platform to deliver various services identified in the project. 'Business Team' is the business team which responsible for setting claims and objectives with different stakeholders and partners of the project.

In the previous phase of the project both technological and need feasibility were assessed. The technological feasibility of the project was evaluated in two dimensions: a) physiological sensors and technology that can best determine the physical characteristics (stress and vigilance), b) can physiological data be acquired in real time for various health services. On in the other hand, need assessment at a very broad level assessed health issues related to the truck drivers and realized the need for this project.

1.4 Problem Statement

The Fit to Perform in the second phase decided to follow an agile approach to introducing a minimum viable product (MVP) into the market by the end of the year. In this regard, we face the challenge of identifying the most important features that must be catered first for staged delivery of the product/service. The challenge in classifying the importance of a feature lies in identifying user satisfaction impact for a particular need. Analyzing the customer satisfaction gives us a better insight to the user perception of a particular need. That is crucial while addressing the features in agile project. Secondly, the successful agile project, since it is staged, targets specific segments of the market. Therefore, another factor that influences the importance of the needs is the product portfolio. The product portfolio is determined by a set of criteria such as cost, attractiveness, uniqueness and other aspects of the various features the product intends to provide.

The second challenge in Fit to Perform is the design of the Open API platform that provides vehicle and physiological sensory data interfaces to enable the features that have been identified in the user study. Fit to Perform aspires for a coherent system that can deliver Health-Care service to the end user seamlessly. The problem faced in the agile project is that since not all requirements or needs can be specified and analyzed in one iteration. Hence, designing an Architecture that can support the currently identified needs, yet generic and extensible for future requirements that may arise becomes challenging. Additionally, in Fit to Perform context it is expected that infrastructure costs for providing the services in real-time significantly influence the design of the Architecture. Therefore, the other challenge faced is to propose an architectural configuration that minimizes the infrastructure costs for providing the Fit to Perform solution.

1.5 Research Question

To solve the problems defined above following three research questions were defined.

1. How can we classify and prioritize user needs in an agile project for the design of product and services?
    - Can we identify and classify the impact of customer satisfaction for a particular feature in product or service development?
    - How can we identify the criteria importance in a product/service portfolio?
2. How to model costs associated in Fit to Perform System Architecture?
    - How to address Question 2 in the context of configurable Architecture for Fit to Perform.
3. How can we design an Open Mobile API platform for Fit to Perform?
    - What factors influence the architecture design of Open API platform in Fit to Perform Context?
    - How can we define function and organization of component in open API platform for Fit to Perform?

1.6 Approach

As part of the ‘Business Team’ and being a Service Design Engineer, the goal was to look into the project for designing the services/product for meeting the business objectives. Secondly, to analyze the infrastructural costs to realize the open API platform and finally based on the observation propose and architecture for the organization of various components of the platform.

My approach first was to analyze the existing literature for developing a fair understanding of the driver problems related to their health, legislation, diet, accommodation, work and social communication. After fair grasp of the problem background, we then define space for analyzing the Fit to Perform project i.e. the required information context, their inter-dependencies and relation with the driver and acquisition of the information context. Followed by the analysis of user needs, in this regard, we had to visit the literature again for analyzes of various user need classification and prioritization techniques. Eventually, to determine a final methodology user need prioritization suitable for the Fit to Perform. To achieve this, we organized three truck driver focus groups and one-day random interviews at the truck stop to collect user need analysis data. User need analysis led to the development of a prototype with the most important functionality to users and meeting the business objectives. Two tests were conducted with the prototype with two different drivers in real environment settings to test technical issues and user feature acceptance.

The Cost Model was developed by identifying the major cost factors associated with the open API platform and e- services. To define an appropriate cost model we utilized existing infrastructure models from cloud service provider mainly 'Amazon Web Services' and mobile network data providers. For a realistic analysis of cost due to infrastructure the parameter estimations, involved in the cost model, were obtained from the prototype. The cost model analyzed two architectural configurations that supported the Fit to Perform scenario. Finally, the concluding open API architecture for Fit to Perform was designed based on the results obtained from the cost model. Along with the additional functional and non-functional requirements laid down by the project stakeholders and health care service genre from the user study.

1.7 Structure of thesis

This thesis proposes a solution to providing e-health services to drivers on the road. The solution is provided by providing answers to three main and significant aspects of product service development. The first major aspect is the impact of satisfaction, classification and prioritization of user needs. These are introduced in Chapter 2 and examined in Chapter 4. Chapter 3 analyzed the information context in the Fit to Perform space.

The other two aspects 'impact of cost on platform' and 'organization and design of the API platform' are introduced and examined in Chapter 5. Finally, the conclusions based on the general answers and the findings of the Fit to Perform project are introduced in the last conclusions chapter together with future work regarding the findings of this thesis.

2 Problem Background

In this chapter, we are going to review the literature related to the problems faced by truck drivers, especially the long haul drivers. This literature would help us establish the directions and criteria to determine the needs and eventually propose new services for the Long-Haul Truck drivers. Along with the problems faced by the drivers, we will also review the literature on existing technologies and systems in research and industry to narrow down our scope targeted user needs in the following chapters.

2.1 Literature Review

2.1.1 Problems Associated With Truck Drivers

Technology and regulatory advances in the recent decade aimed at increasing road safety have brought a positive trend in road fatalities. Specifically, the European Union has observed a continuous positive trend of decreasing road traffic fatalities to 31100 nearly 11% decrease in 2011 since 2009. This has further decreased to 26000, about 16% in 2013 since 2011 (European Commission, 2014). Still this amount is significantly high. According to a recent study on “European Truck Accident Causation” published by the European Commission and International Road Transport Union (IRU). Factors causing road accidents can be grouped into four categories: environment, technical vehicle issues, infrastructure and human Ref (The International Road Transport Union, 2007). The most prominent factor that accounts for almost 85 % of the traffic accidents is human error. Mainly because of lack of attention, tiredness, unhealthy diet, illegal drug, stress and others. All of these followed by 5.3% vehicle failures, 5.1 % infrastructure failures, and 4.4% weather conditions. Another study by European Accident Research and Safety Report (2013) by Volvo Trucking indicates that environmental factors like bad weather and infrastructure failure contribute to nearly 30% of the road fatalities (VOLVO TRUCKS, 2013). According to Department for Transport, bad visibility due to road infrastructure layout and slippery roads due to weather conditions are the two major environment factors for traffic accidents fatalities (Government of UK, 2008).

2.1.1.1 Health

Almost 50 % percent of the truck driver complain lack of sleep. The nature of their work with irregular working hours and fixed routines raises many complications for them to attain desired rest (Passey et al., 2014). Inadequate night sleep leads to inattentiveness, drowsiness, and even micro sleep. A small span of duration where driver loses consciousness while driving results in accidents (Campagne, Pebayle, & Muzet, 2004; Eriksson & Papanikolopoulos, 2001; Kavitha & Perumalraja, 2014). Truck drivers unhealthy eating habits due to lack of availability of the alternatives increases the risk for cardiovascular diseases. This trend is quite common up to 50 % of the truck drivers (Kavitha & Perumalraja, 2014; McDonough et al., 2014). Whereas, 20% percent of the drivers have significantly impaired lung function (Elke Schneider, 2008). Apart from these major health conditions several other conditions are also quite frequent: lower back pain, overweight, and work-related stress. Copsey, S, et al. reports that in EU-27 almost 22% workers in transportation sector report that work affects their health in terms of stress. Whereas, 32% of the workers in land transport sector report back stress (Copsey, Christie, & Drupsteen, 2011). While, McDonough et al. suggest the themes like traffic and route, last minute loads, weather, border issues, and inspection stations affect the stress (McDonough et al., 2014).

2.1.1.2 Legislative

Apart from the driver's health there is some other work related problems that in the long run effect the performance of the truck drivers. One such problem regularly faced by the truck driver is the tachograph restrictions. The Tachograph allows the driver to work for 4hrs 30 min consecutively. The driver can drive a max of 3 hrs and 45 mins. During work duration the driver needs to take a 15 min short break and 30 min long break. Tachograph does not put any restriction on the driver to take a break at specific times within the work duration. Usually, the planner allows the driver to take the 15 min short break earlier at his will and enforces the 45 min break at the end of his driving time. This inflexible routine affects the driver's performance (Apostolopoulos et al., 2011; Passey et al., 2014).

2.1.1.3 Communication

Workplace and communication for the drive pose specific inconveniences and frustration. Often due to lack of communication between the planner and customer drivers have to wait unexpectedly long hours for their delivery. The wait increases the driver's frustration when the delivery location for a particular customer changes at the last minute. Additionally, current systems in use do not help the driver. As they do not provide intelligent means to communicate between customer and planner in cases of events like traffic delays and vehicle breakdown (Apostolopoulos et al., 2011; Passey et al., 2014).

Work life of truck drivers especially the long haul drivers demands them to be on the road for a week and sometimes even longer. During the journey, the drivers are unable to take part in any social activities. Nearly 50% percent of the driver suffer from depression due lone work with no affiliation. This is worsened by the fact that long haul driver irregular working hours and expensive communication infrastructure. Often these drivers have to pay surplus due to roaming, on the road are unable to efficiently and regularly communicate with their families. Evidentially, communication with families turns out to be the most important social activity for the long haul drivers (Apostolopoulos et al., 2011; Passey et al., 2014; Shattell, Apostolopoulos, Collins, Sönmez, & Fehrenbacher, 2012).

2.1.1.4 Nutrition, Accommodation, and Fitness

Truck drivers lack the knowledge for a healthy diet. Though research shows that they are interested in information for maintaining a healthy life. Such information includes daily portion sizes, necessary vitamins, food nutrients (organic and preservative), and energy balance (nutrition values and needed calorie information) (Apostolopoulos et al., 2011; McDonough et al., 2014; Passey et al., 2014). Furthermore, due to redundant location awareness drivers are unable to find decent restaurants or shops nearby where they can get access to healthy nutritive food. Additionally, drivers on the road are unable to find adequate facilities (shower, restroom, motel and others). That are necessary for the needed rest after long hours of the journey (Apostolopoulos et al., 2011; Passey et al., 2014). The effect on unsatisfactory accommodation affects not only the routine work but also progresses to life and well-being of the driver. Insufficient infrastructure and redundant location awareness restrict them to maintain themselves by doing exercises. Fear of injury, inadequate space, and unawareness of exercises that could be performed on the road are the main influencers that restrict driver from exercising on road (Apostolopoulos et al., 2011; McDonough et al., 2014; Passey et al., 2014).

2.1.1.5 Medical Care

Working Environment in the trucking sector does not wage enough consideration to health care of their drivers. Unavailability of monitoring devices for blood pressure, heart rate, and temperature renders significant problem for maintaining health history for health care provider. Irregular and long work schedules make it nearly impossible for them to maintain their appointments.(McDonough et al., 2014; Shattell et al., 2012).

Passey, Apostolopoulas, and McDonough et al. argue that a particular aspect not cause stress. Rather it is should be observed as a consequence of multi-dimensional problems in the work life of the truck drivers. Where each of the aspects discussed above adds a ripple to the overall stress of the driver (Apostolopoulos et al., 2011; McDonough et al., 2014; Passey et al., 2014).

Not surprisingly road safety programs are becoming the increasing concern of the employers. Murray suggests a reduction in road collision would generate benefits like reduced running cost, reduce lost working days due to injury, and stress. Thereby, increasing job satisfaction and reduced risk of work-related ill health (Murray, 2010). Therefore, effective intervention is indispensable to increase road safety through coaching driver's health.

2.1.2 Healthcare Technological Developments

In this passage, we are going to review the system and technologies proposed in the scientific communities and developed in the industry. The purpose of the study is to realize what technologies and the system would be needed to realize a system that could monitor driver health and addition to it provide value-added features to the driver on the road.

The past decade has seen growing concern from the scientific communities, industry and people on increasing the life expectancy. Lately, the amount of attention on providing health services outside the hospitals has increased. With the advancement in the sensor technology, vital signs are now relatively easy to measure with increasing accuracy. This has led to the study and development of ubiquitous healthcare system. Stress is identified as a key health risk, for chronic diseases such as back pains, migraine headaches and life threatening situations such as cardiac arrest as we have discussed in the above section.

2.1.2.1 Technology

The following Table 1 lists the sensor technology and it role in measuring and monitoring health. Li & Chang analyze stress and fatigue by measuring heart signals such heart rate variability and blood pressure through ECG (G. Li & Chung, 2013). On the other hand PPG, a light emitting diode (LED) illuminates the skin and analyzing heart rate signal by measuring changes in the light absorption. Studies used PPG for measuring driver mental state such as stress, fatigue and drowsiness (Boon-Giin Lee & Wan-Young Chung, 2012).

Table 1: List of Sensors and related Physiological measurements

Technology	Physiological Parameters	Physiological Feature
ECG	Heart Signals • Heart rate variability • Blood pressure	Stress, Fatigue
EOG, Eye Tracking, Video Camera	Eye Signals • Eyelid closure • Eye Tracking • Pupilometer • Blinking frequency	Drowsiness Fatigue
Rubber vessel Impedance-based, Video Camera	Respiration: • Respiration rate • Pneumography • Yawning • Change in facial expression	Fatigue
GSR	• Skin Conductance	Vigilance Stress
EEG	• Electrical activity of the Brain	Vigilance Fatigue
PPG	Heart Signals • Heart Rate Variability • Cardiac Cycles	Fatigue Stress

Drowsiness and Fatigue are physiological phenomena's that can be detected through eye tracking and facial recognition. The techniques utilize sensors like EOG and video camera that enable detection of eyelid closure, blinking frequency, eye tracking and pupilometer as proposed by Hammoud, Zhang and Azmi et al (Azmi, Rahman, Shirmohammadi, & El Saddik, 2011; Hammoud & Zhang, 2008). Another study proposed using the video camera to analyze changing facial expression and yawning to detect driver drowsiness(Boon-Giin Lee & Wan-Young Chung, 2012; Lingling Li, Yangzhou Chen, & Zhenlong Li, 2009). On the other hand Baek et al. in their study analyze respiration rate to measure fatigue through a rubber vessel impedance based sensor (Baek et al., 2009). GSR, also known as electrodermal activity, is an indicator of Skin Conductance. Glands in the skin produce ionic sweat, inciting variations of electric conductivity. Studies determined that skin conductance in combination with heart rate features is a good signal to measure fear and anxiety that can be easily be related to stress and vigilance (de Santos Sierra, Avila, Guerra Casanova, & del Pozo, 2011; Schmidt-Daffy, 2013). EEG can detect the brain activity through the electrical signals generated by the neurons. Electrical signals distinguish the mental state such as estimated shifts in driver's levels of arousal, fatigue, and vigilance, as evidenced by variations in their task performance (Chin-Teng Lin et al., 2014; Sonnleitner, Simon, Kincses, Buchner, & Schrauf, 2012).

2.1.2.2 Systems Proposed in Scientific Community

Baek et al. propose a system extending the concept of ubiquitous healthcare services. To monitor the driver's physiological signals nonintrusive they propose using the Electrocardiogram, PPG, galvanic skin response and respiration (using rubber vessel impedance based). Nonintrusive sensors installed on the steering wheel, driver seat, and seat belt measure the physiological signals of the driver in the ubiquitous car. Bluetooth wireless connection transmits the physiological data collected by an embedded computer. The data will be processed to provide a real-time health and stress evaluation of the driver (Baek et al., 2009).

Lee and Chen designed a monitoring system for Android-based smartphone. The smartphone monitoring system receives sensory data via wireless sensor network using the Bluetooth connectivity, the current attitude of the driver is determined after further processing of the data on the phone. Using integrated and synchronized signals from video sensors, for tracking eye movement and facial expression, in combination with PPG, for measuring the heart rate features, to provide a more realistic evaluation of the driver behavior. If the driver fatigue level crosses certain threshold a warning alarm is sounded to alert the driver (Boon-Giin Lee & Wan-Young Chung, 2012). While Azmi et al. propose a CCD camera-based system to deduce multi-level driver drowsiness state with a progressive haptic feedback alerting scheme. They proposed using vibrations from actuators placed on the seat and pedal similar to the mobile vibration alert that would gradually increase its intensity. They suggested using the mobile vibrations to alert drivers. Thus, warning the drowsy operators without scaring or surprising them, in a nonintrusive manner (Azmi et al., 2011).

Using laboratory–oriented biosensor technology for measuring the neurophysiological activities of the drivers while they are driving poses a significant challenge. Lin et al. therefore, presented a dry EEG sensor based mobile wireless EEG system (Mindo) to monitor driver vigilance in real time linking the fluctuations in the driving performance of brain activity. Mindo is Android-based smartphone vigilance monitoring system that receives the sensory data through Bluetooth connectivity from a wireless and wearable EEG signals from hairy regions of the driver conveniently. The proposed Mindo system incorporates the use of a wireless and wearable EEG device to record EEG signals from hairy parts of the driver conveniently. The mobile based system processes and translates the EEG recordings to vigilance levels (Chin-Teng Lin et al., 2014).

2.1.2.3 Driver Health Care Monitoring Systems in the Industry

An analysis of the current driver health monitoring system in the Industry shows that many of the proposed technologies and systems are being implemented. In the following passage, we are going review the systems developed and used in the industry.

Mercedez Benz in 2009 introduced new assistance system Attention Assist that would warn the driver of tiredness and nodding off at the wheel. Attention Assist system is the first nonintrusive technology to observe driver continuously using typical behavior pattern that provide a warning for detecting the risk of accidents. The system uses a high sensitivity sensor that allows extremely precise monitoring of steering wheel movements and steering speed. Based on these data during the first few minutes of every trip an individual behavioral pattern is calculated. The pattern is the continuously compares with the current driving situation and steering behavior. This allows the system to detect typical indicators of drowsiness and alert the driver (Drowsiness-detection system, ATTENTION ASSIST: Mercedes.7/5/2015). Later Volkswagen also introduced nonintrusive Driver Alert System that monitors driving behavior noting any erratic steering wheel movements and lane deviations through the camera. It also continually evaluates traffic signals on the road when driving at speeds of more than 40mph. If the system detects that driver starts to lose concentration, it will alert the driver with a visual display on the dashboard and a warning sound. If the driver does not take a break within 15 minutes, the system will repeat the warning (Driver alert system: Volkswagen UK.7/5/2015).

The Exeros Sleep Watcher-XR employs most advanced noncontact facial recognition infrared cameras to monitor eyelid and Retina status. It continuously monitors the eyelid and retina for signs of fatigue and stress. The system warns the driver with an audio feedback when it observers drowsiness and sleep. As the drivers are less likely to correspond and pull over to take a rest. The Watcher-XR partnered with Exeros Track Eye 4 DVR system can transmit the drowsiness warning alarm to the fleet control center. The fleet operator is alerted to the emergency situation by flashing vehicle and live video of the operator on screen. Image processing technology that tracks the movement of a person's eyes, face, head position, and facial expression is widely used in combination with auditory and vibratory feedback (Sleep Watcher XR -Driver alert system : Exeros.7/5/2015). Caterpillar uses Driver Safety System –In Vehicle System (DSS-IVS) developed by Seeing Machines. That employs image processing technology, auditory and vibration alert to provide safety of drivers in the mining industry (DSS in-vehicle system (DSS-IVS): Seeingmachines.7/5/2015).

Lately, a new system FEELythm has been introduced by Fujitsu Laboratories. FEELythm is a system specifically designed for monitoring the drowsiness, vigilance and stress of Fleet truck driver. Feelythm uses a wearable sensor attached to the earlobe that measures vital signs such as pulse and automatic nervous system. The sensory data is sent back to the receiver that can be linked to the fleet-management in-vehicle system and smartphone, notifying the driver in real time. With the connection to the fleet management system, the fleet managers can monitor the condition of the driver in real time and provide suitable guidance (FUJITSU vehicle ICT FEELythm : FUJITSU.7/6/2015).

2.2 Conclusion

Analysis of the literature indicates that currently the technology exists to realize a system that can monitor physiological phenomenon such as stress, fatigue, drowsiness and vigilance real time. For the sake of easiness, we will call such a system Fit-to-Perform. We can also observe that both the industry and literature have developed pervasive systems that can monitor the driver in real time in a nonintrusive manner. Apparently, these systems are not ubiquitous enough; rather we have learned from the analysis of the problems faced by the drivers. That the stress, fatigue, and drowsiness are physiological phenomena's that are affected by events beyond the driving on the road. While the current system only measures and monitor the driver while they are in the vehicle. Furthermore, these systems lack the external awareness that affects the driver driving behavior and physiology. Traffic, weather conditions, loading, unloading, communication and other activities according to literature influence the physiology of the driver and, therefore, need to be incorporated to realize a real, pervasive system.

Therefore, there is a need to realize a ubiquitous health monitoring system that can not only monitor drivers while they are in the vehicle rather extends to activities that make the working life of the driver. Furthermore, it is necessary to combine the driving status, physiological status, and location awareness to make an effective, reliable, pervasive health monitoring system.

3 Fit To Perform Space

Fit to Perform aims to provide a personalized coaching solution to the driver. The driver is coached on maintaining and improving his health indicators that determine his fitness while on the road. On the other hand, another objective is to prolong the driver's regular driving style by improving his health and fitness. Driver coaching considers that physiological behavior of the driver has a direct impact on the driving behavior of the driver.

Thus by monitoring the driver's physiological (i.e. stress, vigilance, tiredness, sleep) effects over the driving behavior (lane deviation, harsh braking and acceleration) we can observe and predict driver's deteriorating performance. When and what internal and external influences degrade driver's performance. Fit to Perform solution aims to provide optimal resting time for the driver. Along with coaching services with the main goal to support the driver maintain both his mental and physical health.

On the other hand the fleet manager, who creates the schedule and manages the driver while they are in route, would get a holistic view of the driving performance combined with the health information. That would allow him to make a better decision and support the driver while he is at work.

In the first minimum viable product we have decided to focus on the driver, therefore in the following sections we would be analyzing the solution space from the driver perspective only.

3.1 Information Context

To provide holistic coaching, the Fit to Perform solution combines various information context. Physiological information of the driver, vehicle information (driving behavior), fleet information (schedule, route) and external information around the driver as depicted in Figure 2. The objective of this study is to identify the critical elements and their interdependencies that influence the drivers.

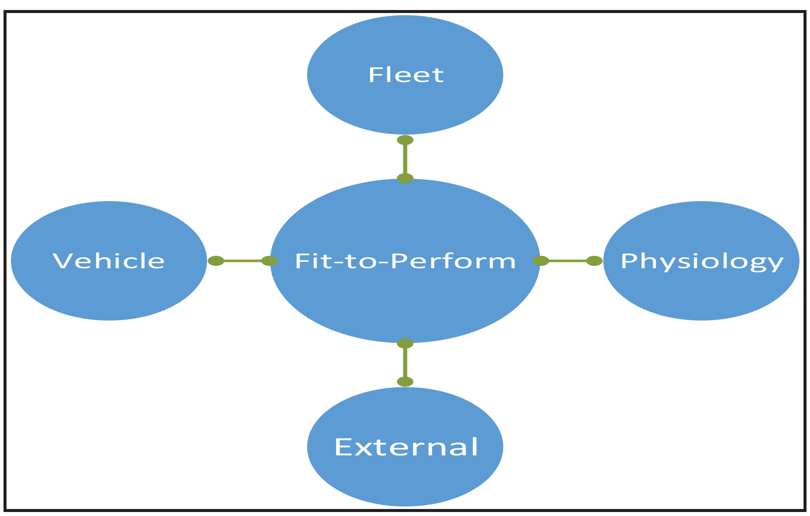


Figure 2 Fit to Perform Information Contexts

3.1.1 Vehicle Context

Table 2 elicits the relevant information context with respect to the Fit 2 Perform solution from the vehicle and fleet as discussed in the previous chapter. The below-listed characteristics define the driving behavior of the driver. These features have a direct impact on the performance of the driver as well as the variation in these characters also reflects the mental state of the driver. The Fleet managers, use the interfaces provided by the telematics service provider.

Table 2 Key Features: Vehicle Context

Driving Behavior	Fleet Information
• Harsh Acceleration • Harsh Braking • Steering Movement • Lane Deviation • Fuel Efficiency • Vehicle Speed	• Route • Breaks • Customer

The interface allows them to set the different Key performance indicators for each driver. The indicators improve the driving style of the driver and reduce the extra cost associated with fuel consumption and truck maintenance.

Acquiring the information like the route, break, and deliveries can help us understand the working life of the driver. Interaction with the customer forms an important part of the daily routine of the driver. Therefore, it would also be useful to observe if these interactions have any effect on the state of the driver.

3.1.2 Physiological Context

Table 3 elicits the relevant information context with respect to the Fit 2 Perform solution from the physiology of the driver.

Table 3 Key Features: Physiological Context

Physiological Characteristics	Physiological Behavior	Physical Activities
• Heart Rate • Temperature • Skin Conductance • Respiration	• Stress • Vigilance • Fatigue • Drowsiness	• Sleep • Driving • Loading • Unloading • Exercising • Relaxing

Research has shown that physiological characters have an impact on the mental state of the driver. The mental situation of the driver varies depending due to the activities he is performing. Therefore, monitoring the driver's physiological characters through all kind of activities in the Fit to Perform solution is required. Fit to Perform coaching solution needs to be flexible and adapt according to the needs of the driver.

3.1.3 External Context

Table 4 elicits the relevant information context with respect to the Fit 2 Perform solution from the external factors surrounding the driver. The literature analysis in the previous section establishes that location awareness is one of the primary concern of the driver and has a direct impact on both, the physiological as well as the driving behavior of the driver. Influence of traffic is a major effect on the everyday routine experience of the driver. Incidents like congestion, road accident, road work and construction not only stress the driver but also affect the driver's planned schedule. Apart from traffic, weather also affects the driving behavior of the driver, slippery road due to rain have turned out to be one of the major reasons for road accidents. .

Table 4 Key Features: External Contexts

Traffic	Weather	Places of Interest
• Congestion • Accidents • Road Works • Road Side Construction	• Temperature • Conditions ○ Rainy ○ Cloudy ○ Thunderstorm ○ Sunny ○ Windy • Humidity • Precipitation • Air Quality	• Maintenance ○ Truck Stops • Parking Spots • Fuel Stops • Food ○ Restaurants ○ Super Stores • Recreation\Exercise ○ Parks ○ Tracks • Accommodation ○ Hotels ○ WC ○ Shower

Fit to Perform solution; on one hand observes the impact of these external factors on the physiological and driving behavior of the driver while on the other hand provides this information to the driver. So that the drivers become aware of the factors that would affect them Fit to Perform sees that providing the information on the places that interest driver and also serve their needs such as accommodation and food that greatly influence the driver health. Drivers are known to be sleep deprived, unhealthy food intake, and suffer from various health condition ranging from cardiovascular diseases to chronic diseases. Hence, providing the information on places of interest along the route: would enable the driver to make a better decision regarding where to take a break and where to sleep. In return, this guarantees to improve the driving behavior and physiological behavior of the driver.

3.2 Interdependencies between Information Contexts

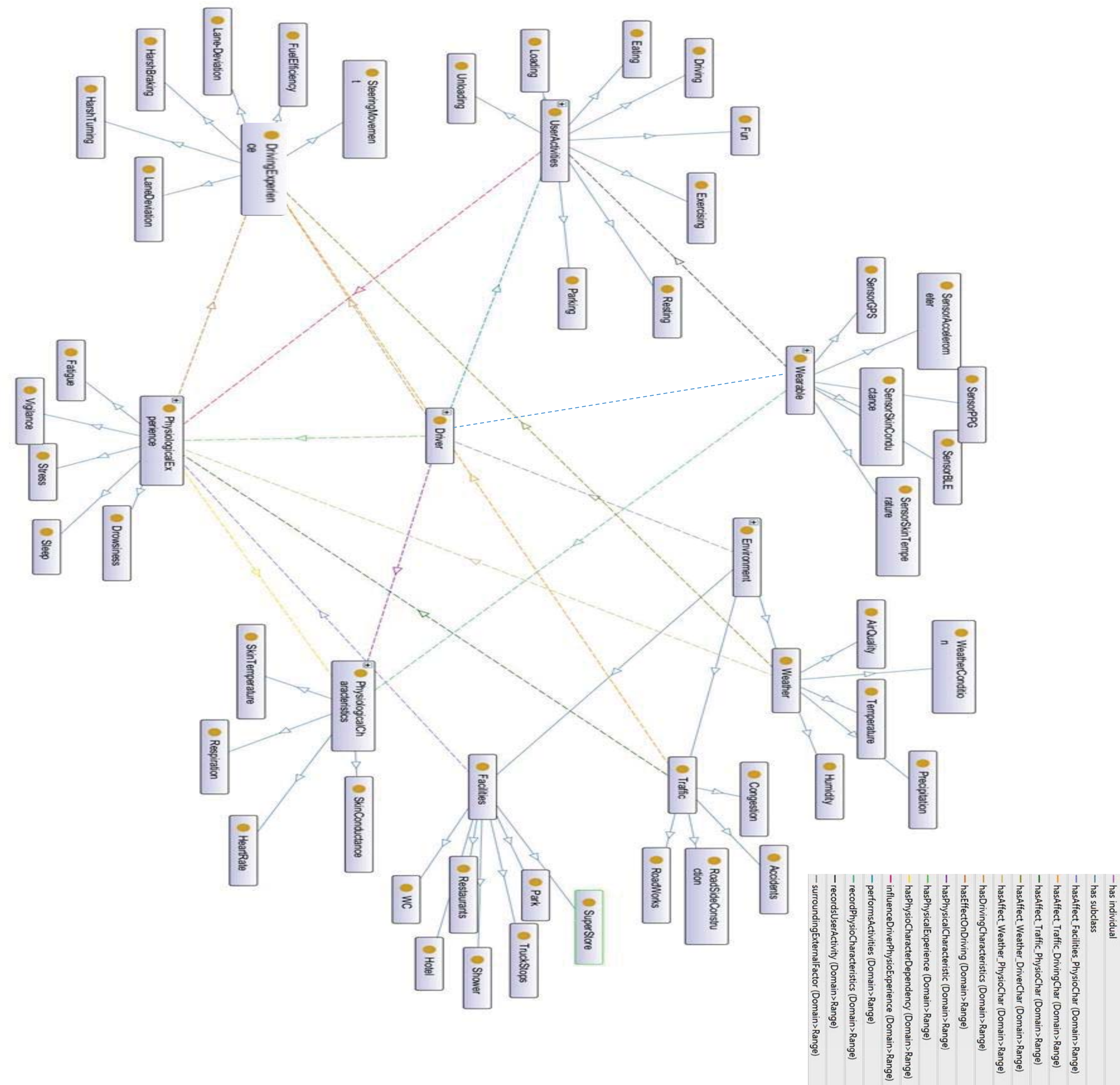


Figure 3 Relation between the driver and information context features

Figure 3 is a map that holistically captures all the information context and related elements that influence the driver in the Fit to Perform solution space. The table enlists the interdependencies between the different components. The Fit to Perform elements can be divided into two broad categories: spatial and temporal. Spatial can be defined by the environment that influences the driver and cannot be influenced by the driver. The spatial elements include weather, traffic, and facilities. On the other hand, temporal elements are based on time and are influenced by either one or more temporal element, spatial elements or both. The temporal elements can, therefore, be considered as aspects that depend on the driver but are influenced by the situation such as driving.

The sensors attached to the wearable records the physiological characteristics of the driver as well as the activity of the driver. These activities and characteristic influence the physiological experience of the driver. Therefore, depending upon the variation of activity and physiological characters of the driver the driver would experience different physiological experiences such as fatigue, stress, and drowsiness. In the Fit to Perform solution, we assume that the physiological experience have a direct impact on the driving behavior of the driver. So we can safely assume that if the driver is stress or drowsy he would frequently be exhibiting one or more characteristic that represent bad driving behavior such as harsh acceleration, harsh braking, lane deviation and others. On the environmental elements such as traffic and weather affect both the physiological experience and driving characteristics. Whereas the facilities (Places of Interest) only affect the physiological experience of the driver. Bad night accommodation results in deprivation of required sleep, which in turn would affect driving. On the other hand, a traffic jam would affect both driving and mental state of the driver.

Apart from the mapped elements, some other aspects might also influence the driver such as the interaction with the customer. We have already seen in research that bad interaction with the customer often affects the driver's performance.

Understanding the relation between the contexts is paramount for designing the coaching services for the driver. As coaching, service aims to improve the working life of the driver. Understanding these relations will help us to identify the key triggers and feedback at a specific time during individual activities that need to be provided to the driver.

3.3 Data Acquisition

3.3.1 Vehicle Data Acquisition

A modern truck has nearly 70 Electronic Control Units (ECU) for engine control, transmission, air bags, anti-lock braking system ABS, cruise control windows and another system necessary for running the truck. Numerous sensors and actuators record vehicle information of the truck controlled by these ECU. The ECU's communicate with each other over a local communication network called Controller Area Network (CANBus). Can Bus is a vehicle multi-master broadcast serial bus standard for connecting the ECU allowing each node to send and receive messages. The CANBus standard is specified and controlled by the Society of Automotive Engineers (SAE), SAE J1939: Recommended Practice for a Serial Control and Communications. All datagrams on the CANBus are proprietary to the OEMs, like MAN, DAF, SCANIA and others, and are not directly accessible to third parties. In 2002, the six European manufacturers Dailmer, MAN, VOLVO, SCANIA, DAF Trucks and

IVECO developed an interface standard, FMS-standard, that allows third-party telematics solutions to access specific datagrams from the CANBus. The third party companies such as Astrata, interface their telematics On Board Unit (OBU) through the FMS gateway to access the sensory information collected by the sensors and actuators. The OBU is a mobile device telematics platform that can communicate with the telematics service providers using the GSM and GPRS channels. . The Telematics Systems on board can process the data locally for monitoring the personalized driving behavior of the driver along with the truck information for maintenance and performance measures. They provide personalized monitoring by connecting to the digital tachograph (DTCO) to identify the drivers when they insert their digital tachograph card into the DTCO. The DTCO is a device fitted to a vehicle that automatically records its speed and distance, together with the driver's working activity selected from a choice of modes. The tachograph determines allowed working time of the working time of the driver.

3.3.2 Physiology Data Acquisition

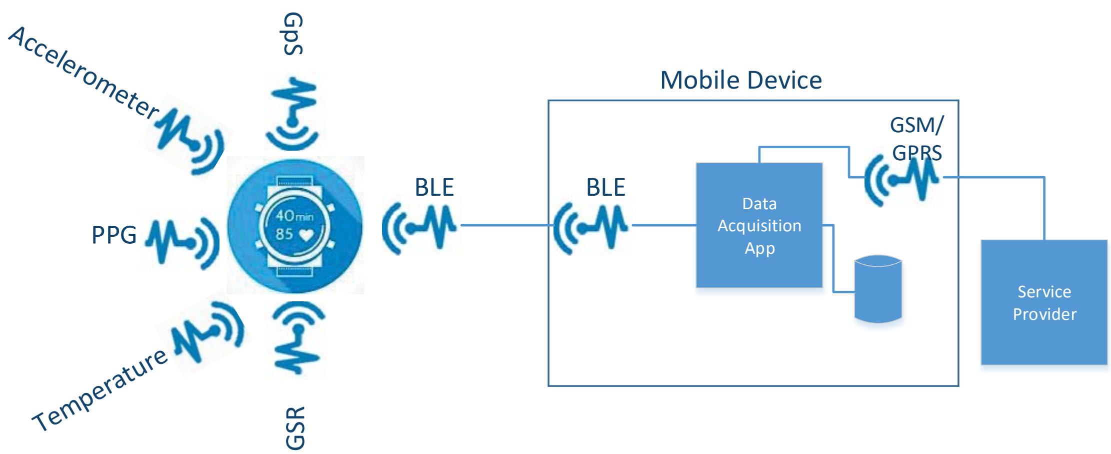


Figure 4 Physiological data acquisition

The wearable industry has grown smarter over the past decade. Now days are there is rarely a gadget manufacturer that does not have any stake in the smart wearable industry. The innovation of mobile platform has now triggered the trend of the internet of things, and wearables form the major future of this industry. Health monitoring has been the premier, especially for sporting activities such as running, biking and swimming. In the industries these days, there is rarely any wearable that does not monitor health, calorie burn and activity of the user. These wearables range from headbands, caps, glasses, wristbands and watches. Table 5 lists some of the widely used wearables that are in the market.

Although these wearables can monitor health quite accurately the Fit to Perform aims for a wearable that is more pervasive and can be worn for longer durations and suitable for all kinds of activities without causing any kind of hindrance to the driver. Apart from monitoring the driver it would also be advantageous for the Fit to Perform to employ a wearable that can identify the various activities of the drive for more accurate monitoring and coaching of the driver. Therefore, Fit to Perform solution has decided to use a smart watch and wristbands as wearable to monitor the driver primarily because it is conventional ease of use, non-intrusiveness, and pervasiveness. As well as the fact that the wristband and watches are the most worn wearables by genders of both class.

Table 5 List Health Care Wearables

Wearable Type	Wearable	Measures	Usability	Sensors
Wristband	• Fitbit[1] ChargeHR • Mio Fuse[2] • Jawbone up[3]	Sleep, Heart Rate Activity, Stress, Vigilance, Temperature	• Non-intrusive • Pervasive: Usable in broad range of activities	• Bluetooth® 4.0 BLE • Tri-axis accelerometer • Optical heart rates monitor • Respiration • Galvanic Skin Response (GSR) • Skin temperature
Wrist Watch	• Mio Alpha[4] • Fitbit Surge[5] • MotoX 360[6] • Apple Watch[7]	Sleep, Heart Rate Activity, Stress, Vigilance, Temperature	• Non-intrusive • Pervasive: Usable in broad range of activities	
Wearable Cap	• Spree Smart Cap[8] • Smart Cap[9]	Heart Rate Activity, Stress, Vigilance	• Intrusive: Driver might find it difficult to perform various activities (driving, loading unloading) • Nonpervasive: cannot measure sleep	• Bluetooth® 4.0 BLE • Tri-axis accelerometer • Heart Rate • Temperature • EEG

Figure 4 provides the schematic of acquiring physiological data. The wearable collect the raw physiological data using PPG, temperature and accelerometer on the device as well as a process this raw data to determine the heart rate and temperature of the user. The accelerometer along with GPS can further also ascertain the activity of the driver such driving, loading, unloading, relaxing, sleeping and exercising. This processed data is then communicated to a nearby smart device such as mobile phone or tablet that is running a data acquisition app. The smart device displays the information to the user by storing information locally or transmitting it to back end service provider through GSM/GPRS.

[1] https://www.fitbit.com/nl/chargehr
[2] https://www.mioglobal.com/Mio-FUSE-Heart-Rate-Activity-Tracker/Product.aspx?ProductID=29
[3] https://jawbone.com/store/buy/up3
[4] https://www.mioglobal.com/Default.aspx
[5] https://www.fitbit.com/nl/surge
[6] https://www.motorola.com/us/products/moto-360
[7] http://www.apple.com/watch/
[8] http://spreewearables.com/products/smartcap/
[9] http://smartcaptech.com/smartcap-overview/

3.3.3 External Data Acquisition

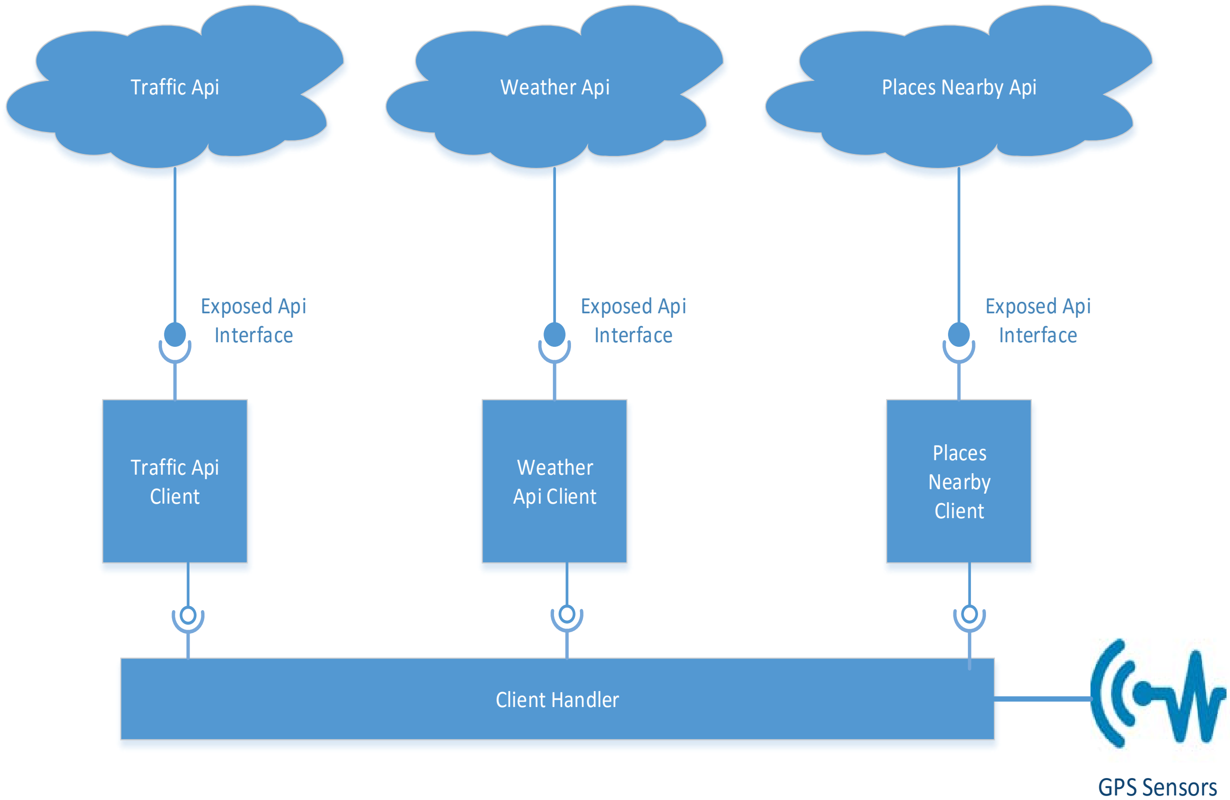


Figure 5 External Data Acquisition

In the previous section, we have already considered the external factors in context to the Fit to Perform driver coaching solution i.e. Traffic, weather, places of interest (POI). With the development of open API platforms and interoperable standards such as JSON and XML location-based services are now readily available to every smart device that has internet access. There is a wide variety of service providers the following contains a list of external service providers.

The service providers expose RESTful API that can be consumed by any mobile or desktop client. These API requests have a specific format. Usually, the location-based services require at least require the current location as an input parameter to provide the response. The current location can be obtained from the GPS sensors on the mobile device or wearables while a local client can be developed to communicate and manage the responses over HTTP as shown in Figure 5. Further, these location-based service providers provide different subscription level depending upon the required usage and nature of the information needed (historical or current). Therefore, it is necessary to evaluate the usage needs before considering any API.

Table 6 List of External Context APIs

Service Type	Service Provider	Subscription	Pros/Cons
• **Maps** • **Routing** • **Navigation** • **Traffic**	• Bing[10]	• Student- unlimited free no of requests • Free- 10,000 requests a month • Historical data Paid Account	• Traffic, routing, navigation are independent of the map and can be consumed by various clients • Provides a complete documentation of requests and response. • One response structure for all types of messages which makes handling and mapping information difficult
	• Google[11]	• Free-25000 calls /day • 10$-40,000 calls/day • to • $37.50-100,000 calls/day	• Traffic, routing and navigation data can only be overlaid on maps. • Documentation for using the api is quite comprehensive
	• Here[12]	• Free (90 day trial)- 100,000 calls to • Professional- $999 2000,000 calls/month	• The professional subscription has many features available, including routing particularly for trucks (In case of F2P this could be advantageous) • Limited number of calls to the API even in the professional subscription
	• TomTom[13]	• Not available	• Currently one of the best routing and navigation service. In use by various companies like our partner Astrata.
• **Weather**	• Yahoo [14]	• Not available	• Provides only five-day weather prediction
	• OpenWeatherMap [15]	• Free- 1,700,000 calls/per day (1200/min) To • Enterprise- $2000 200,000,000 per day (2000,000/min)	• Well documented and easy to use request and response. • Feature rich API with hourly, daily and weekly predictions and updates. • Provides support to current location, city • Historical data available
• **Points of Interest**	• Bing[16]	• Student- unlimited free no of requests • Free- 10,000 requests a month	• Limited support: Places can only be found by location or address. Does not support place types.
	• Google[17]	• Free- 1000 request/ day • Pay by use- 1500,000 requests/ day	• Provides support to all kinds of place search i.e. hotel, motel, restaurant, truck stops and others. • Well documented request and response to the API. • Customer feedback and place rating are also available.

[10] https://msdn.microsoft.com/en-us/library/ff701713.aspx
[11] https://developers.google.com/maps/?hl=en
[12] https://developer.here.com/
[13] http://developer.tomtom.com/
[14] https://developer.yahoo.com/weather/
[15] http://openweathermap.org/api
[16] https://msdn.microsoft.com/en-us/library/ff701715.aspx
[17] https://developers.google.com/places/web-service/

3.4 Conclusion

The various stakeholders of the project decided to use Mio wearable device to record the physiological parameters of the driver. As it is one of the non-obtrusive pervasive wearables developed by a partner of the Fit to Perform project. Due to integration limitations with Astrata Telematics system, vehicle information was acquired directly from the FMS interface provided by the OEM. After consideration of numerous APIs, Bing Maps was selected for the route, traffic, and road conditions. Primarily, because it is free for students and suitable for prototype development. Further, OpenWeatherApi was used for weather updates and Google Maps API for the places of interest.

4 User Need Classification and Prioritization

This chapter is answering the question *How can we classify and prioritize user needs in an agile project for the design of product and services.*

An agile project aims for small iterations and quick delivery of the solution to enter the market. Even for agile success depends to the extent with which we describe the system, by the expectation of the customer. In addition to meeting customer expectations, solution proposed should also meet the laid down objectives of the business.

Prioritization of needs thus becomes necessary since not all necessities can be substantially delivered in the limited amount of time. However, meaningful prioritization can only be achieved if we can efficiently classify the satisfaction of the user for a particular need. User need classification helps to understand the importance of a need for the product user: whether it is a need that is necessary for the user or service or need that attracts the user, providing a competitive advantage to the product but is not mandatory.

Secondly, it is crucial to decide early onstage, in design phases, the portfolio of the product. Portfolio of the product determines whether we should prioritize development of mandatory needs or attractive needs. By doing so, we are also able to identify products entry market segment. For example, if the aim of the fit to perform is to focus on the early adopters then focus should be given to attractive user needs. Early adopters have the capacity to adopt new things even when they are immature and do not provide any value.

Therefore, in agile we need focused development of a system entailing the most important prioritized needs, based on the classification of user expectation and desired portfolio of the product, at the same meeting the business objectives. While sequentially expand the system with less pressing needs in next iterations.

In this chapter, we evaluate the needs of the driver. The first section of the chapter is focused on analyzing the techniques and approaches for the evaluation and prioritization of user need. The second section analyzes the fit to perform use case based on the selected methodologies to get the final needs to develop the system.

4.1 Classification and Prioritization Techniques: Review

In literature, there are many techniques that enable the prioritization of the of the user needs. In this section, we review frequently used methods for prioritization, which are summarized in Table 7. Due to the nature of the Fit to perform project it is hard to generalize the prioritization and classification of user needs, due to time constraint only limited number of interviews can be conducted. Therefore, we need to select techniques that substantially provide both quantitative and qualitative analysis of the user expectation and proprietaries.

The 100 dollar test may be skewed with a limited number of participants since each participant may decide to allocate all units to a particular needs that they want to prioritize. This undermines the feasibility of the system since rarely systems are developed with a single user need (Wiegers & Beatty, 2013). Moreover, our objective is to prioritize based on user expectation for each need; lack of well-defined methodology for user need classification renders this technique unfeasible for Fit to perform.

Table 7 Prioritization Techniques

Method	Description
100 Dollar Test	A direct method where each stakeholder get 100 imaginary units (such as money or hours) to allocate among the given need. More units of value are allocated for a need large set. Need are ranked based on the total of units for each need (Berander & Wohlin, 2004; Leffingwell & Widrig, 2003).
MoSCoW	A need prioritization method based on dynamic software development method. It classifies need into four broad categories based on their importance (Waters, 2009; Wiegers & Beatty, 2013). **Must**: The needs are critical to the success of the solution. **Should**: These are not critical needs but are important and if possible must be provided. **Could**: these are desirable needs that could be differed or eliminated. **Won't**: These reflect needs that would not be implemented.
Top Ten Requirements	Stakeholders select their top-ten needs to be developed without assigning any particular priority (Wiegers & Beatty, 2013).
Relative Weighting	Stakeholder evaluates a need based on the effect of its presence and absence. A weight of 0-9 (low-high) scale is used to identify a needs presence and penalty for absence along with an implementation cost. The final indicator is priority indicator is established by dividing the total weight by cost (Cohn, 2004).
Quality Function Development (QFD)	Structurally defines customer needs and translates them into concrete plans to produce product/service to meet those needs. These needs are usually described as "voice of the customer", they are captured by surveys, focus groups, customer's specifications and others. A product planning matrix or "house of quality" summarizes these customer needs. The matrices are finally used to translate thigh level "what's" to lower level "how's"- product attributes or needs that satisfy these needs (Kenneth, 2002).
Kano Model	Product development methodology established by Noriaki Kano to classify every need into five categories, must-be, one-dimensional, attractive, indifferent and reverse, based on answer to two questions: • Functional Question: How do you feel if feature X is present? • Dysfunctional Question: How do you feel if feature X is not present? **Must-be:** The must-be are the basic needs for a product or the service **One-dimensional:** Requirement fulfillment is relative to the customer satisfaction. **Attractive:** Needs that attract user but are not necessary for the user to use the system. **Indifferent:** Customers are indifferent to whether these needs are filled or not. **Reverse:** They are not only the unwanted needs rather a customer expects them to the opposite. (Shahin, Pourhamidi, Antony, & Sung, 2013)
AHP	Analytical Hierarchal Process (AHP) relies on a pairwise criteria comparison method. It involves structuring multiple choice criteria into hierarchy, assessing the relative importance of the quality characteristics, comparing the needs with each criterion and determining the overall ranking of each requirement (Saaty, 1983)

On the other hand, it is unclear what is meant by "Won't" in MoSCoW i.e. should the "need" not be addressed in the current release or never. This clarity is really significant for the development of any product service (Kukreja, Payyavula, Boehm, & Padmanabhuni, 2012; Wiegers & Beatty, 2013). Although this technique classifies the needs into different categories, but the method does not provide any rationale for its classification. Therefore, it is impossible for us to infer what user means by "must": whether the user just likes the need, or it is really necessary to deliver "the need" in product or service. Often, when the user sees something new he immediately says that he wants it, but on further investigation whether he would use it or not reveals that it is a mere attraction.

The top ten requirements technique works to avoid any conflicts that may arise due to the desire to support specific needs. However, if the stakeholder alignment is small, it is possible that the needs may not conform to any priority list (Alshehri & Benedicenti, 2013).

Relative Weighting is a well-defined technique but requires an associated cost function for implementation and thus cannot be used without experts. Since our aim is to analyze customer expectations, this method is not suitable for Fit to perform solution.

More importantly the techniques above are designed for settings where experts prioritize the needs. Essentially, the techniques do not capture the expectations of the customer where fit-to-perform solution primary objective is to prioritize the voice of the customer. Secondly these methods do not define any rationale as how to measure the customer satisfaction for a staged introduction of critical needs into the market.

QFD is a method that records the voice of the customer and translates them into characteristics in product and service design (Geng, Chu, Xue, & Zhang, 2010). QFD primary objective is to detect existing gaps in the product or service portfolio and to measure the contribution of new ideas to the strategic objectives (P. Wang et al., 2011). However, prioritization measures during QFD that focus on solution generation require the needs to be prioritized before the QFD method could be used (L. Hallowell, 2015). This technique is not suitable for the current stage of fit to perform solution i.e. we are trying to identify the needs at the moment.

Kano model, on the other hand, is a customer channeled tool designed specifically to determine the relationship between customer satisfaction and fulfillment of a feature representing the need of the user. It provides a complete rationale for the need classification different quality characteristics such as must-be, one-dimensional, attractive and others (Table 8), as compared to the other techniques described above. Further, the method has been evolved to identify the average attribute satisfaction impact based on the customer's response. Hence by using Kano we can gain both qualitative and quantitative analysis in a limited amount of respondent. Still Kano lacks a comprehensive prioritization model i.e. if two needs are classified as the same attribute that one gets more priority.

In this regard, AHP a pairwise comparison method that enables us prioritize the classified user needs. Compared to the techniques mentioned above it provides a complete mathematical model for prioritization, which aims at removing bias in decision making. Nonetheless, it cannot classify the user needs.

Imperatively, it is evident from the discussion above that a single technique would not be able to suffice the fit to perform objective of prioritization based on the classification of user expectation for a particular need. Therefore, in our study we propose to combine both techniques, Kano for determining the customer expectation and AHP for prioritizing the overall rank of the needs, to get the final prioritization of the user needs.

4.2 Kano Model for Classification

Noriaki Kano developed a customer channeled tool to reduce a list of features, feature, in this case, represent needs, to those that potentially assemble a successful product or service (Kano, Seraku, Takahashi, & Tsuji, 1984). The Kano method provides an orderly and efficient way to sort through an initial new product feature list and identify a manageable set of functions that resonates with prospective customer need. Kano model has been successfully applied to bring the expectations of customers to the decision-making process, translating the needs into critical to quality characteristics or attribute (CTQ's).

The relationship between customer's satisfaction and fulfilling the quality features is considered as a nonlinear relationship. Therefore, for efficient investment, the managers need to identify the position and impact of the product quality on customers' satisfaction (Fynes & De Burca, 2005; Matzler & Sauerwein, 2002). Kano identified that there are two more components other than the proportional (one-dimensional): Attractive features and must-be features. The Kano model is different from other models as it can quantify the degree of satisfaction and dissatisfaction of the customer. Further, attractive attribute once introduced would be adopted by competitors (Wakhlu, 1998), that makes it quite dynamic. It is important to state that, Kano Model not only provides a mechanism identify the needs that currently satisfy the customers but also address expectations that would excite the user. (Shahin & Zairi, 2009).

There has been considerable research developed from the methodology proposed by Dr. Noriaki Kano. Kano has been widely being applied in the industry for instance: Kano model was used to prioritizing need of air travelers (Shahin & Zairi, 2009), in Web-community service quality (Zhao & Roy Dholakia, 2009), customer brand contacts in hotel business (K. Chang & Chen, 2011),identifying attractive user interface software components (Mayer, 2012), consumer preference in real estate (Llinares & Page, 2011), evaluation of digital library (Garibay, Gutiérrez, & Figueroa, 2010) and maternity care (Aghlmand, Lameei, & Small, 2010).

4.2.1 Kano Attributes

To evaluate the relationship between the quality characteristics (CTQ) of the product and customers' satisfaction, Noriaki Kano divided these features into five categories based on the extent of their impact on the customers' satisfaction.

4.2.1.1 Attractive Features

Kano model considers these customer needs to be the product features that significantly influence the satisfaction of the user. Customers do not get dissatisfied if these conditions are not met, on the contrary if they are met leads to more customer satisfaction (Cheng & Chiu, 2007; Matzler, Hinterhuber, Bailom, & Sauerwein, 1996). Customers neither explicitly express nor expect attractive needs to be fulfilled, therefore providing them gives a competitive advantage to the product or services offered on the market. This type of needs is also known as the wow factor (Breyfogle III, Cupello, & Meadows, 2000)

4.2.1.2 Must-be Features

The must-be needs are the basic needs for a product or the service. Extreme dissatisfaction is sensed by the customer if they are not fulfilled. Hence, they form the features for a product (Matzler et al., 1996). A customer takes these feature for granted, satisfying these needs does not increase the level of satisfaction rather fulfillment only leads to a state of "not dissatisfied". The customer does not explicitly demands the must-be need to be fulfilled, rather considers them the prerequisites for example if a customer wants to buy a smartphone a touchscreen is a precondition. Cheng and Chiu claim that must-be needs in any case are a decisive competitive factor, and if they are not fulfilled customers will be very disappointed (Cheng & Chiu, 2007).

4.2.1.3 One-Dimensional Features

Customers explicitly demand the one-dimensional needs (Matzler et al., 1996). Providing these features with enhanced quality increases the customer satisfaction, whereas as if the feature quality somehow gets degrades would increase customer dissatisfaction.

4.2.1.4 Indifferent Features

Customers are indifferent to whether these needs are filled or not (Cheng & Chiu, 2007). Berger et al. explains that they are not willing to spend more on these features (Berger et al., 1993).

4.2.1.5 Reverse Features

They are not only the unwanted needs rather a customer expects them to the opposite (Berger et al., 1993). Hence, no product feature should belong to this category.

4.2.1.6 Customer Need Evaluation

The last two attributes indifference and reversal attributes do minimum impact on the user satisfaction, at least for the current iteration. Therefore, they do not increase the customer satisfaction only the first three quality attributes are mandatory to fulfill (Matzler & Sauerwein, 2002; Ting & Chen, 2002).Though, it is still possible in the future that some of the indifferent needs can become attractive. Identifying the important quality aspects of the user needs are essential for the value-centric agile approach. For example investing on must-be needs that are already at the satisfactory level would not be useful, and then improving the one–dimensional and attractive that influence product service perceived quality. One of greatest assets of Kano method that it helps in a tradeoff situation in the product service development stage. Many a time, two or more service needs cannot be met, due to constraints on time, technical availability or budget. Therefore, identification of the impact on user satisfaction can help us make tradeoffs.

4.2.2 Kano Classification

Kano questionnaire amasses the expectation of the customer by asking him positive (functional) and negative (dysfunctional) question. The positive questions are mapped on a positive scale, and the negative question is assigned to the negative level. The positive scale measures the extent to which the customer is satisfied in the case of the presence of the desired features, and negative scale measure the user performance in the event of absence of desired characteristics of the product.

The evaluation is designed one a five-point Likert scale of "like," "must-be," "neutral," "live-with," and "dislike," and the respondents were required to give a dual response to each item. The results from the user are evaluated according to Table 8 below

Table 8 Kano Evaluation Matrix

CRs			How do you feel if requirement X is not present?				
			DYSFUNCTIONAL Question				
			1.like	2.must-be	3.neutral	4.live with	5.dislike
How do you feel if requirement X is present?	FUNCTIONAL Question	1.like	Q	A	A	A	O
		2.must-be	R	I	I	I	M
		3.neutral	R	I	I	I	M
		4.live with	R	I	I	I	M
		5.dislike	R	R	R	R	Q
	A=Attractive			M=Must-be		R=Reverse	
	O=One-dimensional			I=Indifferent		Q=Questionable	

Source: Adapted from Kano et al. (1984)

The needs of the user are prioritized in the manner M>O>A>I>R.

In the traditional Kano model classification of the terminology used for capturing the quality attributes associated with the customer needs are quite vague. Consequentially, respondents get confused when interpreting scale points. Furthermore, the question designed in the traditional model are ambiguous in the sense that it is not clear to the evaluator whether the respondent actually understood the context of the question.

Apart from the weak design of the traditional Kano model classification is that it is unable to distinguish the relative degree the features are attractive or must-be. This problem is because human beings rarely perceive things in one dimension, rather they always assess things in relative degrees. The traditional Kano Model is unable to map the relative level of perception.

4.2.3 Modified Kano Model Classification

Therefore in our study we would be using a modified version of the Kano Model classification as proposed by (Shahin et al., 2013). Shahin et al. in 2014 modified the traditional Kano Model to remove the vagueness of the terminologies, accompanied by the Likert scale. To cater the relative degree of human perception, it extends the quality attributes attractive and must-be to high attractive, attractive and low attractive and high must-be, must-be, low must be respectively as shown. The modified classification follows the following order: high must-be (M_c) → must-be (M_b) → less must-be (M_a) → one dimensional → less attractive (A_1) → attractive (A_2) → highly attractive (A_3) → indifferent → reverse. The evaluation Table 9 below reflects the changes in the Kano Classification. The prioritization rule remains same with small alteration M>0>A>I.

Table 9 Revised Kano evaluation table Shahin et al. in 2014

Customer needs		Dysfunctional form of the question: 1. I like this feature omitted	2. I need this feature omitted	3. I am neutral about this feature	4. I can live with omitting this feature	5. I dislike omitting this feature
Functional form of the question	1. I like this feature included	Q	A_3	A_2	A_1	O
	2. I need this feature included	R_{A_3}	Q	I	I	M_a
	3. I am neutral about this feature	R_{A_2}	I	I	I	M_b
	4. I can live with including this feature	R_{A_1}	I	I	Q	M_c
	5. I dislike including this feature	R_O	R_{M_a}	R_{M_b}	R_{M_c}	Q

The revised and proposed Kano evaluation table

Notes: A – Attractive need; O – one-dimensional need; M – must-be need; I – indifferent; R – reverse; Q – questionable

The evaluation table replaces the vague ambiguousness Likert system with more concrete, understandable terminologies i.e. like this feature included, need this feature and others. Furthermore, this classification method and the used terminologies aptly fit into fit-to-perform context since the aim of the project is to introduce feature services for the truck drivers.

4.2.4 User Satisfaction

(Berger et al., 1993) proposed the Customer Satisfaction Index (CSI). CSI is a method to identify attribute's satisfaction impact, based on the user's response to their sentiment to a particular need. Since different customers have different expectation and needs, calculating customer satisfaction (CS) and Dissatisfaction (DS) corresponds to the average impact of overall satisfaction of all customers if the need is fulfilled and overall dissatisfaction if the need is not met, respectively (Clegg, Wang, & Ji, 2010). Where (Tontini, Søilen, & Silveira, 2013) showed that nonfulfillment of the must-be attributes affects the offering of one-dimensional and attractive features. This primarily because a low performance of the primary needs of the user, must-be attributes, brings a limitation to impact the one-dimensional, and the attractive attribute has on satisfaction of the customer.

The CS and DS coefficient are calculated according to the equation 2 and 3. The positive CS-coefficient ranges from 0 to 1; the closer the value is to 1, the higher the influence on customer satisfaction. A positive CS-coefficient which approaching 0 signifies that there is a petite influence on customer satisfaction. At the same time. However, negative CS-coefficient should be taken into consideration. If it approaches −1, the impact on customer dissatisfaction is especially strong if the analyzed product feature is not fulfilled. A value of about 0 signifies that this feature does not cause resentment if it is not met.

$$Satisfaction = \frac{A + O}{A + O + M + I} \tag{1}$$

$$Dissatisfaction = \frac{A + M}{(A + O + M + I)(-1)} \tag{2}$$

4.3 Fuzzy Analytical Hierarchal Process (FAHP) for Prioritization

Analytical Hierarchal Process (AHP) relies on a pairwise criteria comparison method. It involves structuring multiple choice criteria into a hierarchy, assessing the relative importance of these criteria, comparing the needs with each quality characteristic and determining the overall ranking of each need (Saaty, 1983). It helps capture both subjective and objective prioritization measures. AHP aims at reducing the bias of decision making by providing a useful mechanism for checking the consistency of evaluation measures (Lai, Trueblood, & Wong, 1999). AHP is a widely used Multi-Criteria Decision Making (MCDM) and has been successfully applied to many decision-making problems (Thomas, 1988). In spite of its wide use and popularity this method is often criticized for its incapability to handle reliably inherent vagueness and inaccuracy, regarding the representation and mapping of human's judgment as exact (crisp, according to fuzzy logic terminology) numbers (Deng, 1999). In most of the practical cases, human preference model is uncertain and often exact cannot be associated with comparative judgments.

Zadeh (1965) developed Fuzzy logic set to deal with the ambiguity and vagueness of human thought. Fuzzy sets and fuzzy logic are influential tools used broadly for different problems to overcome human inaccuracy. They are characterized by a membership function that assigns to each element zero to one-degree membership. Crisp sets only permit either full membership or non-membership, whereas fuzzy sets permit partial memberships (Torlak et al. 2011). (Lee and Huang 2009) evaluate that it is reasonable to apply fuzzy logic in scientific research if the respondents express the intent by utilizing membership and interval numeric. Let $A^{-} = (a_1, a_2, a_3)$ and $B^{-} = (b_1, b_2, b_3)$ two positive triangular fuzzy numbers and r be a positive real number.

$$(a_1, b_1, c_1) + (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2) \tag{3}$$

$$(a_1, b_1, c_1) - (a_2, b_2, c_2) = (a_1 - a_2, b_1 - b_2, c_1 - c_2) \tag{4}$$

$$(a_1, b_1, c_1) \times (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2) \tag{5}$$

$$(\lambda, \lambda, \lambda)\ (a_1, b_1, c_1) = (\lambda a_1, \lambda b_1, \lambda c_1)\ \lambda > 0,\ \lambda \in R \tag{6}$$

$$(a_1, b_1, c_1)^{-1} = \left(\frac{1}{a_1}, \frac{1}{b_1}, \frac{1}{c_1}\right) \tag{7}$$

Using linguistic terms to represent preferences of quality attributes is much easier than assigning deterministic numbers. For example, it is much easier for decision makers to classify as: strongly more important, equally important, weakly more important, etc. Thus, in order to extract the weight of the criteria in this phase, linguistic variables are used for pairwise comparison of the quality attributes instead of deterministic numbers. For this purpose, the linguistic scale for the triangular numbers illustrated in Figure 7 Linguistic Scale triangular numbers , fuzzy conversion scale given in Table 10 Triangular Fuzzy Conversion Scale and Figure 6 are used in the proposed model. In this study, the extent analysis approach of Chang (D. Chang, 1996; D. Chang, 1992) has been utilized since the steps in this approach are relatively easier than other FAHP approaches and are similar to the conventional AHP (Isaai, Kanani, Tootoonchi, & Afzali, 2011).

Fuzzy AHP has been widely used in different industries to prioritize and analyze the needs. FAHP was used for web service composition based on quality of service (Yu, Zhang, & Zhang, 2012), group buying website evaluation (Chen, Li, & Tang, 2012), evaluation and ranking hotels offering e-service (Shahin, Khazaei Pool, & Poormostafa, 2014) and intelligent time table evaluation for railway (Isaai et al., 2011).

The details on Chang's pairwise comparison is provided in Appendix A.

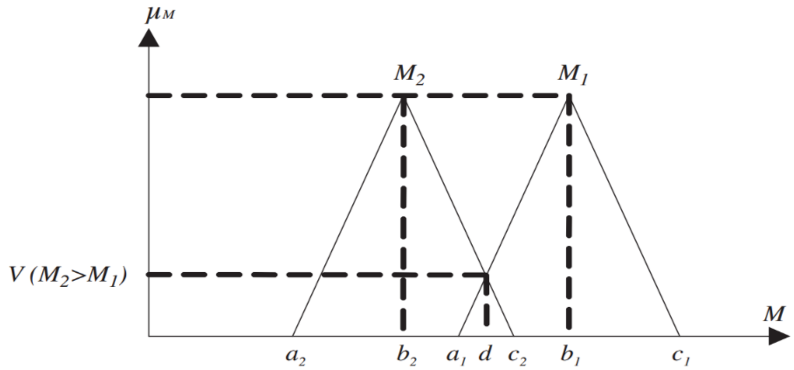


Figure 6 The intersection of M_1 and M_2

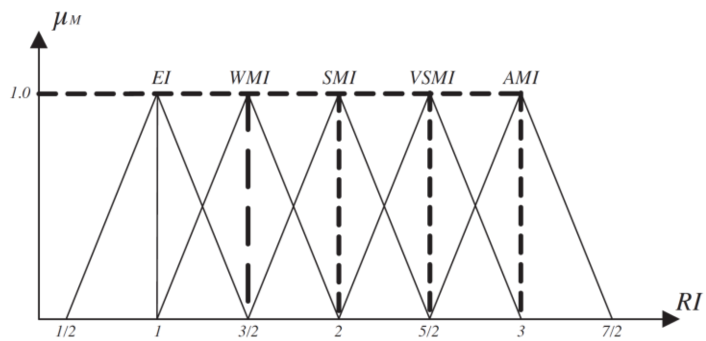


Figure 7 Linguistic Scale triangular numbers

Linguistic scale	Fuzzy scale	Fuzzy reciprocal scale
AMI: absolutely more important/improved	(5/2,3,7/2)	(2/7,1/3,2/5)
VSMI: very strongly more important/improved	(2,5/2,3)	(1/3,2/5,1/2)
SMI: strongly more important/improved	(3/2,2,5/2)	(2/5,1/2,2/3)
WMI: weakly more important/improved	(1,3/2, 2)	(1/2,2/3,1)
EI: equally important/improved	(1/2,1,3/2)	(2/3,1, 2)
Just equal	(1,1,1)	(1,1,1)

Table 10 Triangular Fuzzy Conversion Scale

Fuzzy AHP responds to the problem of human uncertainty while representing a pairwise comparison of the CTQ's. It analyzes and prioritizes the CTQ's in regard to the uncertainty and imprecision for mapping human judgment as compared to the crisp mapping of the conventional technique.

4.4 Steps for Prioritization

Kano in combination with AHP has been used in various literature: rating customer requirement final importance (Y. Li, Tang, Luo, & Xu, 2009), prioritizing factors affecting bank customers (Kazemi, Kariznoee, Moghadam, & Sargazi, 2013), optimizing verities for smart cameras (C. Wang & Wang, 2014), requirement management for service system design (Lee, Sugumaran, & Park, 2011).

Figure 8 below describes the steps applied for prioritization. The process starts by identifying the key stakeholders (long haul truck drivers). Followed by listing the user needs to be gathered from the literature analysis of the problems faced by the drivers in their routine work life and existing driver monitoring systems as described in the previous section. One of the most important steps in the process is designing the questionnaire for capturing the customer perception of the proposed features representing the need. After recording the observation of the customer, the user needs must classify and evaluated using Kano Model. The decision-makers would then decide if the registered customer responses correspond to the observations they gained from discussion and interviews with the customer at a broader level. Once the decision about the reliability and consistency of recorded and observed perception of the stakeholder has been taken, the decision-makers will then prioritize the classified needs. The classified needs from the previous step will be ranked based on the desired product portfolio that is determined by the decision-makers. The product portfolio of the desired system is based on the importance of the criteria, such as mandatory needs, one-dimensional needs, and attractive needs, cost, and time, determined by a pairwise comparison using FAHP. The entire process would be repeated for the entire duration of the product portfolio.

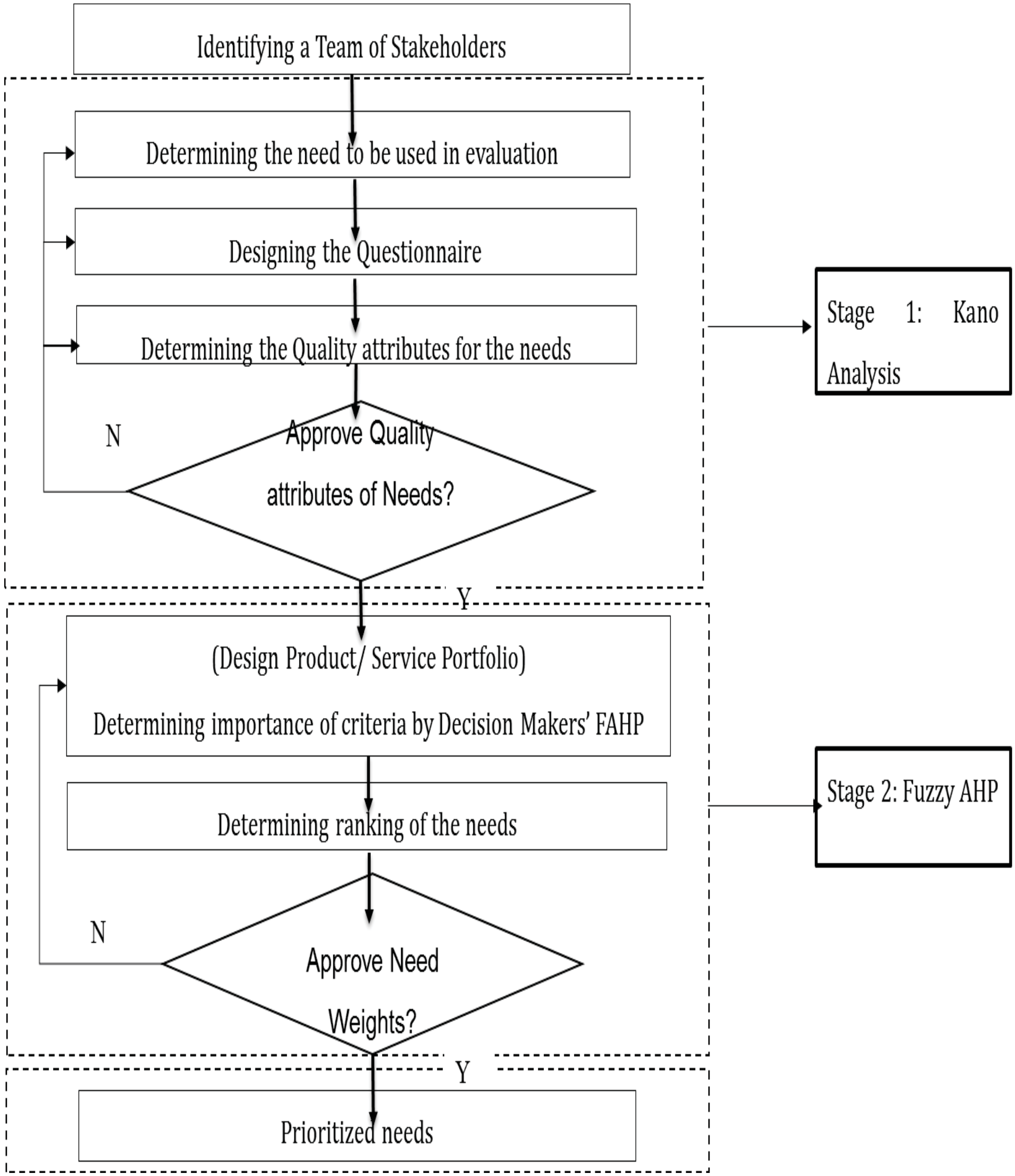


Figure 8 User Needs Prioritization Methodology Overview

4.5 Use Case Analysis

The following section analyzes the fit to perform use case for classifying and prioritizing the user needs.

4.5.1 Stakeholders

Long haul truck drivers were identified as the key stakeholders for classifying and getting an insight into the user needs. Responses were collected from ten truck drivers in organized focus groups at companies and random interviews with drivers at truck stops.

A second set of replies were also obtained from three decision makers of different team leads, to create a product service portfolio.

4.5.2 Needs Description

Table 11 Selected needs for analysis

C_n	Needs
C1	Stress Advices
C2	Safety Alerts Sleep/Drowsiness
C3	Medical Assistance
C4	Customer/Planner feedback
C5	Scheduling Proposal to Planner
C6	Nutritive Suggestions
C7	Exercise Coaching
C8	Physical Activity Monitoring
C9	Facilities along the route
C10	Road Conditions along the route
C11	Communication Family & Friend

The needs mentioned above in Table 11 were selected after analyzing the literature and information context discussed in the previous chapters.

Stress Advises: The driver would be provided with advice such as listening to music, a small break or a short walk along the road and even talking to his friends or family.

Safety Advises: This feature would alert the driver when he is falling asleep, getting drowsy or losing vigilance on the road that may lead to an accident. The feedback could be provided in the form of audio and visual. In future, it would also be possible to park automatically the cars on the side road.

Medical Assistance: The driver in trucking company suffer from extreme cardiovascular and chronic diseases. Unfortunately, many a time incident like heart stroke occur while they are driving. This leads to many fatalities not only to the driver but people nearby. Predictive medical assistance could be provided by informing the nearest hospital and local traffic authorities about the current condition of the driver.

On the other, hand this could also be a virtual medical assistance that advises particular actions for specific diseases such as diabetes, cardiovascular diseases, and others.

Communication Customer & Planner: The driver faces many challenges like traffic delays, accidents, truck maintenance problems in their usual working day. This feature would allow simple means to communicate these issues with both the planner and delivery client.

Communication Family & Friends: This need was identified in the literature as social isolation faced by the driver that in return accumulates as the stress of the driver. Affordable, innovative means to keep in contact with their families.

Schedule tasks with Planner: This feature would allow the drivers to share their preferences such as travel times, delivery client, appointments and events with the planner so that he can schedule more appropriate plans.

Exercise Coaching: Maintaining the health of the driver is the primary objective of Fit to perform. Fit-to-perform can provide a personalized exercising plan for the drivers with suitable exercises that can be carried out on the road.

Nutrition: Since the Health is an individual factor to every driver a personalized wellbeing solution would be offered. Medical history, daily consumption, and preferred food of the driver are accounted to provide a tailored nutrition map that recommends details of portion sizes, energy balance and other nutritional pieces of advice. Further, recommendation on healthy food and habits would also be provided to the driver.

Activity Monitoring: Monitoring the activity such as sleep patterns, loading, unloading walking and driving to show the driver his\her vitals, energy consumption, and stress level.

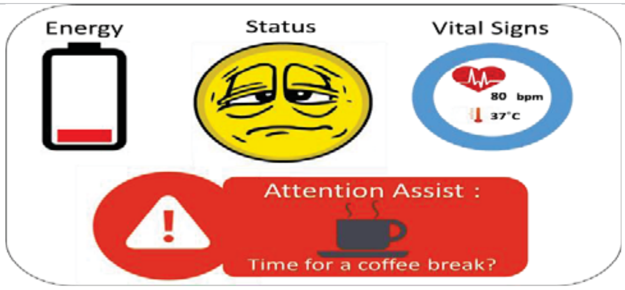
Facilities Nearby: Location based solution that suggests healthy eating, and resting places by combining route information, break and personalizes physical wellbeing. The suggestions should also provide a rating on factors such as (nutrition, affordability, facility, and others).

Road Conditions: Providing location-based information that affects the normal driving of the driver as well as his mental statuses such as traffic, road works, and weather. The solution would not only provide information for the current location but also predict traffic and weather along his entire route.

4.5.3 Questionnaire Design

After we select the criteria that we need to investigate, we have to design the questionnaire for recording the responses and views of the respondents. As discussed in the previous section we would be following (Shahin et al., 2014) design methodology. To resolve the criticism on the understandability of the context in the Kano functional and dysfunctional question pictures were added to improve context understandability. The Figure 8 Kano functional question below shows the layout of the functional question.

The second part of the questionnaire, as shown in Figure 8, was used for a comparative study that was conducted with the decision makers to determine the weight of each quality attribute. The Decision Maker compares the individual categories using the scale in Table 10.

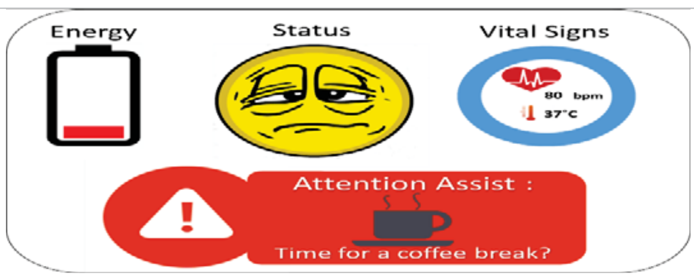


If the application helps alert you when you are sleepy, how do you feel?

 I dislike this feature	 I can live with including this feature	 I am neutral about this feature	 I need this feature included	 I like this feature included

Figure 8 Kano functional question

Figure 9 represents the dysfunctional form of a question.



If the application does not alert you when you are sleepy, how do you feel?

I like this feature omitted	I need this feature omitted	I am neutral about this feature	I can live with omitting this feature	I dislike omitting this feature

Figure 9 Kano dysfunctional question

Appendix B elicitates all the survey questions asked from the drivers for this study.

	Must-be	One-dimensional	Attractive
Must-be			
One-dimensional			
Attractive			

Figure 10 Quality attribute evaluation matrix

4.5.4 User Need Classification Analysis

With the aid of Kano evaluation matrix in Table 9, the responses to the functional and dysfunctional questions led to the classification of each need into one of the following Kano attributes: must-be high, must-be medium, must-be low, one-dimensional, attractive high, attractive medium, attractive low, indifferent and reverse. Expectedly, different respondents had a different opinion towards the needs. The difference of views by selecting the most frequent attribute was chosen to classify the need. The case study results for the classification of the criteria shown above (Table 12).

Table 12 Case Study Results for Classification of Criteria

C_n	Need	M_{Cn} (Mc,Mb,Ma)	O_{Cn}	A_{Cn} (A3,A2,A1)	I_{Cn}	R_{Cn}	Criteria Evaluation (CTQ)	CS	DS
C1	Stress Advices			1,1,1	3		Attractive low	0.5	-0.5
C2	Safety Alerts Sleep/Drowsiness	0,0,1	1	1,2,0	1		Attractive Medium	0.66	-0.66
C3	Medical Assistance	0,0,1		2,0,1	2		Attractive High	0.5	-0.66
C4	Customer/Planner feedback		3		3		One-dimensional	0.5	0
C5	Scheduling Proposal to Planner				6		Indifferent	0	0
C6	Nutritive Suggestions		1		4	1	Indifferent	0.25	0
C7	Exercise Coaching				5	1	Indifferent	0	0
C8	Physical Activity Monitoring			0,1,1	4		Indifferent	0.33	-0.33
C9	Facilities along the route	1,1,0	3		1		One-dimensional	0.5	-0.33
C10	Road Conditions along the route	1,1,2	1		1		Must-be low	0.16	-0.66
C11	Communication Family & Friend	2,1,1		0,1,1			Must-be High	0.33	-1

C_n= nth Need
M_{Cn}=must-be frequency
O_{Cn}=one-deimensinoal frequency
***A_{Cn}**= attractive frequency*
I_{Cn} =indifferent frequency
R_{Cn} =reverse frequency
CS= customer satisfaction coefficient
DS= customer dissatisfaction coefficient

We can see from (Table 12) that if we evaluate each need according to the frequencies of their quality attributes then we can categorize “Communication with Family and Friends” and “Road Conditions along the route” as “must-be needs”, “Facilities along the route” and “Planner and Customer feedback” as “one dimensional needs”, “Stress”, “Safety Alerts” and “Medical Assistance” as “attractive needs”, whereas rest of the four needs as indifferent. According the M>O>A>I rule the two must-be needs be most important to the user. The two one-dimensional needs provided with enhanced performance to improve the experience of the user. Whereas attractive needs are more important in interesting the users towards the product and should be ensured before moving on to any indifferent criteria's. On this note, it does not mean that we should not invest on the indifferent criteria's since they do have the potential to move up to attractive or one-dimensional and even must-be.

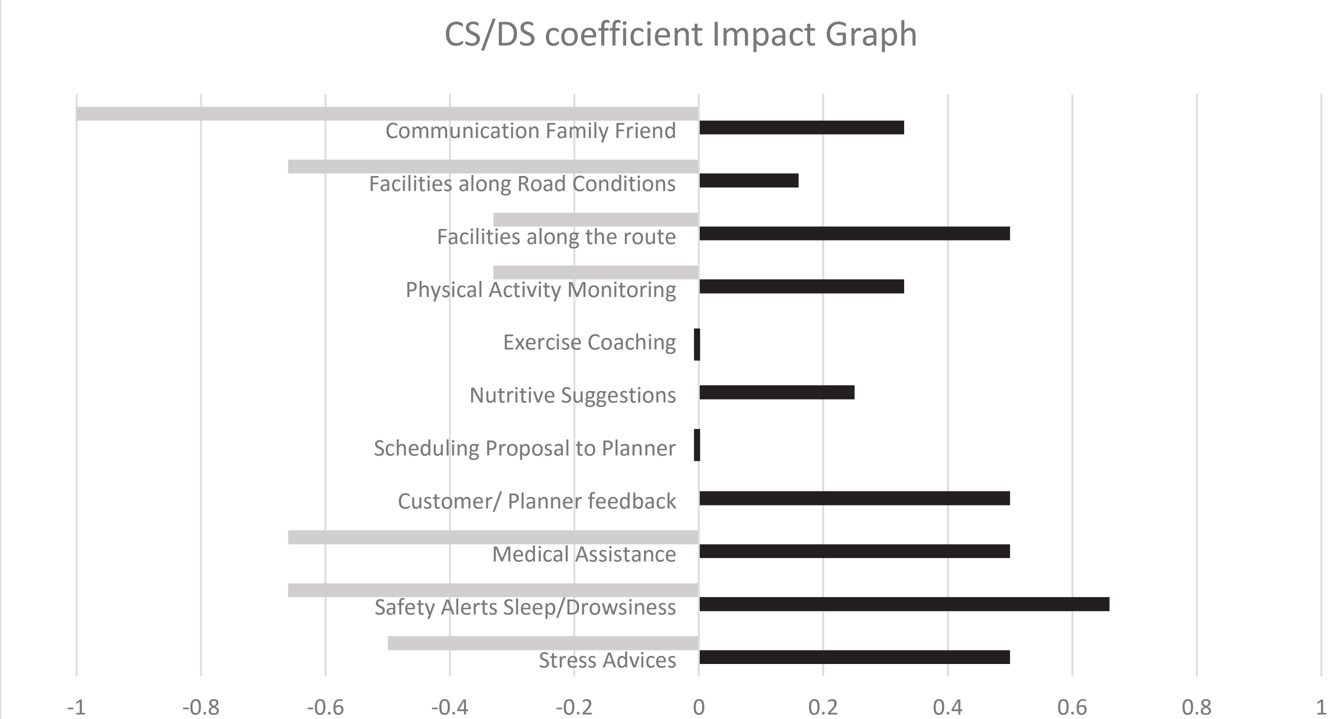
The empirical results summarized in the table above show two must-be, two one-dimensional, three attractive and four indifferent. The results are highly consistent with the literature that quality classification attributes follow life cycle indifferent->attractive->one-dimensional -> must-be (Ko, Lu, & Yu, 2012).

Further using the Table 9 evaluation matrix we can classify the each must-be and attractive attributes additionally into three level of importance i.e. high, medium and low. For example, the two must-be attributes can be further distinguished into Communication with family and friends as must-be high and Road Conditions on the road as must-be low. This differentiations allows us to understand in more depth about the needs of the user.

4.5.5 User Need Satisfaction Analysis

The impact of each criterion on the customer satisfaction and dissatisfaction can be determined by applying equation (1) and (2) on the evaluated criteria Table 12. As we have discussed in the previous section that a CS coefficient, representing the satisfaction of the user approaches 1, the fulfillment of this criteria would have maximum impact on the satisfaction or appreciation of the user. Accordingly, a DS coefficient approaching -1 has the most impact on the dissatisfaction of the user. Whereas, for both coefficient criteria's approaching 0 have little or no effect on the satisfaction or dissatisfaction of the user. Figure 11 shows the satisfaction and dissatisfaction impact of each criterion if they are fulfilled or not fulfilled respectively.

It is evident from the graph that "Safety alerts" provides the highest satisfaction (0.66) to the user. This infers, that if we decide to provide this feature in the product or service the user will perceive great satisfaction impact and positive experience from the product. At the same, time we need to analyze the needs impact of dissatisfaction (-0.66) on product perceived by the user. That is if the provided feature in the service or product does not fulfill the expectation of the user, the user would be highly dissatisfied. Since we determine "safety alerts" as an attractive feature that means that user is attracted to it, but perceives no value in it. This is consistent with the Kano Model's attractive attribute since the criteria have a high impact if provided and high dissatisfaction level when it does not meet the expectation. We can see the same consistency with the other attractive needs "stress advises", except for "medical assistance" where the impact of dissatisfaction is higher than the impact of satisfaction. Probably because this criterion, is more inclined towards one-dimensional, has some value to the user or simply because of the small sample space.



	Stress Advices	Safety Alerts Sleep/Drowsiness	Medical Assistance	Customer/ Planner feedback	Scheduling Proposal to Planner	Nutritive Suggestions	Exercise Coaching	Physical Activity Monitoring	Facilities along the route	Facilities along Road Conditions	Communication Family Friend
DS	-0.5	-0.66	-0.66	0	0	0	0	-0.33	-0.33	-0.66	-1
CS	0.5	0.66	0.5	0.5	0	0.25	0	0.33	0.5	0.16	0.33

DS CS

Figure 11 Satisfaction & Dissatisfaction impact

Similarly, we analyze the must-be criteria “communication with family and friends” has the highest impact on the dissatisfaction of the user (-1). This infers that if we do not provide this feature on the product or service, the overall product will not come up to the expectation of the user, an apparent cause for dissatisfaction. But interestingly, even if we do provide it with performance up to the expectation of the user, still it does not impact the satisfaction (0.33) of the user. Since we understand from the Kano model that must-be attributes are critical or necessary for the user to use the product. The absence of such need would force the user to look for an alternative. This is consistent with the other must-be attribute “road conditions along the route”.

From this analysis, we can conclude, that satisfaction and dissatisfaction coefficient for each kind of quality attribute should be perceived differently and do not hold the same meaning.

4.5.6 Determining Importance of Criteria: Product Portfolio Development

Different portfolios of the product could be developed by determining the importance of various criteria and then judging the final rank of the need based on the importance of the criteria. The following is the list criteria that influence the portfolio of the product.

- must-be needs
- one-dimensional needs
- attractive needs
- cost for implementing
- time for implementation

In the case study, only considered criteria are must-be needs, one-dimensional needs, and attractive needs. As mentioned earlier these criteria can help to build the desired portfolio of the product. For example by emphasizing more on the attractive needs we can bring new innovative features into the market that would make the product more suitable for early adopters. On the other hand, if we emphasize on one-dimensional features we have to develop a competitive product that can perform better than the rest of the products in the market. It is important to note that whether the decision makers give importance to attraction or performance for product development, mandatory needs, identified as must-be, are critical to enticing the user. Cost and time analysis of the product development is beyond the scope of this study.

Since the key decision makers are most likely to have a difference of opinion on the importance of particular criteria, a pairwise comparison can easily determine aggregated importance weight for multiple decision makers.

	Must-be	One-dimensional	Attractive	Weight (W_g)
Must-be	(1,1,1)	(1.25,1.5,1.75)	(1.25,1.75,2.25)	0.74
One-dimensional	(0.57,0.66,0.8)	(1,1,1)	(0.91,0.95,1.25)	0.14
Attractive	(0.44,0.57,0.8	(0.8,1.05,1.09)	(1,1,1)	0.12

Figure 12 Evaluated Criteria weights using FAHP

Figure 12 represents the prioritized criterion which were determined from the responses received by three decision makers and evaluation matrix (Table 10). It is evident from the results that maximum priority is provided to must-be attributes $W_m=0.74$, whereas both one-dimensional and attractive have nearly the same weights $W_o=0.14$, $W_a=0.12$.

4.5.7 User Need Prioritization

Final user needs prioritization would be determined by multiplying each criterion with the weight of the quality attribute from (Figure 13) and adding them together, using the following formula.

$$Wc_n = \left(M_{c_n} \times W_m\right) + \left(O_{c_n} \times W_o\right) + \left(A_{c_n} \times W_a\right) \quad (8)$$

Where c_n $(n = 1,2,3 \ldots \ldots \ldots n)$ *is the set of criteria's.*

Figure 13 provides us an overview of the prioritized user needs according the classification of the driver responses, using Kano model, and service portfolio defined by decision makers, determining the weights of quality attributes using FAHP. It is evident from the overview that must-be attributes still hold the most importance for the decision makers. Interestingly, we find that two of the attractive criteria's "Safety Alert" and "Medical Assistance" hold the same priority. Whereas "Stress advices" has the least attractive feature. Criteria have the same priority can further prioritize using the M>O>A>I, followed by High-low for criteria's evaluated as the same quality attribute.

C_n	Needs	Criteria Weights (Wc_n)	Criteria Evaluation (CTQ)
C11	Communication Family & Friend	0.276	Must-be high
C10	Road Conditions along the route	0.268	Must-be low
C9	Facilities along the route	0.16	One-dimensional
C3	Medical Assistance	0.095	Attractive high
C2	Safety Alerts Sleep/Drowsiness	0.095	Attractive medium
C4	Customer/Planner feedback	0.036	One-dimensional
C1	Stress Advices	0.031	Attractive low
C8	Physical Activity Monitoring	0.020	Indifferent
C6	Nutritive Suggestions	0.012	Indifferent
C7	Exercise Coaching	0	Indifferent
C5	Scheduling Proposal to Planner	0	Indifferent

Figure 13 Overview of Prioritized User Needs

4.6 Selecting the User Needs

Though, all the needs of the user studied have been prioritized, but still we need to analyze the needs base on the business objective for developing the initial MVPs. Fit to perform is a multi-stakeholder project with defined set of objectives. Hence, needs meeting the objectives of the project must be considered for the success of the project. While business objectives are important, it is equally important to observe what features could be easily developed without technical limitation such as (resource limitation and technology development). Table 13 below lists the business objective that aim at reducing the total cost of ownership (TCO). Table 14 provides an overview of the business objectives that are satisfied by the user needs. This helps finalize the selection of user needs that should be developed for the product service solution.

Table 13 Business Objectives

O_n	Business Objective
O_1	Reducing oil consumption
O_2	Reducing employee absenteeism
O_3	Reducing Wear and Tear
O_4	Reduce employee early retirement
O_5	Increase employee retention

It is quite evident for the table that "communication with family and friends" does not meet the long objectives of the project, although this needs most essential for the customer (must-be). Similarly, the features of "medical assistance" and "customer feedback" need a complex information sharing architecture that makes them impossible to render in the initial solution of fit to perform. "Safety Alerts" based on sleep and drowsiness are not technically possible yet.

Table 14 Overview User Needs and Business Objectives

C_n	Needs	Ranking/ Weights (Wc_n)	Criteria Evaluation CTQ	O_1	O_2	O_3	O_4	O_5
C11	Communication Family & Friend	0.276	Must-be high	×	×	×	×	+
C10	Road Conditions along the route	0.268	Must-be low	+	×	+	×	×
C9	Facilities along the route	0.16	One-dimensional	+	+	×	×	+
C3	Medical Assistance	0.095	Attractive high	×	+	×	+	+
C2	Safety Alerts Sleep/Drowsiness	0.095	Attractive medium	×	×	+	+	+
C4	Customer/Planner feedback	0.036	One-dimensional	+	×	×	×	+
C1	Stress Advices	0.031	Attractive low	×	+	+	+	+

Based on these factors decision was made that the initial fit to perform solution would be based on "Road Conditions along the route", "Facilities along the route" and "Stress Advices". Though, stress advice is the least attractive feature but still it would be valuable to provide it in the first solution since the algorithms are more mature compared to drowsiness and vigilance. Furthermore, this need meets most of the business objective that are critical to the success of the project as shown above in Table 14.

4.7 Limitation and Observations

Although Kano model helped us classify the needs yet it has some limitations in practice. Before respondents use e Kano model for the user study, they need to be tutored on how to perform the survey. Four results out of total ten results obtained were invalidated due to the reason that respondents did not understands how to answer the questions. Therefore for the rest of the respondents a small explanation was provided prior to the survey. Secondly the designed questionnaire, although contextually rich with the addition of picture, provided an abstract level understanding of features. Therefore, the subcategories of the broader need were not captured. Inevitably, we need to add a second tier to the abstract need, though defining questionnaire in such a manner would increase the length of the survey. Thirdly, Kano model provides most insight through discussions, for example, it came to understanding that the indifferent need "Exercise Coach" was not because that they did not like or need it, rather it was practically infeasible for them due to lack of time. With help of Kano model we can identify pre-conditions associated with the indifferent needs, resolving these pre-condition can transform the current indifferent needs to attractive in future

Similarly, evaluating the weight of different criteria, using FAHP, needs substantial mathematical background. Also creating the FAHP matrix is complex, and decision makers need prior understanding before using it.

5 System Design

Agile project dictates small iterations and rapid development of the system. In the agile faster, the system is validated with users in the real environment the better the end results would be. In this chapter, we are going to start with the prototype developed for the validating the user needs that were classified and prioritized in the previous chapter. Moreover, the aim of Fit to Perform is to provide an innovative framework where developers can provide cheap services to the truck drivers in real time, therefore this chapter provides a study of the cost model for the aimed system. The prototype development also helps we estimate the costs associated, especially the infrastructure costs for delivering such a system. Further, we would analyze different configurations of the system under development. Lastly, we design and analyze the architecture of Fit to perform multi-service provider fleet system, the open API platform.

5.1 Prototype: Design

Based on the results from the previous chapter three most needs on "Road Conditions along the route", "Facilities along the route" and "Stress Advices" were developed for the first prototype. The feature represented in Figure 14 is the bird's-eye view of a delivery route of the driver to his final destination with a prominent marker showing the "Road Condition along the route". The App requests the route information provider API (Bing maps). The API suggests three routes to the user out which he selects one. The figure below shows the selected route with the traffic, weather and parking spots along the route to the end destination on the left division of the screen. The 'User Acceptance Team' decided to provide a bird's-eye overview after analyzing the existing used system that only provide the navigational view to the truck drivers. The problem with navigational view is that it is only limited to a distance of only to five to ten kilometers ahead that makes it difficult for the driver to avoid traffic, road condition or slippery roads since that information arrives at him delayed.

The right part of the display is fixed for providing dashboard, in the current build the dashboard widgets are fixed but in future the drive can select desired features to display on the dashboard. The dashboard provides various features to the driver such as

- estimated time to complete the journey,
- remaining a time for driving according to tachograph,
- expected delay due to traffic,
- next nearest parking spot,
- and the current weather outside.

The driver can also see his live heart rate on the screen, the heart rate of the driver is received from pairing the device with the app. Apart from these there is also a division for the driving performance widgets on the bottom of the dashboard.

The second feature in Figure 15 is 'Places of interest'. Currently, there is no system in the market that provides this feature to the driver. According to our insights gained with the interviews with the truck drivers in focus groups and open interviews, they have prior knowledge of the stops along their route where they take their breaks or randomly stop at any gas station near their break time. Unlike Google maps that overlays all the places of interest as markers over the map, the 'User Acceptance Team' decided to provide a screen widget that would appear when requested, as shown in Figure 15, with details about the nearby places. The selected place would then appear as a marker on the map. The reason behind this is that overlaying all the places on the map, over crowds the map and distracts the attention of driver from the road. To deliver this feature, we use Google Places API to find nearest places of interest. The user can set place-types and preferences such as fuel stops, restaurants, truck stops and recreation places (parks). The user can also specify the maximum distance he wants to travel out his original route to the facility he wants to visit. By default, the system searches for desired places a radius of 1 KM ahead of the current location of the user. Further, the feature also provides the details on the facilities at the place of interest, with visited customer reviews.

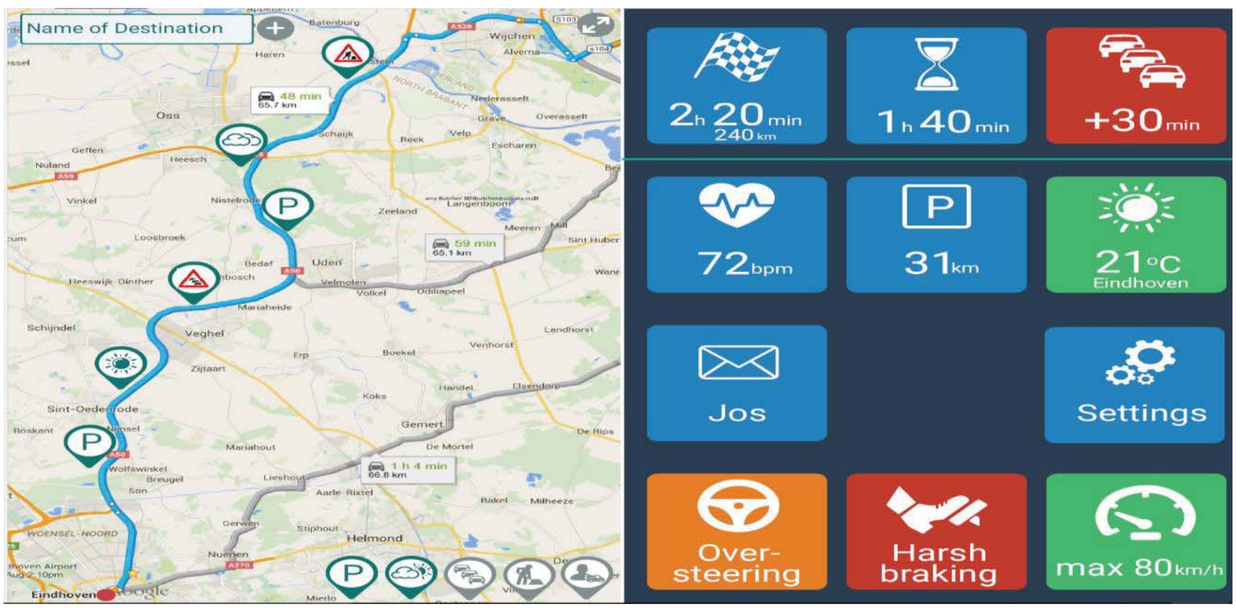


Figure 14 Feature: Dashboard with route, traffic, weather and heart rate

Figure 16 represent the most important feature from the Fit to perform perspective is 'Stress Overview'.As identified in the previous chapter that stress is an attractive feature that user has never been introduced in any context. Therefore, our main objective around this feature is to gain an initial understanding of how to represent this feature that the driver can understand and finds useful. The feature 'Stress Overview' provides the an overview of the day to the driver about weather and traffic observed along the route along with stress. The stressed duration of the driver is represented by the orange bars overlaying a continuous graph of HRT, weather and traffic.

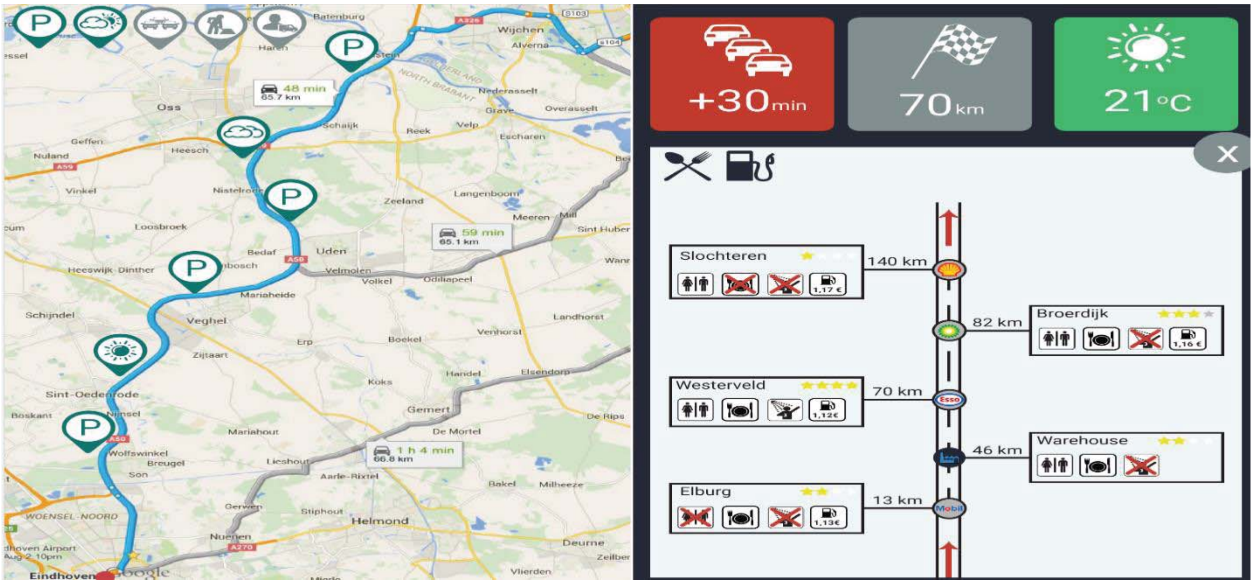


Figure 15 Feature: Places of Interest

Secondly, stress was overlaid on the map for the route the driver took for the journey. The user can use the slider that is connected to the location marker, to view the stress along the route. The overview is provided during the break times or at the end of the journey of the driver for the day. Stress is calculated by an algorithm on the mobile device; the stress algorithm is currently primitive based on average heart rate (due to the limitation of Mio wearable device).

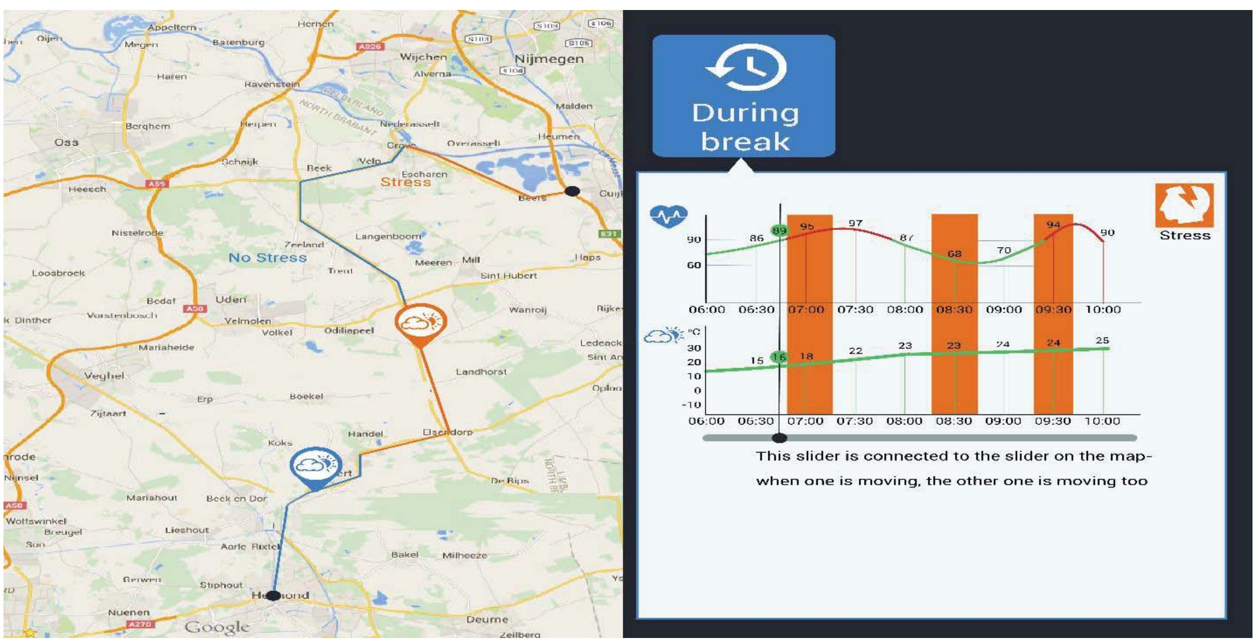


Figure 16 Feature: 'Stress Overview' of the day with HRT, traffic, and weather

The objective of the study is two folds. First we want to test the user need acceptance that we have identified in the previous chapter. Secondly we want to estimate certain parameters, such as frequency, data sizes and the number endpoints (interfaces) required to deliver the features. These parameters are later used in estimating the cost of the system.

5.2 Prototype: Testing

The system was validated with two drivers in the real-time environment on the road for a journey of 9 hours. A representative of the 'User Acceptance' team traveled with the truck driver as part of the testing. The app was installed on a 4G Nexus 9 tablet for mobile data connectivity to enable mobile network data-dependent services. Mio wearable device attached to the driver was paired with the app to record physiological sensory data to monitor the stress of the driver.

5.2.1 Technical Issues

- The system observed much connectivity issue due the missing mobile network. As a result for a fair part of the journey, most of the mobile network data dependent service became unavailable.
- The Bluetooth connectivity between the Mio wearable device and tablet was often lost. The error seemed to be due to the implementation of the Bluetooth inter-process handler. This error can be resolved by reviewing and stabilizing the implementation.

5.2.2 Feature Testing

- Our analysis for the road condition along the route, a must-be need, turned out to be true. Especially, it turned out to be useful for the driver for the part of the international part of the journey. Where current systems do not provide any traffic update.
- Weather based on current location, also a must-be feature, turned out to be false. The driver expressed "I can see the weather outside". Therefore, 'weather based on current location' is not a need for the driver. This feature should not yet be dropped since our validation tests are two small to make any final decisions. On the other hand, it would be interesting to see driver's response if the system provides weather information for location some hours ahead of him
- Places of Interest feature could not be validated due to mobile connectivity issues on roaming bandwidth. The response to the Google Place API is rather heavy for transmission over the mobile data services, especially during roaming. This issue could be resolved by pre-requesting and saving on the tablet all the places of interest before the driver starts his journey or at least before roaming network.
- Though our validation is again quite limited to make conclusions. The graphical representation of the 'Stress Overview' was obscure and useless for the driver. Whereas, overlaying it on the map turned out to be more useful for the driver as he could see his stress locations.

5.3 System Design: Cost Model

This section is answering the question *how to model costs associated in Fit to Perform System Architecture.*

5.3.1 Cost Model: Introduction

Realizing the system discussed in the previous section requires an underlying architecture. We can observe from the previous discussion that system aims at providing various contextual information, obtained from third party information providers, such as traffic, weather and places of interest, to the user in real-time. In addition to them, physiological information and vehicle information of the driver are the other contexts that the system needs to provide and maintain for the user. This mandates a study of the main influencers associated with the information flow between the various components of the system. Therefore, in this study we are going to analyze the associated costs of maintenance, storage and information interaction of the distributed system. This analysis will help us to propose an optimized architecture configuration of the system based on cost.

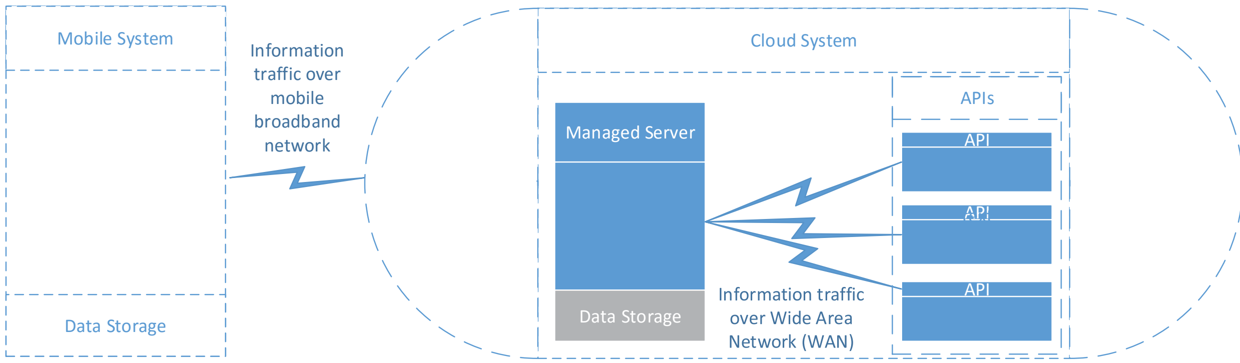


Figure 17 Cost Model: System Abstraction

At an abstract level, the main communication of the system can be assumed between the following subsystems as shown in Figure 17.

- Mobile System
- Cloud System

The communication with these two subsystems takes place over a mobile network. The mobile networks have different tariff rates depending upon the usage of the data. Since the distributed system has much information communication between the two subsystems. It is expected that the cost of data usage, if not addressed properly, could pose an impediment to the feasibility of realizing the system. Moreover, the long-haul the truck drivers often have to travel cross borders for delivery, which implies that the company would incur expensive roaming charges in providing e-services. On the other hand, if we consider a localized system for the Fit to perform solution then we run into the issues of limited storage space and reliable information. Hence determining a balanced approach between the localized mobile processing and cloud processing for the distributed system is necessary.

5.3.2 Cost Model: Scope

Various factors such as development, maintenance, and infrastructure influence the cost for realizing the Fit to Perform system. In our scope of the study, we will mainly focus on infrastructure costs of the system. The infrastructure costs mainly comprise of transport/bandwidth, system data usage, and storage. Previously, we emphasized that Fit to perform, a distributed system, needs to interact with various cloud information providers to provide e-health services in real-time. Therefore, it is expected that significant interaction between the mobile system and cloud is going to take place over the cellular network. It is important to note at this point, that the data transport services provided by different mobile vendors are usually quite expensive, especially during roaming where they go up to euro 0.20*/MB.* Additionally, monthly or yearly subscription rates also add to the cost of the system. Further, we also need to maintain a significant amount of physiological data and vehicle information on the cloud due to limited storage on the mobile device. This requires synchronizing and processing a fair amount of data on a web server. The costs of web server vary depending on whether we buy an exclusive server or rent them from cloud service, such as Amazon web service. These are all factors affecting the cost of the system. The modeling of infrastructure costs for the system will, therefore, play a significant role in providing a viable architecture that trucking companies can adopt.

Though the development cost plays an important part in realizing the system, but they are out of the scope of our study. Firstly, because the Fit to perform is still in an early prototyping phase. Thus, a proper estimation of the different component and feature development is not possible. Secondly, in the architecture development we need to focus on factors that would have a pervasive effect on the cost of the system. The development costs in this regard are one time and dealt with, whatever design decisions. Therefore, they do not help us optimize the architecture. Maintenance, on the other hand, just like infrastructure costs, is a pervasive factor influencing the system cost model. Since the designed system has to maintained and extended over the years. In this study, we restrict the maintenance to an average cost of maintaining the mobile system and management server. Since, we could not extensively estimate the cost of developing each component and feature maintenance estimates at a detailed level is also not possible.

5.3.3 Cost Model: Description and General Assumptions

The main components and the interaction (data transfer and storage) between the components representing tariff costs are depicted in Figure 18. As mentioned earlier the cost model comprises of two main components the mobile System (MBS) and cloud system (CS). In this study, we assume that the communication between the mobile system and the cloud system will always take place over a mobile network (MN). The costs modeling the mobile system are defined the in the section below (section 5.3.4). Since the costs of the mobile network due to interaction with a cloud server, therefore we refer these costs as the costs of the cloud system.

The tariff structure modeling the mobile network is discussed in section 5.3.5.1). The cloud system as shown in the above figure comprises of two main components: management server (MS) and third party application provider interfaces (APIs). It is important to note at this point, that the cloud system can exist in various configurations. For Instance, the mobile system can interact with a cloud system comprising of mainly the management server or a set of APIs (see Figure 18 for more details). The tariff modeling the interaction between the mobile system and management server over the mobile network is provided in the section 5.3.7.1. It is also possible for the management server to communicate with APIs within a cloud, this internal communication within the cloud takes place over a wide area network (WAN). The tariff structure over the WAN can be defined in multiple ways. In this study, we consider the WAN structure to be governed by the management server. The management server in our study is based on a cloud service provider, such as Amazon web service (WS). Therefore, the tariff structure of WAN based on data transfer in-out of the "management server" is also defined by the Amazon web service, for more details see section 5.3.5.2. The tariff costs between a management server and APIs are calculated in the section 5.3.7.6. It is also possible for the management server to communicate with another management server over WAN. In this study, each cloud system can consist of one "management server" as different servers in the cloud could have different tariff structure. The tariff calculation modeling such an interaction can be found in section 5.3.7.5. As shown in the figure above that the storage of data can take place at either the management server or the mobile system, as the mobile system costs are fixed. Therefore, we only define the tariff storage model for the management server (section 5.3.7.7).

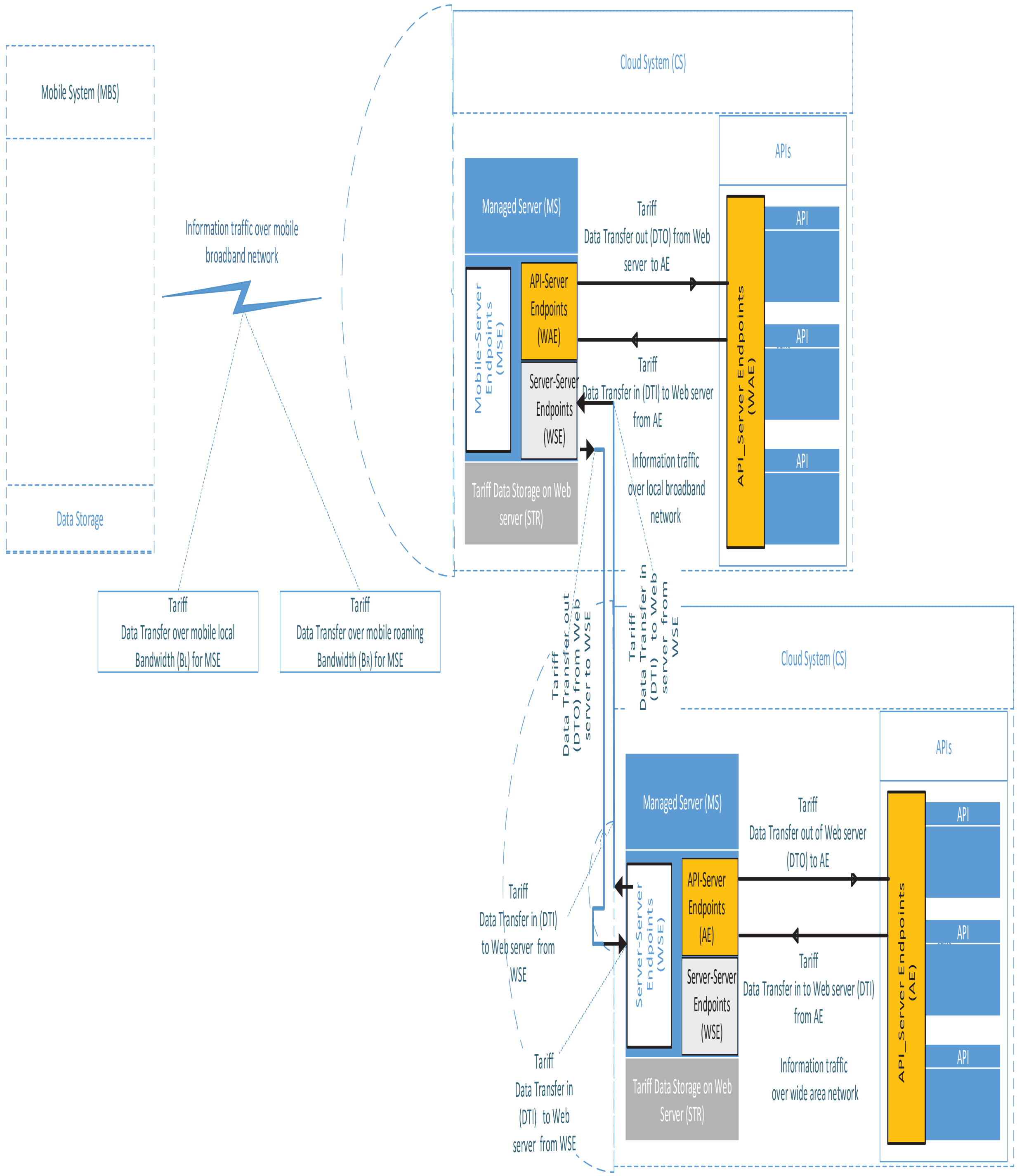


Figure 18 Detail System Cost Model

The data traffic transferred or saved between different components determines the information traffic of the cost model. In reality, the amount of data transfer depend upon request and response data size of each interface of various components, therefore in this study we define these interfaces as endpoints. Section 5.3.5.4 model in details the structure of information traffic of endpoints.

5.3.4 Cost Model Specification: Mobile System

The main costs associated with the mobile system are as follows: The mobile application development cost, maintenance cost, and the storage cost. The Fit to perform project is still in prototyping phase hence a proper estimation of the development cost of various functionalities could not be assessed. Therefore, we will disregard this parameter. The following parameters model the mobile costs of mobile system(MBS).

$M_{MBS} = Mantinance\ cost\ for\ the\ mobile\ application$

STR_{MBS} =*Storage cost on the mobile device*

$ST_{MBS} = Storage\ size\ in\ MB$

Mobile devices have limited storage. Therefore, parameter $App_{storage}$ has a fixed cost and has a maximum limit, usually a mobile device can support up to 64GB or 128GB. In addition, not all storage space can be utilized by Fit to perform solution since many internal process and other, application are also executing on the same device. Further, if we consider the frequency with which we obtain data from sensors (i.e. assuming its 10KB/sec), the physiological and vehicle sensors, will fill up the mobile storage space in a matter of six months. This poses a serious limitation to the extent we can localize the system on the mobile device. To overcome this situation we can discard all the obtained regarding physiological, driving, and external context data. This strategy is ill wised for Fit to perform solution as the main objective is to coach the driver and improve the driver health and driving performance, based on registered experience over the time. Therefore, it is necessary to synchronize the data frequently to a cloud server.

Further, the limited storage on the mobile device also influences both the qualitative and quantitative data regarding the physiological status of the driver. The physiological information recorded such as heart rate, temperature, and skin conductance are registered with one-hertz frequency. Maintaining such physiological information with high frequency would be impossible, over months, on the mobile device. On the same note, even synchronizing such amount of data with a server over a mobile network would incur considerable costs. Especially over the roaming bandwidth of mobile network where the charges can go up to € 0.20/Megabyte(MB). On the other hand, losing this information is also not feasible. Therefore, we need to balance the physiological information to an extent where it does not lose its meaning and storing it on a cloud system does not incur an enormous cost. Hence, in our study the total cost of the mobile system is based on fixed maintenance cost:

$$C_{MBS} = M_{MBS} \tag{9}$$

5.3.5 Cost Model Specification: Tariff Structure for Information Traffic

One of the major influencers of costs in Fit to perform solution is due to the different tariff rates incurred over the mobile network and local broadband. The mobile tariff rates are quite expensive, especially roaming charges, compared to a wide area network.

5.3.5.1 Mobile Network Tariff

In this study, tariff structures are based on the mobile network. The following parameter defines the mobile tariff.

$$S_{mobileTariff} = Subscription\ fixed\ cost\ of\ mobile\ data\ package\ per\ month$$

The mobile tariff rates are different for local bandwidth (B_L) and roaming bandwidth (B_R) . Mobile vendors charge differently based on the bandwidth type.

$$P_{B_L} = tariff\ \ over\ the\ local\ bandwidth\ per\ day.$$

$$P_{B_R} = tariff\ rate\ over\ the\ roaming\ bandwidth\ per\ day.$$

$$DL_{B_R} = data\ limit\ (mb) available\ per\ day\ with\ tariff\ rate\ P_{B_R}.$$

Whereas if we exceed the data limit (for roaming) per extra roaming charges incur

$$PE_{B_R} = tariff\ rate\ per\ (mb)\ of extra\ data\ usage$$

5.3.5.2 Wide Area Network Tariff: Web Server

The Wide Area Network tariff costs incurred for the interaction of sub-systems within a cloud. For instance, if the third party API's communicate with a cloud-based system such as managed server or when two or more servers communicate within the cloud. Since the managed server is hosted in the cloud. Therefore, the cost structure for interaction over wide area network is based on Amazon web services. The following parameters determine the wide area network tariff for a *Web Server* (WS).

$$S_{CS_{WS}} = Subscription\ cost\ of\ a\ Web\ Server\ per\ month.$$

$$P_{CS_{WS_{DTI}}} = fixed\ tariff\ for\ data\ transfer\ into\ the\ server\ \ per\ mb\ .$$

$$P_{CS_{WS_{DTO}}} = fixed\ tariff\ for\ data\ transfer\ out\ of\ the\ server\ per\ mb$$

$$DL_{CS_{WS_{DTO}}} = data\ limit\ in\ (mb) available\ per\ month\ with\ \ tariff\ rate\ P_{WS_{DTO}}$$

Whereas if we exceed the data usage limit DL_{WS} for data transfer out of server in a month then:

$$PE_{CS_{WS_{DTO}}} = tariff\ \ for\ extra\ data\ usage\ \ per\ (MB)$$

Note that this cost would also be incurred as an additional cost when the managed server communicates over the mobile network.

5.3.5.3 Tariff Structure for Information Storage

We have already discussed in the previous section that a few services in Fit to perform solution can rely on prehistoric data. Therefore, we need to store certain amounts of data on the cloud. Similar to wide area network tariff we use Amazon web service storage model.

$$P_{CS_{WS_{STR}}} = \ tariff\ for\ data\ storage\ on\ server\ \ per\ mb.$$

$$DL_{CS_{WS_{STR}}} = data\ limit\ in\ (mb) available\ per\ month\ with\ fixed\ tariff\ rate\ P_{WS_{STR}}$$

Whereas if we exceed the data storage limit $DL_{WS_{STR}}$ in a month then:

$$PE_{CS_{WS_{STR}}} = \ tariff\ for\ extra\ data\ usage\ data\ usage\ per\ (MB)$$

5.3.5.4 Structure for Information Traffic: Endpoint

The information traffic in the Fit to perform solution can occur over both mobile network and wide area network. The information traffic tariff depends on the duration and the frequency of information communication between different components.

$$E_n \; = Endpoint\ defining\ a\ logical\ information\ communication$$
$$component\ (interface)\ n = (1,2,3, \dots, \infty).$$
$$U_{CS_{E_n}} \; = Upload\ data\ size\ of\ a\ request\ for\ a\ particular\ endpoint\ (MB).$$
$$D_{CS_{E_n}} \; = Download\ data\ size\ of\ a\ response\ for\ a\ particular\ endpoint\ (MB).$$
$$F_{CS_{E_n}} \; = Number\ of\ calls\ per\ minute\ to\ the\ endpoint.$$

Let us assume a truck TR, a company can have $TR = 1,2,3, \dots, X$ number of trucks.If we define TR_d as the trip of the truck for a particular day $d = 1,2,3, \dots, dy$ then Dur_{TR_d}refers to the total duration (in minutes) of the trip on day *d,* where dy is either 30 or 31.

5.3.5.4.1 Data traffic over mobile network

The data traffic on a mobile network, as mentioned above, depends on whether the data traffic occurs over the local bandwidth or roaming bandwidth. Since both bandwidths have different cost of usage, therefore, in our study, we are going estimate them separately.

If, $RDur_{TR_d}$ refers to the duration of trip spent under roaming then:

$$TLCall_{CS_{E_n}} \; = F_{E_n} \times \left(Dur_{TR_d} - RDur_{TR_d}\right), \qquad (10)$$

$$equation\ (10)\ determines\ the\ total\ number\ of\ calls\ per\ day\ on\ a\ mobile\ network\ with$$
$$bandwidth\ B_L\ for\ a\ particular\ endpoint.$$

$$TRCall_{CS_{E_n}} = F_{E_n} \times \ RDur_{TR_d}, \qquad (11)$$

$$equation\ (11)\ determines\ the\ total\ number\ of\ calls\ per\ day\ on\ a\ mobile\ network\ with$$
$$bandwidth\ B_R$$

$$TLD_{TR_d} = \sum_{n=1}^{E_n} \left(D_{CS_{E_n}} \times \ TLCall_{CS_{E_n}}\right)\ , \qquad (12)$$

$$equation\ (12)\ determines\ total\ upload\ data\ \ over\ local\ mobile\ network\ for\ all\ requests$$
$$of\ all\ API\ endpoints\ per\ day$$

$$TRD_{TR_d} = \sum_{n=1}^{E_n} \left(D_{CS_{E_n}} \times \ TRCall_{CS_{E_n}}\right)\ , \qquad (13)$$

$$equation\ (13) determines\ total\ upload\ data\ \ over\ roaming\ mobile\ network$$
$$for\ all\ requests\ of\ all\ API\ endpoints\ per\ day$$

$$TLU_{TR_d} = \sum_{n=1}^{E_n} U_{CS_{E_n}} \times \ \ TLCall_{CS_{E_n}}\,, \qquad (14)$$

$$equation\ (14)\ determines\ total\ upload\ data\ \ over\ local\ mobile\ network$$

$for\ all\ requests\ of\ all\ API\ endpoints\ per\ day$

$$TRU_{TR_d} = \sum_{n=1}^{E_n} U_{CS_{E_n}} \times \ TRCall_{CS_{E_n}}, \tag{15}$$

$equation\ (15)\ determines\ total\ upload\ data\ \ over\ roaming\ mobile\ network$

$for\ all\ requests\ of\ all\ API\ endpoints\ per\ day$

5.3.5.4.2 Data traffic over wide area network: web server

Similarly, we need to evaluate the data usage of each endpoint over the wide area network

$$TCall_{CS_{E_n}} = F_{CS_{E_n}} \times \ Dur_{TR_d}, \tag{16}$$

$equation\ (16)\ determines\ the\ total\ number\ of\ calls\ per\ day\ on\ a\ local\ broadband\ network$

$for\ a\ particular\ endpoint.$

$$TD_{TR_d} = \sum_{n=1}^{E_n} D_{CS_{E_n}} \times \ TCall_{CS_{E_n}}, \tag{17}$$

$equation\ (17)\ determines\ total\ download\ data\ for\ all\ responses\ of\ all\ \ endpoints\ per\ day$

$$TU_{TR_d} = \sum_{n=1}^{E_n} U_{CS_{E_n}} \times \ TCall_{CS_{E_n}}, \tag{18}$$

$equation\ (18)\ determines\ total\ upload\ data\ for\ all\ requests\ of\ all\ endpoints\ per\ day$.

5.3.6 Cost Model Specification: Cloud System

The cloud system (CS) interacting with the mobile system is divided into two subsystem.

- Third Party Information Provider or APIs such as Bing, OpenWeather, and Google.
- Managed Server.

We consider that different configuration and information flow between these sub-systems, of cloud ($CS = 1,2,3 \dots Z$), and the mobile system can bring immense variation to the overall cost incurred. Therefore, we need to investigate the parameters that govern both of these sub-systems.

5.3.6.1 Management Server

The management server is a typical web server or content management server hosted in the cloud. Since we have already analyzed that limited data storage space on the mobile device requires web server storage for later use. In addition to storage, the management server can act as a middle layer for information providers.

In this study, we assume that the management server is hosted on a cloud web service provider such as Amazon web service. Therefore, our cost model for the management server would be dependent on Amazon. In addition to data traffic, storage and subscription, one important aspect governing the management server (MS) cost is maintenance, though development is also important in this case but we will not consider in this study primarily because of the early stage of Fit to perform project, these estimations are impossible.

$$M_{CS_{MS}} = maintenance\ cost\ of\ Web\ server$$

Similarly, the information traffic cost with the management server depends upon the whether the interaction with various server interfaces happens over the mobile network or the wide area network. Contrary to API, the management server can hold interaction over mobile network and wide area network at the same time. Therefore, we need to differentiate the endpoints for each type network

$$MSE_{CS_n} = Endpoint\ defining\ a\ logical\ information\ communication\ component\ (interface) of\ a\ Web\ Server\ where\ n = (1,2,3, \dots, \infty)\ over\ mobile\ network.$$

$$WSE_{CS_n} = Endpoint\ defining\ a\ logical\ information\ communication\ component\ (interface) of\ a\ Web\ Server\ where\ n = (1,2,3, \dots, \infty)\ over\ wide\ area\ network.$$

5.3.6.2 Third Party Information Provider (APIs)

The third party API's provide different information such as context, traffic, weather, and places necessary for the provision of services in the Fit to perform solution. These API's expose a various interface for interaction with different clients. Since the API development and maintenance is not under our control, therefore we do not take this cost into consideration. Whereas, consumption of these API's requires an annual or monthly subscription fee. Apart from the subscription fee the other major cost factor influencing the Fit to perform architecture in this perspective is the request and response data size of each interface.

The following parameters define the APIs' cost structure.

let

$$S_{API} = Subscription\ cost\ of\ all\ API\ per\ month.$$

$$AE_{CS_n} = Endpoint\ defining\ a\ logical\ information\ communication\ component\ (interface) of\ all\ APs\ overmobile\ network\ where\ n = (1,2,3, \dots, \infty).$$

$$WAE_{CS_n} = Endpoint\ defining\ a\ logical\ information\ communication\ component\ (interface) of\ all\ APIs\ over\ wireless\ network\ where\ n = (1,2,3, \dots, \infty).$$

Then the information traffic cost with the APIs depends upon the whether the interaction with various interfaces happens over the mobile network or the local broadband, therefore,

5.3.7 Cost Model Specification: Data Traffic and Storage

In this section, we are going to investigate the cost of data traffic and storage for the interaction of subsystem of the Fit to perform.

5.3.7.1 Data traffic cost over mobile network: mobile system to management server

As shown in Figure 18 the management server communicates with the mobile system. In this case the data usage between the two systems is determined by the MSE_n endpoints

Therefore,

$$E_{CS_n} = MSE_{CS_n}$$

Hence using the equations (10)-(15) we can calculate the information traffic for communication with endpoints defined for the server over a mobile network.

$$C_{MS_{B_L}} = P_{B_L} \times \left(TLD_{TR_{d_{CS}}} + TLU_{TR_{d_{CS}}} \right), \tag{19}$$

equation (19) *determines the cost for communicating with a web server over local bandwidth on a mobile network.*

$$C_{MS_{B_R}} = \begin{cases} P_{B_R} & \left(\sum_{CS=1}^{Z} \left(TRD_{TR_{d_{CS}}} + TRU_{TR_{d_{CS}}} \right) \right) \leq DL_{B_R} \\ PE_{B_R} & \left(\sum_{CS=1}^{Z} \left(TRD_{TR_{d_{CS}}} + TRU_{TR_{d_{CS}}} \right) \right) > DL_{B_R} \end{cases}, \tag{20}$$

the cost of communication with the web server over roaming bandwidth is defined by the function (20) *and can be calculated using the equation* (21).

$$C_{MS_{B_R}} = P_{B_R} + \left[PE_{B_R} \times \frac{1}{2} \left[\begin{array}{c} \left(\left| \sum_{CS=1}^{Z} \left(TRD_{TR_{d_{CS}}} + TRU_{TR_{d_{CS}}} \right) - DL_{B_R} \right| \right) \\ - \left(DL_{B_R} - \left(\sum_{CS=1}^{Z} \left(TRD_{TR_{d_{CS}}} + TRU_{TR_{d_{CS}}} \right) - DL_{B_R} \right) \right) \end{array} \right] \right] \tag{21}$$

The total cost of communication over a mobile network (MN), for a month of (dy) days, is the sum of local and roaming bandwidths equation (22).

$$C_{MS_{MN}} = \sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(C_{MS_{B_L}} + C_{MS_{B_R}} \right) \tag{22}$$

5.3.7.2 Data traffic cost over mobile network: mobile system to API

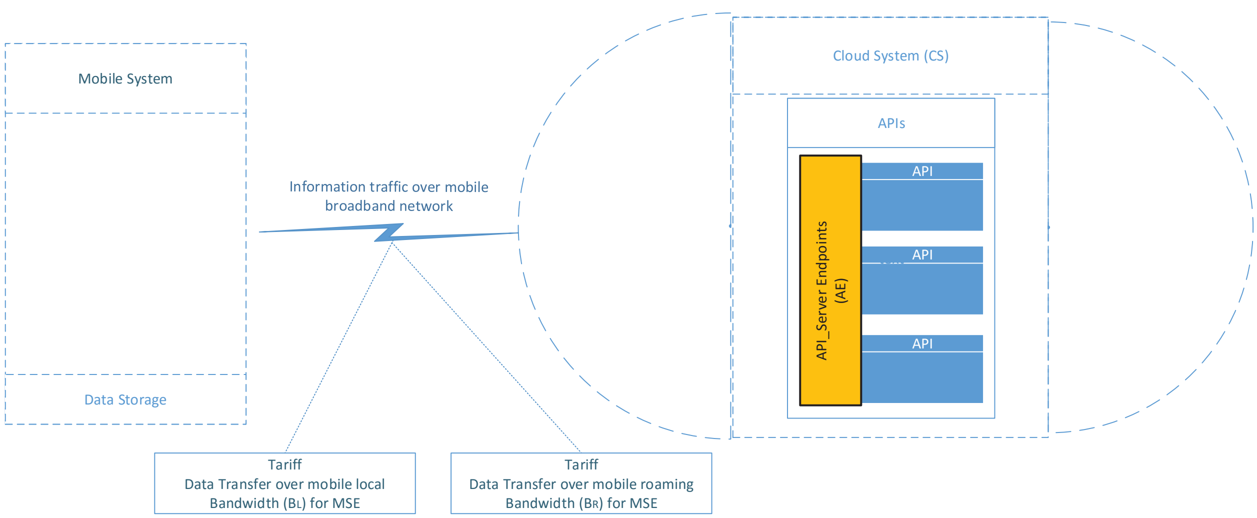


Figure 19 Interaction between Mobile System and APIs

The Figure 19 Interaction between Mobile System and APIs represent the possible configuration where the mobile system can communicate directly with APIs without any middleware. Hence using the equations (10)-(15) we can calculate the information traffic for communication with endpoints defined for the APIs' over the mobile network.

$$E_{CS_n} = AE_{CS_n}$$

The cost of communication with the APIs over a local bandwidth of a mobile network $\left(C_{API_{B_L}}\right)$ can be calculated using equation (19) defined above i.e. sum of total download and upload of all endpoints of API in all cloud systems. Whereas, the cost of communication over roaming bandwidth over a mobile network $\left(C_{API_{B_R}}\right)$ is estimated using the function (20) and equation (21)

Hence, the total cost of mobile system communicating directly with an APIs is as follows.

$$C_{API_{MN}} = \sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(C_{API_{B_L}} + C_{API_{B_R}}\right) \tag{23}$$

5.3.7.3 Data traffic cost over mobile network: mobile system to server and API

Additionally, it is also possible that both management server and the API communicate directly with the mobile system over the mobile network. In such a case we need to calculate the data traffic for both MSE_{CS_n} and AE_{CS_n}collectively. Therefore the endpoint E_{CS_n} is as follows.

$$E_{CS_n} = MSE_{CS_n} \wedge AE_{CS_n}$$

Similarly, cost of communication with the APIs and management server over a local bandwidth of a mobile network $\left(C_{MS\_API_{B_L}}\right)$ can be calculated using equation (19) defined above i.e. sum of total download and upload of all endpoints of APIs and management server in all cloud systems. Whereas, the cost of communication over roaming bandwidth over a mobile network $\left(C_{MS\_API_{B_R}}\right)$ is estimated using the function (20) and equation (21)

Hence, the total cost of mobile system communicating directly with an APIs is as follows.

$$C_{MS\_API_{MN}} = \sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(C_{MS\_API_{B_L}} + C_{MS\_API_{B_R}}\right) \tag{24}$$

5.3.7.4 Data traffic cost over wide area network: mobile system to server

If a server communicates with a mobiles system then the data traffic cost going in and out of the server, which we also refer to wide area network, needs to be calculated. Equations (16)-(18), calculates data traffic on endpoints.

$$E_{CS_n} = MSE_{CS_n}$$

$$CE_{MS_{WS_{DTI}}} = P_{CS_{WS\ DTI}} \times \left(\sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TU_{TR_{d_{CS}}}\right) \right) \tag{25}$$

equation (25) *describes the cost of data transfer into the server over a wide area network*

$$CE_{MS_{WS_{DTO}}} = P_{CS_{WS_{DTO}}} \times DL_{CS_{WS_{DTO}}} + \left[PE_{CS_{WS_{DTO}}} \times \frac{1}{2} \left[\begin{array}{c} \left(\left| \sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TD_{TR_{d_{CS}}}\right) - DL_{CS_{WS_{DTO}}} \right| \right) \\ - \left(DL_{CS_{WS_{DTO}}} - \sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TD_{TR_{d_{CS}}}\right) \right) \end{array} \right] \right] \tag{26}$$

equation (26) *describes the cost of data transfer out of the server over the local broadband network.*

5.3.7.5 Data traffic over wide area network: server to server

If the management server A interacts with endpoints of management server B, then data traffic going in and out of A due to be endpoints of B should also be calculated as shown in Figure 18. Equations (16)-(18) calculates amount of data traffic on endpoints

$$E_n = WSE_n$$

Using the following formula's we can calculate the tariff associated with the management server.

$$CW_{MS_{WS_{DTI}}} = P_{WS_{DTI}} \times \left(\sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TD_{TR_{d_{CS}}} \right) \right), \tag{27}$$

the equation (27) *provides the cost of data transfer into the server over a wide area network*

$$CW_{MS_{WS_{DTO}}} = \begin{cases} P_{CS_{WS_{DTO}}} & \left(\sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TU_{TR_{d_{CS}}} \right) \right) \le DL_{CS_{WS_{DTO}}} \\ PE_{CS_{WS_{DTO}}} & \left(\sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TU_{TR_{d_{CS}}} \right) \right) > DL_{CS_{WS_{DTO}}} \end{cases}, \tag{28}$$

the cost of data transfer out of the server to the web server is defined by the function (28) *and can calculated using the following formula* (29).

$$CW_{MS_{WS_{DTO}}} = P_{WS_{DTO}} \times DL_{CS_{WS_{DTO}}} + \left[PE_{WS_{DTO}} \times \frac{1}{2} \left[\begin{array}{l} \left(\left| \sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TU_{TR_{d_{CS}}} \right) - DL_{CS_{WS_{DTO}}} \right| \right) \\ - \left(DL_{CS_{WS_{DTO}}} - \sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TU_{TR_{d_{CS}}} \right) \right) \end{array} \right] \right] \tag{29}$$

The total cost of communication with the web server is the sum of costs of data transfer in and out of the over wide area network (WAN) represented by equation (30). *Management server communication with a mobile system or another server.*

$$C_{MS_{WAN}} = \sum_{CS=1}^{Z} CW_{MS_{WS_{DTO_{CS}}}} + CW_{MS_{WS_{DTI_{CS}}}} + CE_{MS_{WS_{DTO_{CS}}}} + CE_{MS_{WS_{DTI_{CS}}}} \tag{30}$$

5.3.7.6 Data traffic cost over wide area network: management server to API

In the previous section, we discussed the costs of a management server interaction over a mobile network with a mobile system and wide area network with another management server. As shown in Figure 18, it is also possible for a management server to communicate with APIs over a wide area network. Using equations (16)-(18) we can calculate the information traffic for communication with endpoints defined for the API over wide area network.

$$E_n = WAE_n$$

Using the following formula's we can calculate the tariff associated with APIs.

$$CW_{MS_{WS_{DTI}}} = P_{WS_{DTI}} \times \left(\sum_{TR=1}^{X} \sum_{d=1}^{dy} \left(TD_{TR_{d_{CS}}} \right) \right), \tag{31}$$

equation (31) *provides the cost of data transfers into the server from the API over a wide area network*

$$CW_{API_{WS_{DTO}}} = \begin{cases} P_{CS_{WS_{DTO}}} & \left(\sum_{TR=1}^{X}\sum_{d=1}^{dy}\left(TU_{TR_{d_{CS}}}\right)\right) \leq DL_{CS_{WS_{DTO}}} \\ PE_{CS_{WS_{DTO}}} & \left(\sum_{TR=1}^{X}\sum_{d=1}^{dy}\left(TU_{TR_{d_{CS}}}\right)\right) > DL_{CS_{WS_{DTO}}} \end{cases}, \quad (32)$$

the cost of data transfer out of the server to API is defined by the function (32) *and can be calcula using the formula* (33)*.*

$$CW_{API_{WS_{DTO}}} = P_{WS_{DTO}} \times DL_{CS_{WS_{STR}}} + \left[PE_{WS_{DTO}} \times \frac{1}{2}\left[\begin{matrix}\left(\left|\sum_{TR=1}^{X}\sum_{d=1}^{dy}\left(TU_{TR_{d_{CS}}}\right) - DL_{CS_{WS_{DTO}}}\right|\right) \\ -\left(DL_{CS_{WS_{DTO}}} - \sum_{TR=1}^{X}\sum_{d=1}^{dy}\left(TU_{TR_{d_{CS}}}\right)\right)\end{matrix}\right]\right] \quad (33)$$

Total cost of communication with the APIs is the sum of cost of data transferred in and out of management server and APIs interaction over wide area network (WAN) provided in equation (34)

$$C_{API_{WAN}} = \sum_{CS=1}^{Z} CW_{API_{WS_{DTO_{CS}}}} + CW_{API_{WS_{DTI_{CS}}}} \quad (34)$$

5.3.7.7 Data storage on management server

Above we already discussed the limitation of the mobile system to maintain data that needed to provide service to the drivers. Therefore, we need to manage the data in the cloud system. Since the amount of data we want to store depends on how much data we want to store from various sources, like mobile, API and other management server, over mobile and wide area network. Therefore, for ease of study we will only store data that would be sent or received over mobile network i.e. interaction between mobile system. Further, currently we do not need to store any information other than that is processed by the services or for the services. $E_{CS_n} = MSE_{CS_n}$

In future, it might be that we want to store more external information to provide more or better services. In that case, we can also include APIs endpoints. Hence using the equations (10)-(15) we can calculate the information traffic for communication with endpoints defined for the server over a mobile network.

$$C_{MS_{WS_{STR}}} = \begin{cases} P_{CS_{WS_{STR}}} & \left(TU_{TR_d} + TD_{TR_d}\right) \leq DL_{CS_{WS_{STR}}} \\ PE_{CS\,WS_{STR}} & \left(TU_{TR_d} + TD_{TR_d}\right) > DL_{CS_{WS_{STR}}} \end{cases}, \quad (35)$$

the cost of data transfer out of the server to the web server is defined by the function (35) *and can calculated using the following formula*(36)*.*

$$C_{MS_{WS_{STR}}} = P_{MS_{STR}} \times DL_{CS_{WS_{STR}}} + \left[PE_{WS_{STR}} \times \frac{1}{2}\left[\begin{matrix}\left(\sum_{TR=1}^{X}\sum_{d=1}^{dy}\left(TU_{TR_{d_{CS}}} + TD_{TR_{d_{CS}}}\right) - DL_{CS_{WS_{STR}}}\right) \\ -\left(DL_{CS_{WS_{STR}}} - \sum_{TR=1}^{X}\sum_{d=1}^{dy}\left(TU_{TR_{d_{CS}}} + TD_{TR_{d_{CS}}}\right)\right)\end{matrix}\right]\right] \quad (36)$$

$$C_{MS_{STR}} = \sum_{CS=1}^{Z} C_{MS_{WS_{STR_{CS}}}} \quad (37)$$

5.3.8 Cost Model Specification: Overall Costs

Overall system cost depends on the system data traffic over the mobile network(C_{MN}), wide area network (C_{WAN}) and data storage (C_{STR}) on the management server. Since, data traffic varies upon the frequency and amount of data transferred over the two networks, therefore these costs are also variable. As we have identified we have identified numerous interaction over the mobile network. Therefore we assume that the communication cost over the mobile network for a system could either be with APIs or "management server "or both.

$$C_{MN} = C_{MS_{MN}} \vee C_{API_{MN}} \vee C_{MS\_API_{MN}} \quad (38)$$

Whereas, the total cost over wide area network is as follows

$$C_{WAN} = C_{MS_{WAN}} + C_{API_{WAN}} \quad (39)$$

The storage cost is incurred only over the management server

$$C_{STR} = C_{MS_{STR}} \quad (40)$$

Hence the variable cost of the system($C_{Variable}$) ,

$$C_{Variable} = C_{MN} + C_{WAN} + C_{STR} \quad (41)$$

There is also some additional cost associated with the system such as the mobile system maintenance and storage, mobile network subscription, management server subscription, and APIs subscription. Hence the extra costs (C_{Extra}) for an $month\ m = 1$ are estimated as follows.

$$C_{Extra} = \sum_{TR=1}^{X} STR_{MBS} + \sum_{month=1}^{m} (\sum_{TR=1}^{X} (S_{mobiletariff}) + \sum_{CS=1}^{m} (M_{MS_{CS}} + S_{WS_{CS}} + S_{API_{CS}}) + \boldsymbol{C_{MBS}}) \ where\ month = 1,2,3 \ldots .m. \quad (42)$$

The total cost of the system thus is the sum of fixed and variable cost

$$C_{Total} = C_{Extra} + C_{Variable}$$

5.4 System Design: Configuration Cost Analysis

In this section, we are going to analyze the system costs that can be expected by a trucking company. System costs need to be analyzed with different system configurations. In this study, we will limit our investigation to two possible configurations: Configuration A and Configuration B (as shown in Figure 20 and Figure 21). Our primary objective in this study is to see how infrastructure costs and maintenance vary in above mentioned possible configuration. This study would help us optimize the distributed system architecture over the mobile and wide area network.

5.4.1 Configuration: General Description

In this analysis, we apply realistic estimation based on a prototype, discussed in section 0, for the cost elements in the cost model described above. The analysis is based on five endpoints from three different APIs (see Figure 20 and Figure 21 for more details) that either communicate over a mobile network or a wide area network. The mobile networks tariff is based on data services provided by mobile vendors in Netherland since most vendors have similar pricing and structure. Accordingly to our prior discussion on the wide area network and storage tariffs are based on the Amazon web service. The infrastructure cost for both shall remain constant in our analysis. Table 15 provides details on the estimate for different tariff elements that remain constant in our analysis.

A typical trucking company has a fleet of on average 150 trucks in total out of which almost 75 truck are on road, hence X =75. According to the truck driving legislation the driver can at max travel nine hours a day. Therefore, in this analysis the $Dur_{TR_d} = 540\ min$ and since we are analyzing the long- haul drivers in our study, that implies they have to deliver cross-border we assume that they six hours of driving in roaming therefore, $RDur_{TR_d} = 360\ min$.

The maintenance cost of the management server and the mobile system depends on the configuration of the architecture of the system and, therefore, discussed in the individual system configuration.

In our system, we use three APIs. The third party APIs have different subscription plans that are dependent on the number of calls made to the API in a day or month. However, in our case due to student package we get an unlimited number of calls. Therefore, we assume that all three APIs provide an unlimited number of requests for €1000.

Table 15 Tariff Rate

Component	Element Name	Values
Information Storage Tariff	$P_{CSWS_{STR}}$	€3×10^{-5}
	$DL_{CSWS_{STR}}$	$1 \times 10^{6}\ MB$
	$PE_{CSWS_{STR}}$	€ 2.95×10^{-5}
Wide Area Network Tariff	$P_{CSWS_{DTI}}$	€ 0
	$P_{CSWS_{DTO}}$	€ 9×10^{-5}
	$DL_{CSWS_{DTO}}$	$1 \times 10^{7}\ MB$
	$PE_{CSWS_{DTO}}$	€ 8.5×10^{-5}
Mobile Network Tariff	$S_{mobiletariff}$	€ 3.75
	P_{B_L}	€ 0
	P_{B_R}	€ 1.8
	DL_{B_R}	35 MB
	PE_{B_R}	€ 0.20/MB
Mobile System	STR_{MBS}	€65
	ST_{MBS}	128000 MB
APIs	S_{API}	€1000

5.4.2 Configuration: System A

The “Figure 20 Configuration: System A” demonstrates a possible configuration of the system. The System A comprises of two cloud systems according to the model we specified above. The cloud system comprising only the API endpoints communicates directly with the mobile system. The data request and response data size for each individual endpoints $AE_{1_{1,\ldots,5}}$ are provided in the Figure 20. Prior, we established that limitation of storage space on the mobile deivce needs to be resolved using a management server. This is represented in System A by the second cloud system which only contains a mangement server. The management server exposed the endpoint MSE_{2_1}which is primarily used for synchronizing the data. We can realize from “System A” that most of the processing in this configuration would only be possible on the mobile system. As there is no middle layer between the API and the mobile system. It is also important to note that the mobile system apart from the external information from APIs is also responsible for the processing the physiological and vehicle information.

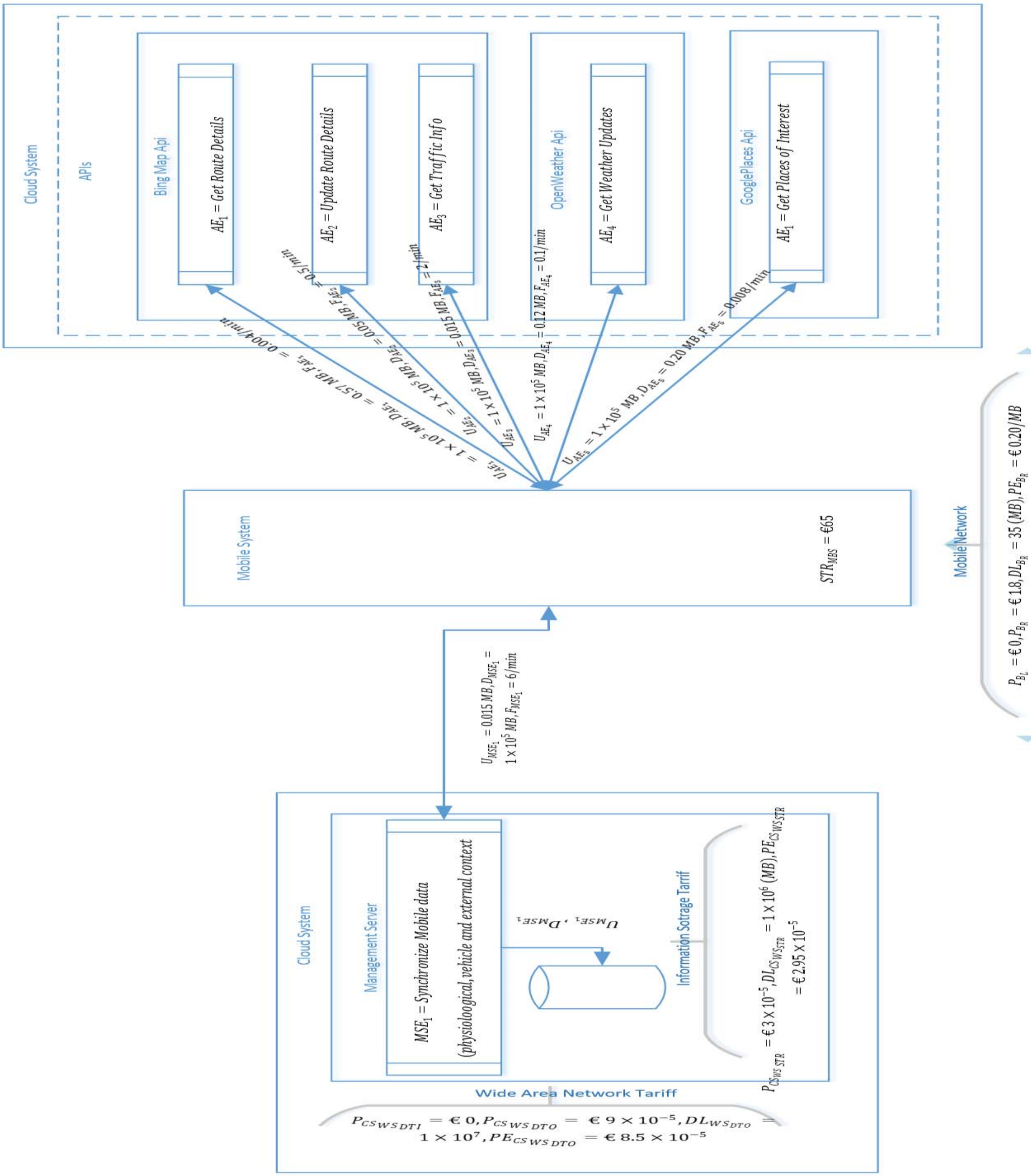


Figure 20 Configuration: System A

Therefore under this configuration it is expected that the maintenance of the mobile system would be substantially high, based on some web analysis on the average monthly maintenance of a high-end medium enterprise mobile application costs about €1000-€4500. Since the in this configuration nearly all the processing is taking place on the mobile therefore $M_{MBS} = €4500$. Management server , based on Amazon web service, on the other hand it is processing minimum information therefore maintenance of the server, on average for medium enterprise server €500-€2500[18], is also substantially low $M_{MS} = €500$. Other than maintenace the Management Server also needs to be subscribed, typically two basic Amazon server cost around €700 but since we only need minimum processing on the server one would be enough. Hence, $S_{CS_{WS}} = €350$. The information data traffic of the configuration System A are estimated in the Table 16 below.

Table 16 Configuration: System A Data Traffic

CS	***E***	***N***	TLD_{TR_d} ***(MB)***	TRD_{TR_d} ***(MB)***	TLU_{TR_d} ***(MB)***	TRU_{TR_d} ***(MB)***	TD_{TR_d} ***(MB)***	TU_{TR_d} ***(MB)***
1	AE	5	8.66	32.07	0.003	0.01	40.63	0.013
2	MSE	1	7.4×10^{-3}	0.0264	11.2	37.4	0.032	48.6

The system A depicts that both the management server and APIs communicate with the mobile system over the mobile network. Therefore, the information data traffic cost over mobile network $\boldsymbol{C_{MN} = C_{MS\_API_{MN}}}$. The Table 17 below elicits the estimated costs associated with the System A.

Table 17 Configuration: System A Total Cost

$C_{MS_{MN}}$ ***(€)***	$C_{API_{MN}}$ ***(€)***	$C_{MS\_API_{MN}}$ ***(€)***	C_{MN} ***(€)***	$C_{MS_{WAN}}$ ***(€)***	$C_{API_{WAN}}$ ***(€)***	C_{WAN} ***(€)***	C_{STR} ***(€)***	$C_{Variable}$ ***(€)***	C_{Extra} ***(€)***	C_{Total} ***(€)***
0	0	22,278	22,278	0.006	0	0.006	3.28	22,281	13,456	35,737

5.4.3 Configuration: System B

The "Figure 21 Configuration: System B" demonstrates the second configuration of the system. The System B comprises of a single cloud systems according to the model we specified. The cloud system comprises of both management server and the APIs. The management server interacts with the mobile system over the mobile network. Whereas, the API interact with the management server over the wide area network. The data request and response data size for each individual endpoints $MSE_{1_{1,\ldots,6}}$ and $WAE_{1_{1,\ldots,5}}$ are provided in the Figure 21. System B adds a middle layer of a management server between the APIs and mobile system. We can realize from "System B" that most of the processing that was only possible on mobile system, in System A, can now be split. Therefore, the external information can be processed over the management server which would reduce processing on the mobile system. Therfore under this configuration it is expected that the maintenance of the mobile system would be comparitively low, but still the physiological and vehicle information can only be

[18] http://www.comentum.com/mobile-app-development-cost.html

processed on the mobile i.e. for real-time services.Therfore, according to rates defined earlier moobile system maintenance $M_{MBS} = €3000$. Management server on the other hand , based on Amazon web service, acts as service provider for external information context for the mobile system by processing the information obtained from APIs. Secondly, it is still handling synchronizing of data from the mobile system. Comparitvely, to Sytem A the System B has a high maintenace management server. Therefore, we assume $M_{MS} = €500$

According to rates identified above. Similarly, we now also need two Amazon servers to handle the processing, hence $S_{CS_{WS}} = €700$. The external information from APIs is processed before mobile system request the infromation, this reduces the total amount of external inoformation traffic. Seconldy, the data synchronized back to management server reduces significantly as the external infromation can already be pre-saved. In this regard, the amount of data saved over the server increases. Although, data requested from APIs can all be saved, for rich services or analysis, we are going to restrict the data saved on the server to the same as trafficed over the mobile network. Simply because at this stage we do cannot identify how much qualitative amount of data is required for providing services.

The information data traffic of the configuration System B is estimated in Table 18.

Table 18 Configuration: System B Data Traffic

CS	***E***	***N***	TLD_{TR_d} ***(MB)***	TRD_{TR_d} ***(MB)***	TLU_{TR_d} ***(MB)***	TRU_{TR_d} ***(MB)***	TD_{TR_d} ***(MB)***	TU_{TR_d} ***(MB)***
1	WAE	5	8.66	32.07	0.003	0.01	40.63	0.013
2	MSE	6	2.84	10	5.6	18.7	12.84	24.3

System B depicts that only the management server communicates with the mobile system over the mobile network. Therefore, the information data traffic cost over mobile network $\boldsymbol{C_{MN} = C_{MS_{MN}}}$. Table 19 elicits the total estimated costs associated with System B.

Table 19 Configuration: System B Total Cost

$C_{MS_{MN}}$ ***(€)***	$C_{API_{MN}}$ ***(€)***	$C_{MS\_API_{MN}}$ ***(€)***	C_{MN} ***(€)***	$C_{MS_{WAN}}$ ***(€)***	$C_{API_{WAN}}$ ***(€)***	C_{WAN} ***(€)***	C_{STR} ***(€)***	$C_{Variable}$ ***(€)***	C_{Extra} ***(€)***	C_{Total} ***(€)***
3917	**0**	**0**	**3917**	**259**	**0.026**	**259.26**	5.37	**4179**	**14356**	**18535**

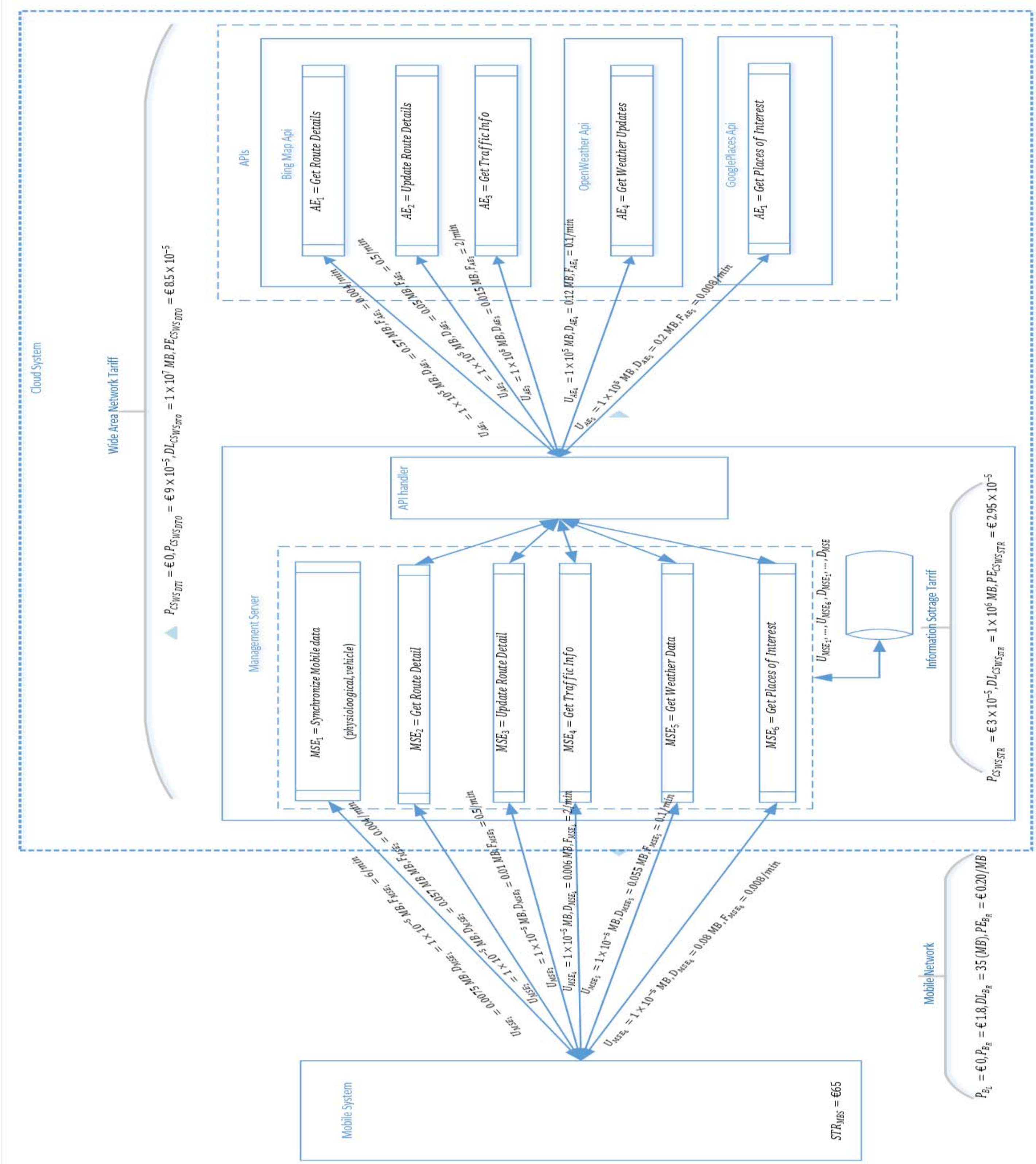


Figure 21 Configuration: System B

5.4.4 Configuration: Comparison Analysis

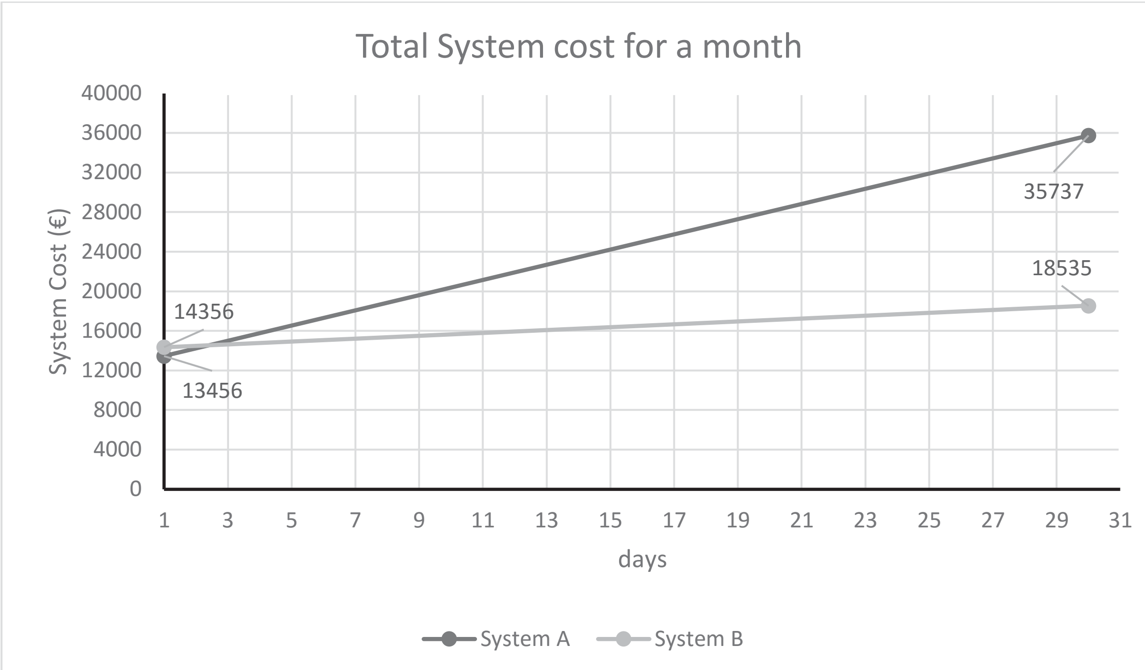


Figure 22 Total Cost for a month: System A and System B

Figure 22 shows the cost of both System A and System B for a month of 30 days and a fleet of 75 trucks. We can see that the both System A and System B have almost the same initial costs (Extra Cost) for the month. System B being a little more expensive initially than System A. Progressing over the month we can realize that the System A cost increases linearly at a rate of €742/day. Whereas, System B linear cost growth is at a rate of €130/day. This decrease of approx 82.5%, for the same number of endpoints, the growth rate difference of the system cost is primarily due to the difference in the data traffic over the mobile network. Figure 24 depicts the linear growth of data traffic against the increasing number of endpoints over a mobile network for both configurations System A and System B. In comparison to System A, processing the external information on the management server reduces mobile network data of Server B traffic by 42%. During prototyping, we analyzed that the APIs have a fixed data response structure that contained extra unnecessary information. Therefore, we were able to manage the above-managed data traffic reduction by just filtering the unrequired information. Figure 23 shows the mobile network cost for both configurations, for the System A they contribute 62% of the total cost whereas for System B it is only 21%. Therefore, we can conclude mobile network costs is the major factor that directly relates to the variable and overall system cost. Whereas, wide area network cost and storage cost on the management server have negligible influence at the expense of the system.

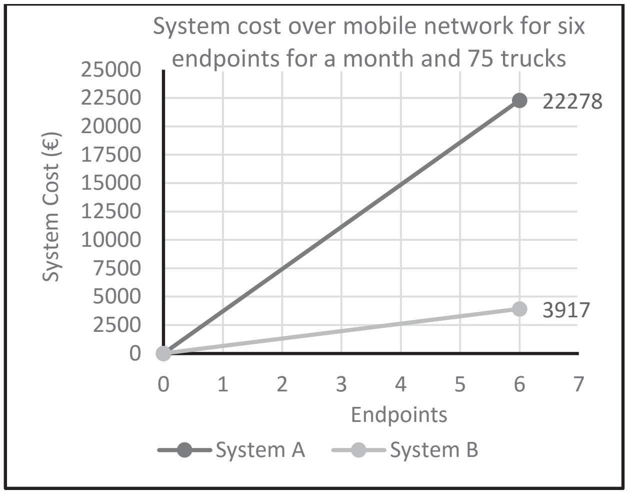


Figure 23 System Cost over mobile network: System A and System B

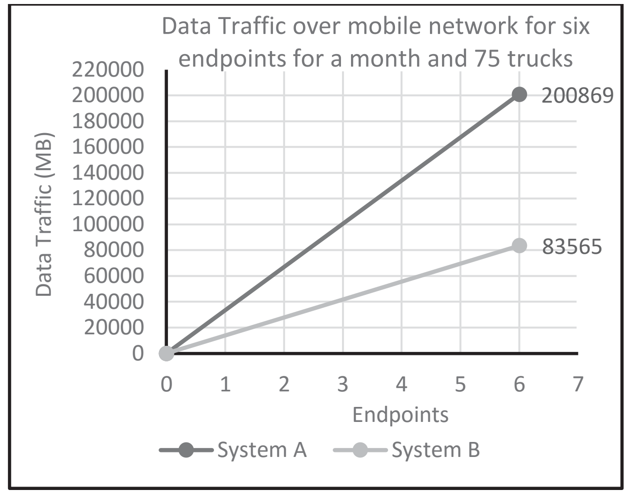


Figure 24 Data Traffic over mobile network: System A and System B

Additionally, it is also important to analyze the impact adding more information context to both systems. Consider that each endpoint as an information context then we can analyze that for System A addition of each context information costs on average €3713. On the other hand, System B the same context costs on average €696. Remember that although the although the overall size of information in the System B is less than System A, the required contextual quality is the same. This infers that using System A we can provide more information contexts in the system, especially in the case of physiological and vehicle information. In the current scenario, that we are analyzing we do not reduce the quality of information recorded from the sensors by the mobile system for both configurations. As a result, almost 50% of the data that is uploaded back to the server in System A is due to the above two mention contexts, whereas the rest of the 50% is due to external context. On the other hand, in the System B only physiological and vehicle information are uploaded to the server. Therefore, uploaded information is half that of System B. Consider, that if we increase the quality of physiological and vehicle information of System B by 100%, to provide better health monitoring service. Thereby, the same amount of data is uploaded as System A, while keeping other factors consistent; the overall system cost increases to €7840. On the other hand, the physiological and vehicle information of System A have to be reduced by almost 97%. To attain the same costs over the mobile network as System B i.e. information has to be reduced to a mean of 1MB/day that is a significant loss of information. Therefore, we can conclude that configuration System B is the most optimal of the two as it can deliver detailed physiological information with minimum impact on the cost of the system.

5.5 System Design: System Architecture

This section is answering the question *how can we design an Open Mobile API platform for Fit to Perform.*

In this section, we will identify and discuss component that are required to enable to desired functionality of the user of the system. Our aim to develop an independent technology architecture may be implemented on different platforms in different ways. However, we need to provide a clear perspective what functions our architecture should support, and how various components should be organized.

In this point of view, we need to analyze a few key architectural requirements to specify Fit to perform system Architecture. These requirements are defined in the following sections.

5.5.1 Open Architecture

The different context required in the system are domain specific and provided by stakeholder specialized in that specific domain. Therefore, Fit to Perform solution aims for an open architecture where different stakeholders can take different roles.

The four broad roles identified for the architecture are as follows.

Physiological Information Provider:

The physiological information provider as the name suggests handles providing the physiological data from the sensors on the wearable such as HRT, PPG, GSR, and others identified in Table 1. It is also responsible for providing processed physiological states of the driver such as stress, vigilance, and drowsiness under the physiological context discussed in 3.1.2. In the current context of the project, Philips handles this role.

Vehicle Information Provider:

The vehicle information provider handles providing different features regarding the driving performance of the driver on the road. These features are identified in section 3.1.1, and the acquisition of vehicle data is provided by Article 3.3.1. Currently, Astrata a telematics system provider is uptakes the responsibility of this role.

External Information Provider:

This role handles providing the external context such as weather, traffic, route, and places of interest. The details on the various providers of external context and the type of context are provided in section 3.3.3 and 3.1.3, respectively.

Multi-Information Service Provider (MISM):

The role Multi-Information Service Provider handles multiple responsibilities in the Fit to perform architecture. This role first combines all the information contexts in a single space. Secondly, exposes this combined information context to the different in mobile apps to provide various services to the user. Another, important responsibility of this role is to ensure privacy and security of physiological and vehicle data from the driver. Privacy and security of the data are out of the scope of this study.

5.5.2 Interoperability and Scalability

We discussed earlier that in Fit to perform we aim for an "Open Architecture" where we identified that different stakeholders handle different roles. Therefore, interoperability in the architecture design conforms that domain specific components need to be modulated in such a manner that new or external partner can take the role of contextual provider. Particularly, in the case of external context where companies can opt for APIs that suit their needs e.g. Here or TOMTOM for traffic updates.

The trucking companies has a varying size of fleets between 100-1000 trucks. From previous section "Cost Model", we can infer that the size of fleet influences the infrastructure of the system. Therefore, scalable Fit to perform architecture should able to support the varying size of the fleet of different companies.

Further, interoperability and scalability also refers to well-defined interfaces in architecture that could be adopted by other transportation sectors such as public, private, aerial and maritime. As well as, extend beyond the transportation domain to defense, teaching, and chronic patients.

5.5.3 Integrity and Availability

Integrity in Fit to perform scope refers to data integrity of various contexts involved (driver physiology, vehicle and external). Data especially physiological and vehicle needs to remain uncorrupted, lossless and persistent throughout the life cycle of the Fit to Perform system. The integrity of the system is a shared responsibility of each role that process and expose data to internal or external partners.

Availability of the data demands how frequently and promptly the data of various context can be available. Availability, of the data, determines the service delivery level of the system i.e. can the architecture of the system support real-time services such as vigilance that need to be carried in a matter of seconds. Alternatively, it can only support differed services such as stress that can be delivered at a later time.

5.5.4 Extensibility

Another, important aspect of Fit to perform project is to allow third party developer to develop innovative new mobile apps or cloud services for the truck companies. The contextual nature of the apps varies with the functionality they provides to the user. Therefore, the architecture should be able to extend the contextual information it could support. Hence, the article should be able to extend roles and support new functionality.

A point of note that the extensibility of the architecture should be limited by the scope of the project. For instance, the system is created to improve the health of the drivers, therefore extending the system to support supply chain or logistic context should be kept out of the scope of the system.

5.6 System Architecture: Design

This section describes the function and organization of various underlying components that are required to enable Fit to Perform system. This section will also discuss briefly how various components interact and exchange data, through exposed component interfaces.

5.6.1 Architecture Design: Functional View

As the Figure 25 shows, the functional view represents a layered functional model as part of the Data Enabling infrastructure, in which:

The ***'Data Gathering'*** layer contains the 'Data Acquisition' and the 'Data Processing & Enrichment' modules that are App's or applications that take care that the data stores include the right information. As such, these modules do 'one-time-processing' of the data in the data stores, by filling the data stores and doing processing on the data and the data stores, respectively. These modules do not store data themselves.

The ***'Data Storage'*** layer contains the local 'Local Temporary Data Store' module and the 'Back-end (cloud) Historical Data Store' module. Both the local and back-end (cloud) data stores contain encrypted data. The normal SQL database one Android (SQL Lite) does not support encryption i.e. the data is exposed and accessible to any application on mobile. Therefore, to secure data on mobile we need use SQLCipher that is a third party, data encryption database system.

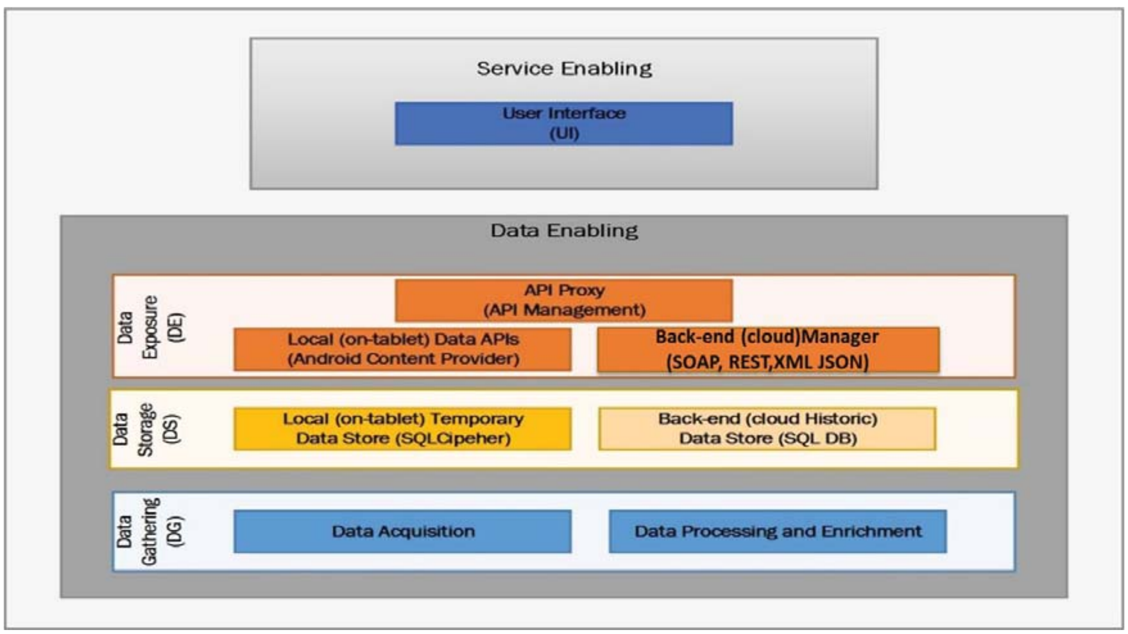


Figure 25 Fit to Perform (F2P) Architecture: Functional View

The ***'Data Exposure'*** layer exposes the data in the local and back-end cloud data stores through the 'Data Exposure' modules. These modules provide the APIs for CRUD-operations on the data in these local and back-end cloud data stores. Local 'Data Exposure' modules on a mobile system, running an Android OS, are called content providers. Content Provider exposes interfaces that allow third party applications CRUD-operation. The cloud 'Data Exposure ' modules are RESTful web services using either JSON or XML formats.These local and back-end cloud API's are shielded from the end-user through a single API Proxy provided using an API Management platform.

The Service Enabling infrastructure consists of '***User Interface***' layer. The User Interface layer is defined by the apps that provide different functionalities and services to the user. The User Interface interacts with the Data Exposure layer, specifically from the MISM.

5.6.2 Architecture Design: Component View

Figure *26* depicts the organization of various components as part of data information flow and service enabling infrastructure. The Component View depicts the components, their interfaces and their interaction within the local mobile system and back end cloud system.

The 'Physiological Data Collector App', data gathering module, interfaces with a wearable device that is registering and transmitting physiological sensor data via a Bluetooth inter -process. The 'Physiological Data Collector app' is mainly responsible for acquiring the raw data, processing and enriching the data to extract features such as stress and vigilance. Further, the app is also responsible for recording data in the physiological data store 'Physio Database'. The 'Physio Database', data storage module, is an encrypted database using SQLCipher. The 'Physio-Context Content Provider' is a data exposure module that provides an interface for external apps to perform CRUD-operations on the physiological data. In the open architecture specification, we have divided the roles. Therefore, only request-operation can be carried out via the 'Physio-Context Content Provider'. Collectively these components processing physiological information structure the 'Physiological Information Provider API'.

Similarly, 'Vehicle Information Provider API' is also comprised of three modules. The 'Vehicle Data Collector App ', data gathering module, acquires the vehicle data from an FMS interface provided by the OEM via Bluetooth inter process. It performs a processing on the data and stores data temporarily in, data storing module, the encrypted database 'Vehicle Database'. The data is then exposed by to external application by a content provider, data exposing module, 'Vehicle-Context Content Provider'.

The 'External Information Provider API' has the same schematics as the other two API identified above. The content provider exposes 'External-Context content provider' interface for the external apps within the mobile. The encrypted database 'External Database' stores the external. Compared to the other vehicle and physiological data collector apps, the 'External Data Collector App' interacts with the back-end 'F2P API Manager Service' through the web service exposed interfaces. The 'External Data Collector app', in the configuration we selected i.e. Configuration B in the previous section 5.4.4 (Configuration: Comparison Analysis), is only responsible for data acquisition. On the other hand, according to the Configuration B the 'F2P Manager Service' acts as both data exposure module and data gathering module. When a request is made to the RESTful web service through it exposed the interface, the web service delegates the request to specific API client, either Bing, OpenWeather or Google Places. Depending on the nature of the request, the client interacts the specific external API for the required information. The external API have their specific exposed interfaces that return data. On the return of data, the web service further processes the external data and saves the data in the data storage module 'F2P Database'. Further, the web service also filters out insignificant information from the API returned request before sending it back to the mobile client.

Lastly, the most important local API is the 'Multi-Information Service Management API (MISM)'. MISM API firstly handles enforcing privacy of driver's physiological and vehicle data from the local third party apps. We have already mentioned that privacy is out of the scope of this study. Similar to the other APIs, MISM also has three main modules. The 'MISM Data Collector APP' unlike the other app's that collect sensory either data or cloud- contextual data handles combining all the contextual data locally from the three providers API's exposed interfaces. It is important to note an architectural restriction that the only app allowed to access data from the physiological, vehicle or external API is the 'MISM Data collector APP'. Further, the app can also process and enriches the combined data, such as location data, before storing it into the encrypted database 'MISM Database'. To ensure privacy and security are observed in the architecture design, the third party app's can only request for information contexts via the MISM API content provider 'MISM-Context Content Provider'.

The content provider before responding to the application ensures that specified privacy policy for the requesting app is enforced. For example, if the driver restricts a third party app from using its stress data then the MISM content provider should deny such a request. Apart from data acquisition from all APIs locally, the MISM Data Collector App is also responsible for synchronizing data with the to the 'Cloud Management Server' via RESTful web service 'F2P Data Management Service'. According to the discussion in section 5.4.4, the mobile system has a limited amount of storage, and a substantial amount of data traffic over the cloud increase the infrastructure costs of the system. Therefore, 'MISM Data Collector App' is also responsible for processing the raw data into aggregated information that conforms to the infrastructure cost the trucking company can afford. Another reason for aggregation is that the driver's privacy policy that does not allow the Fleet Owner to get access to detailed data.

The cloud 'F2P Data Management Service' stores the acquired data in the 'F2P Database' to maintain the historical data. We have earlier established that various health and wellbeing services require can be provided to the driver that require historical data. Further, fleet owners need the driver data, especially the physiological data. To cater these needs, 'F2P Data Management Service' exposes an interface over the cloud for fleet management system and third party service provider to get access to this data. Again, just like on the mobile system the web service ensures that the driver's privacy policy is enforced by providing access to especially the physiological data.

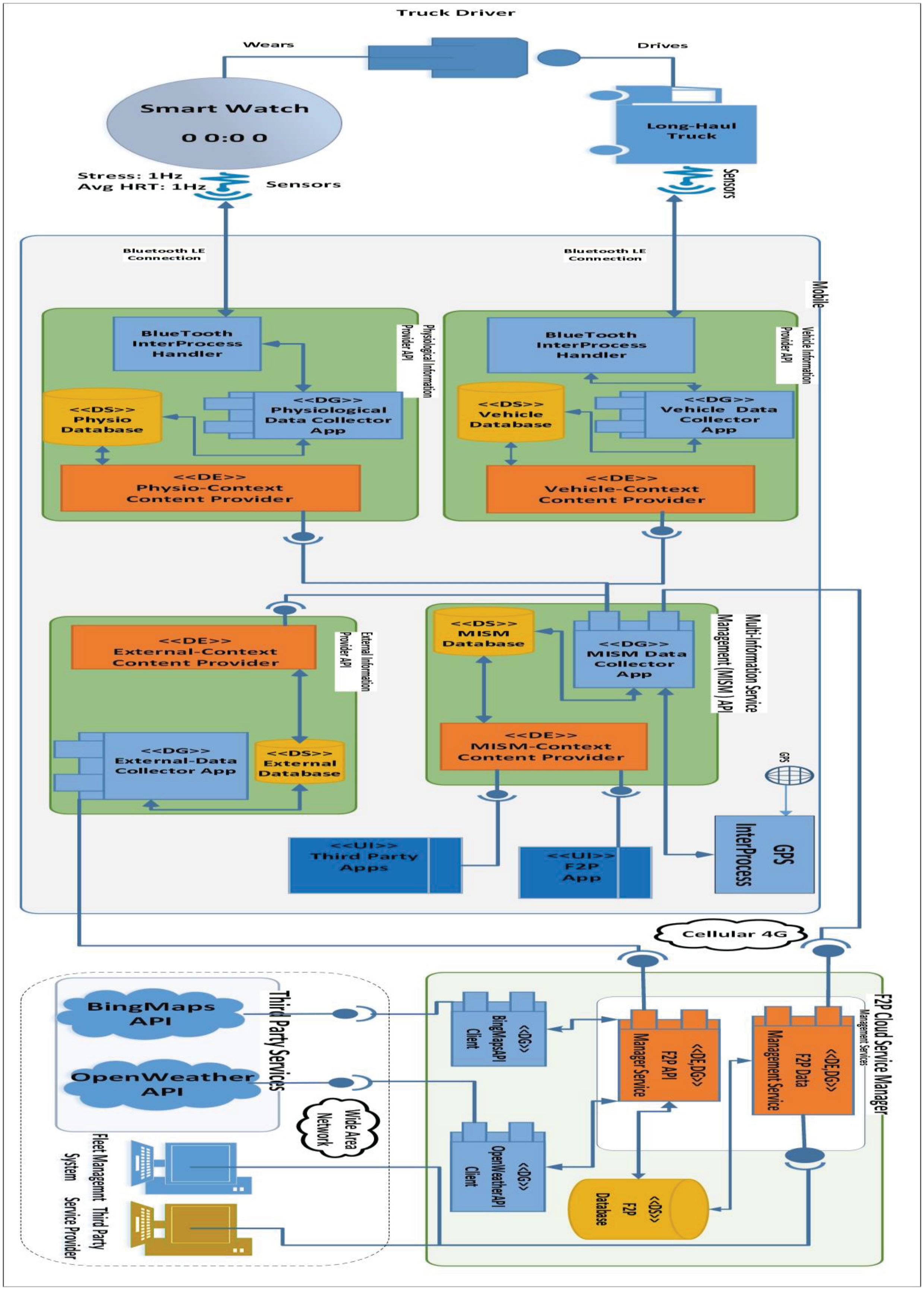


Figure 26 Fit to Perform (F2P) Architecture: Component View

5.7 Conclusion

With the above specified architectural component organization, we have achieved support for an open architecture where various domain specific stakeholder can syndicate with one another to provide a homogenous data and services enabling to the end user. With the local API structure, the system can is substantially available for real-time service as well as equally useful for deferred services. The distribution of the architecture into local cloud service allows us to scale and support any fleet size. With well-defined API interfaces (content provider), any stakeholder can be part of the value chain of the system. Though, architecture is extensible with further development but if we consider dynamic extensibility is still not possible where any provider can easily enhance the context without affecting other modules. In this regards the interoperability of the APIs is also a due consideration since currently trucking companies cannot change provider without affecting the service manager.

6 Conclusion

This thesis provides a study of an open service innovation framework that intends to improve the health and wellbeing of the professional long-haul truck drivers by augmenting physiological sensor data to the existing Vehicle Intelligent Fleet Management Systems. As mentioned earlier, that the existing vehicle system are inadequate to extend due to closed architecture while Fit to Perform aims to for an open architecture where different can join the framework to bring new cheap and innovative services for trucking sector.

The first research question, '*How can we classify and prioritize user needs in an agile project for the design of product and services'*, presents a methodology for classifying and prioritizing user needs in an agile project for identifying features that should be marketed in the first MVP. The observations were collected in the form of Kano survey questionnaires from 10 truck drivers in three focus groups and one-day random interview on truck stop. Eleven user needs (Table 11) from five genres: Health, Medical Care, Legislative, Communication, and 'Work Life' were analyzed in the user need analysis study. The Kano Model classified the user needs into must-be, one-dimensional, attractive, indifferent and reverse features while FAHP determined the importance of criteria determining the product portfolio. The classified user needs were then prioritized based on criteria importance (Figure 13). This methodology enabled us to get in-depth overview of the importance and user satisfaction about each requirement. The system designers were able to utilize the classification and satisfaction impact for a particular need while designing features of Fit to Perform prototype. The analysis also brought out the understanding that features pertaining to stress, medical care, and drowsiness attracted the user with high dissatisfaction impact. High dissatisfaction impact implies that if these features are not delivered properly then the user might lose its inclination towards these feature genre for future releases. Therefore, the MVP should be introduced in such a way where these features are combined with the necessary, 'must-be', features. The first prototype developed in the Fit to Perform is therefore, the aftermath of the user needs analysis study.

The second research question, '*How to model costs associated in Fit to Perform System Architecture'*, models the infrastructure cost for associated with the Fit to Perform system architecture. As mentioned earlier, that the agile projects tend to deliver the contextual information in real-time to the driver enabling tailored services. Therefore, the key cost parameter associated with system maintenance, data storage, transport/bandwidth, and system data usage over the mobile network and wide area network for both local mobile system and cloud system were identified and modeled. The result of this study was a cost model that helped estimate the cost of configurable the architectures i.e. where we place the mobile system, management server and API in different settings. The model was analyzed two configuration settings System A and System B with the same number of endpoints. Our analysis concludes that data traffic over the mobile network is the main influencer for the overall costs of the system Fit to Perform context. We estimate reducing the mobile network data traffic by 42% (System B) reduces the mobile network costs by 82% of System A and the overall costs by 50%. While even 98% increase in the data traffic (over the wide area network) and data storage (in System A compare to System B for the management server) increases their overall system cost contribution to a mere 1.4% from 0.009%. This study helped us to estimate optimal endpoint data traffic size (including upload and download) and frequency of interaction over the mobile network, i.e., 0.0359MB with 1.49 calls/ min. As a result of this study configuration: System A was adopted to design the open API platform for Fit to Perform.

The third research, *How can we design an Open Mobile API platform for Fit to Perform*, question focuses on identifying and organizing the component of an open API platform that enables an open service innovation framework. To design the platform numerous non-functional requirement were analyzed and defined such as open architecture, scalability, interoperability, availability, integrity and extensibility in the Fit to Perform context as discussed in section 5.5.1 to 5.5.4. The architecture was modulated based on three main identified roles i.e. physiological, vehicle and external. The system components were designed and organized based on three functional layer model (section 5.6.1): Data Gathering, Data Storage, and Data Exposure. The physiological sensor, vehicle sensor and external data provider interface components of the open API platform enable third parties to realize new services (especially the services identified in the user study) both locally on the in-cabin device and over the cloud. Moreover, in section 5.6.2, the decoupling of the architecture into domain-specific contextual APIs that interface together with a central API enables the required openness intended by the framework where any new domain specific provider could become part of Fit to Perform value chain.

The first part of the user need study identified the required information the open API needs to expose for the third-party service providers to realize the intended services. Further, the first Fit to Perform prototype developed and tested was based on the results of classification and prioritization of user needs. The second part of this study, system cost analysis, determined the key infrastructural cost-influencers for providing the Fit to Perfrom solution in real environment. The cost analysis study suggests a cost sustainable system configuration for the Fit to Perform solution that will be adopted while developing the open API platform. The result of this study concludes with a designed API platform architecture that exhibits the organization and interfacing of the required components that enables the realtime health care services for professional truck drivers both locally on the in-cabin device and over the cloud. The designed open API platform architecture will be used in the future developments of Fit to Perform open service innovation framework.

7 References

Aghlmand, S., Lameei, A., & Small, R. (2010). A hands-on experience of the voice of customer analysis in maternity care from iran. *International Journal of Health Care Quality Assurance, 23*(2), 153-170.

Alshehri, S., & Benedicenti, L. (2013). Ranking approach for the user story prioritization methods. *Journal of Communication and Computer, 10*, 1465-1474.

Apostolopoulos, Y., Sönmez, S., Shattell, M., Haldeman, L., Strack, R., & Jones, V. (2011). Barriers to truck drivers' healthy eating: Environmental influences and health promotion strategies. *Journal of Workplace Behavioral Health, 26*(2), 122-143.

Azmi, N., Rahman, A. S. M. M., Shirmohammadi, S., & El Saddik, A. (2011). LBP-based driver fatigue monitoring system with the adoption of haptic warning scheme. *Virtual Environments Human-Computer Interfaces and Measurement Systems (VECIMS), 2011 IEEE International Conference On,* 1-4. doi:10.1109/VECIMS.2011.6053852

Baek, H. J., Lee, H. B., Kim, J. S., Choi, J. M., Kim, K. K., & Park, K. S. (2009). Nonintrusive biological signal monitoring in a car to evaluate a driver's stress and health state. *Telemedicine and E-Health, 15*(2), 182-189.

Berander, P., & Wohlin, C. (2004). Differences in views between development roles in software process improvement-a quantitative comparison. *Proceedings of the 8th International Conference on Empirical Assessment in Software Engineering (EASE 2004),* 57-66.

Berger, C., Blauth, R., Boger, D., Bolster, C., Burchill, G., DuMouchel, W., . . . Shen, D. (1993). Kano's methods for understanding customer-defined quality. *Center for Quality Management Journal, 2*(4), 3-35.

Boon-Giin Lee, & Wan-Young Chung. (2012). Driver alertness monitoring using fusion of facial features and bio-signals. *Sensors Journal, IEEE, 12*(7), 2416-2422. doi:10.1109/JSEN.2012.2190505

Breyfogle III, F. W., Cupello, J. M., & Meadows, B. (2000). *Managing six sigma: A practical guide to understanding, assessing, and implementing the strategy that yields bottom-line success* John Wiley & Sons.

Campagne, A., Pebayle, T., & Muzet, A. (2004). Correlation between driving errors and vigilance level: Influence of the driver's age. *Physiology & Behavior, 80*(4), 515-524.

Chang, D. (1996). Applications of the extent analysis method on fuzzy AHP. *European Journal of Operational Research, 95*(3), 649-655.

Chang, D. (1992). Extent analysis and synthetic decision, optimization techniques and applications, vol. 1.

Chang, K., & Chen, M. (2011). Applying the kano model and QFD to explore customers' brand contacts in the hotel business: A study of a hot spring hotel. *Total Quality Management & Business Excellence, 22*(1), 1-27. doi:10.1080/14783363.2010.529358

Chen, S., Li, R., & Tang, B. (2012). Group-buying website evaluation based on combination of TOPSIS, entropy weight and FAHP. *Journal of Convergence Information Technology, 7*(7), 130-139.

Cheng, B., & Chiu, W. (2007). Two-dimensional quality function deployment: An application for deciding quality strategy using fuzzy logic. *Total Quality Management and Business Excellence, 18*(4), 451-470.

Chin-Teng Lin, Chun-Hsiang Chuang, Chih-Sheng Huang, Shu-Fang Tsai, Shao-Wei Lu, Yen-Hsuan Chen, & Li-Wei Ko. (2014). Wireless and wearable EEG system for evaluating driver vigilance. *Biomedical Circuits and Systems, IEEE Transactions On, 8*(2), 165-176. doi:10.1109/TBCAS.2014.2316224

Clegg, B., Wang, T., & Ji, P. (2010). Understanding customer needs through quantitative analysis of kano's model. *International Journal of Quality & Reliability Management, 27*(2), 173-184.

Cohn, M. (2004). *User stories applied: For agile software development* Addison-Wesley Professional.

Copsey, S., Christie, N., & Drupsteen, L. (2011). A review of accidents and injuries to road transport drivers. european agency for safety and health at work (EU-OSHA).

de Santos Sierra, A., Avila, C. S., Guerra Casanova, J., & del Pozo, G. B. (2011). A stress-detection system based on physiological signals and fuzzy logic. *Industrial Electronics, IEEE Transactions On, 58*(10), 4857-4865. doi:10.1109/TIE.2010.2103538

Deng, H. (1999). Multicriteria analysis with fuzzy pairwise comparison. *International Journal of Approximate Reasoning, 21*(3), 215-231.

Driver alert system : Volkswagen UK. (7/5/2015). Retrieved from http://www.volkswagen.co.uk/technology/passive-safety/driver-alert-system

Drowsiness-detection system, ATTENTION ASSIST : Mercedes. (7/5/2015). Retrieved from http://www.daimler.com/dccom/0-5-1210218-1-1210332-1-0-0-1210228-0-0-135-0-0-0-0-0-0-0-0.html

DSS in vehicle system (DSS-IVS) : Seeingmachines. (7/5/2015). Retrieved from http://www.seeingmachines.com/solutions/fleet/

Elke Schneider, X. I. (2008). Occupational safety and health in the transport sector—An overview (EU-OSHA).

Eriksson, M., & Papanikolopoulos, N. P. (2001). Driver fatigue: A vision-based approach to automatic diagnosis. *Transportation Research Part C: Emerging Technologies, 9*(6), 399-413.

European Commission. (2014). Statistics – accidents data - european commission. Retrieved from http://ec.europa.eu/transport/road_safety/specialist/statistics/index_en.htm

FUJITSU vehicle ICT FEELythm : FUJITSU. (7/6/2015). Retrieved from http://www.fujitsu.com/global/about/resources/news/press-releases/2015/0119-02.html

Fynes, B., & De Burca, S. (2005). The effects of design quality on quality performance. *International Journal of Production Economics, 96*(1), 1-14.

Garibay, C., Gutiérrez, H., & Figueroa, A. (2010). Evaluation of a digital library by means of quality function deployment (QFD) and the kano model. *The Journal of Academic Librarianship, 36*(2), 125-132.

Geng, X., Chu, X., Xue, D., & Zhang, Z. (2010). An integrated approach for rating engineering characteristics' final importance in product-service system development. *Computers & Industrial Engineering, 59*(4), 585-594.

Government of UK. (2008). Department of transport annual report 2008.*2015*(7/7/2015)

Hammoud, R. I., & Zhang, H. (2008). Alertometer: Detecting and mitigating driver drowsiness and fatigue using an integrated human factors and computer vision approach. In R. I. Hammoud (Ed.), (pp. 301-321) Springer Berlin Heidelberg. doi:10.1007/978-3-540-75412-1_14

Isaai, M. T., Kanani, A., Tootoonchi, M., & Afzali, H. R. (2011). Intelligent timetable evaluation using fuzzy AHP. *Expert Systems with Applications, 38*(4), 3718-3723.

Kano, N., Seraku, N., Takahashi, F., & Tsuji, S. (1984). Attractive quality and must-be quality.

Kavitha, K., & Perumalraja, R. (2014). Smart wireless healthcare monitoring for drivers community. *Communications and Signal Processing (ICCSP), 2014 International Conference On,* 1105-1108.

Kazemi, M., Kariznoee, A., Moghadam, M. R. H., & Sargazi, M. T. (2013). Prioritizing factors affecting bank customers using kano model and analytical hierarchy process. *International Journal of Accounting and Financial Management-IJAFM, 6*

Kenneth, A. C. (2002). Customer-focused development with QFD. *DRM Associates,*

Ko, H., Lu, H., & Yu, H. (2012). Comparative analysis of experience-oriented customer needs based on the kano model: An empirical study. *The Service Industries Journal, 32*(12), 1973-1990.

Kukreja, N., Payyavula, S., Boehm, B., & Padmanabhuni, S. (2012). Selecting an appropriate framework for value-based requirements prioritization. *Requirements Engineering Conference (RE), 2012 20th IEEE International,* 303-308.

L. Hallowell, D. (2015). QFD: When and how does it fit in software development? Retrieved from http://www.isixsigma.com/tools-templates/qfd-house-of-quality/qfd-when-and-how-does-it-fit-software-development/

Lai, V. S., Trueblood, R. P., & Wong, B. K. (1999). Software selection: A case study of the application of the analytical hierarchical process to the selection of a multimedia authoring system. *Information & Management, 36*(4), 221-232.

Lee, J., Sugumaran, V., & Park, S. (2011). Requirements management using KANO model and AHP for service systems design. *Dependable, Autonomic and Secure Computing (DASC), 2011 IEEE Ninth International Conference On,* 1159-1166.

Leffingwell, D., & Widrig, D. (2003). *Managing software requirements: A use case approach* Addison-Wesley.

Li, Y., Tang, J., Luo, X., & Xu, J. (2009). An integrated method of rough set, kano's model and AHP for rating customer requirements' final importance. *Expert Systems with Applications, 36*(3), 7045-7053.

Li, G., & Chung, W. Y. (2013). Detection of driver drowsiness using wavelet analysis of heart rate variability and a support vector machine classifier. *Sensors (Basel, Switzerland), 13*(12), 16494-16511. doi:10.3390/s131216494 [doi]

Lingling Li, Yangzhou Chen, & Zhenlong Li. (2009). Yawning detection for monitoring driver fatigue based on two cameras. *Intelligent Transportation Systems, 2009. ITSC '09. 12th International IEEE Conference On,* 1-6. doi:10.1109/ITSC.2009.5309841

Llinares, C., & Page, A. F. (2011). Kano's model in kansei engineering to evaluate subjective real estate consumer preferences. *International Journal of Industrial Ergonomics, 41*(3), 233-246.

Matzler, K., Hinterhuber, H. H., Bailom, F., & Sauerwein, E. (1996). How to delight your customers. *Journal of Product & Brand Management, 5*(2), 6-18.

Matzler, K., & Sauerwein, E. (2002). The factor structure of customer satisfaction: An empirical test of the importance grid and the penalty-reward-contrast analysis. *International Journal of Service Industry Management, 13*(4), 314-332.

Mayer, J. H. (2012). Using the kano model to identify attractive user-interface software components.

McDonough, B., Howard, M., Angeles, R., Dolovich, L., Marzanek-Lefebvre, F., Riva, J. J., & Laryea, S. (2014). Lone workers attitudes towards their health: Views of ontario truck drivers and their managers. *BMC Research Notes, 7*, 297-0500-7-297. doi:10.1186/1756-0500-7-297 [doi]

Murray, W. (2010). Sustaining work-related road safety in hard times: Understanding collision costs. *Unpublished Guidance on Fleet Safety Costs.Interactive Driving Systems,*

Passey, D. G., Robbins, R., Hegmann, K. T., Ott, U., Thiese, M., Garg, A., . . . Murtaugh, M. A. (2014). Long haul truck drivers' views on the barriers and facilitators to healthy eating and physical activity. *Intl J of Workplace Health Mgt, 7*(2), 121-135. doi:10.1108/IJWHM-08-2013-0031

Saaty, T. L. (1983). Priority setting in complex problems. *Engineering Management, IEEE Transactions On,* (3), 140-155.

Schmidt-Daffy, M. (2013). Fear and anxiety while driving: Differential impact of task demands, speed and motivation. *Transportation Research Part F: Traffic Psychology and Behaviour, 16*(0), 14-28. doi:http://dx.doi.org/10.1016/j.trf.2012.07.002

Shahin, A., & Zairi, M. (2009). Kano model: A dynamic approach for classifying and prioritising requirements of airline travellers with three case studies on international airlines. *Total Quality Management, 20*(9), 1003-1028.

Shahin, A., Khazaei Pool, J., & Poormostafa, M. (2014). Evaluating and ranking hotels offering e-service by integrated approach of webqual and fuzzy AHP. *International Journal of Business Information Systems, 15*(1), 84-104. doi:10.1504/IJBIS.2014.057966

Shahin, A., Pourhamidi, M., Antony, J., & Sung, H. P. (2013). Typology of kano models: A critical review of literature and proposition of a revised model. *Int J Qual & Reliability Mgmt, 30*(3), 341-358. doi:10.1108/02656711311299863

Shattell, M., Apostolopoulos, Y., Collins, C., Sönmez, S., & Fehrenbacher, C. (2012). Trucking organization and mental health disorders of truck drivers. *Issues in Mental Health Nursing, 33*(7), 436-444.

Sleep watcher XR -driver alert system : Exeros. (7/5/2015). Retrieved from http://www.exeros-technologies.com/car-cameras/sleep-watcher-xr

Sonnleitner, A., Simon, M., Kincses, W. E., Buchner, A., & Schrauf, M. (2012). Alpha spindles as neurophysiological correlates indicating attentional shift in a simulated driving task. *International Journal of Psychophysiology, 83*(1), 110-118. doi:http://dx.doi.org/10.1016/j.ijpsycho.2011.10.013

The International Road Transport Union. (2007). Scientific study "ETAC" european truck accident causation. *The International Road Transport Union (2007), 2015*(7/4/2015)

Thomas, L. S. (1988). Multicriteria decision making: The analytic hierarchy process.

Ting, S., & Chen, C. (2002). The asymmetrical and non-linear effects of store quality attributes on customer satisfaction. *Total Quality Management, 13*(4), 547-569.

Tontini, G., Søilen, K. S., & Silveira, A. (2013). How do interactions of kano model attributes affect customer satisfaction? an analysis based on psychological foundations. *Total Quality Management & Business Excellence, 24*(11-12), 1253-1271.

VOLVO TRUCKS. (2013). EUROPEAN ACCIDENT RESEARCH AND SAFETY REPORT 2013.*2015*(7/7/2015)

Wakhlu, B. (1998). *Total quality: Excellence through organization-wide transformation* AH Wheeler Publishing Company Limited.

Wang, C., & Wang, J. (2014). Combining fuzzy AHP and fuzzy kano to optimize product varieties for smart cameras: A zero-one integer programming perspective. *Applied Soft Computing, 22*, 410-416.

Wang, P., Ming, X. G., Li, D., Kong, F., Wang, L., & Wu, Z. (2011). Modular development of product service systems. *Concurrent Engineering, 19*(1), 85-96.

Waters, K. (2009). Prioritization using moscow. *Agile Planning, January, 12*

Wiegers, K., & Beatty, J. (2013). *Software requirements* Pearson Education.

Yu, Z., Zhang, L., & Zhang, C. (2012). Web service composition method based on FAHP and TOPSIS. *Journal of Communications & Information Sciences, 2*(1)

Zhao, M., & Roy Dholakia, R. (2009). A multi-attribute model of web site interactivity and customer satisfaction: An application of the kano model. *Managing Service Quality: An International Journal, 19*(3), 286-307.

8 Appendix A: Fuzzy Analytical Hierarchal Process

Let $X = (x_1, x_2, x_3, \ldots\ldots.., x_n)$be an object set, and $U = (u_1, u_2, u_3, \ldots\ldots.., u_n)$ be a goal set. According to Chang's extent analysis, each object is taken and the extent analysis for each goal, g_i, is performed, respectively. Therefore, M extent analysis values for each object can be obtained with the following signs, where all the M_{gi}^{j} $(j = 1,2,3 \ldots\ldots\ldots n)$ are triangular fuzzy numbers (TFNs):

$$M_{gi}^{m}, M_{gi}^{m}, \ldots\ldots\ldots\ldots\ldots., M_{gi}^{m} \qquad i = 1,2,3, \ldots\ldots\ldots., n \tag{43}$$

The parameters for these TFNs include a, b and c which denote the least possible value, the mid possible value, and the largest possible value, respectively. A TFN is represented as *(a, b, c).* The steps of Chang's extent analysis can be given as follows:

Step 1: Let $C_i|\ i = 1,2, \ldots\ldots.. n$ be the set of criteria. The pairwise comparison of n criteria can be summarized in an $(n \times m)$ evaluation matrix. The value of the fuzzy synthetic extent with respect to the i^{th} object is defined as:

$$S = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{k=1}^{n} \sum\nolimits_{j=1}^{m} M_{gk}^{j}\right]^{-1} \tag{44}$$

To obtain $\sum_{i=1}^{m} M_{gi}^{j}$ the fuzzy additional operation of m extent analysis values is performed for a particular matrix such as:

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} a_j, \sum_{j=1}^{m} b_j, \sum_{j=1}^{m} c_j\right) \qquad i = 1,2,3, \ldots\ldots\ldots., n \tag{45}$$

And to obtain$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$, the fuzzy addition operation of M_{gi}^{j} $(j = 1,2,3, \ldots\ldots\ldots., m)$ values is performed such that

$$\left[\sum_{i=1}^{n} \sum\nolimits_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{m} c_i}, \frac{1}{\sum_{i=1}^{m} b_i}, \frac{1}{\sum_{i=1}^{m} a_i}\right) \tag{46}$$

Step 2: The degree of possibility of $M_2 = (a_2, b_2, c_2) \geq M_1 = (a_1, b_1, c_1)$ is defined as:

$$V(M_2 \geq M_1) = sup\lfloor min(\mu_{M_1}(x), \mu_{M_2}(y))\rfloor \tag{47}$$

Or

$$V(M_2 \geq M_1) = hgt(M_2 \cap M_1) = \mu_{M_2}(d) = \begin{cases} 1, & if\ (b_2 \geq b_1) \\ 0 & if\ (a_1 \geq c_2) \\ \dfrac{a_1 - c_2}{(b_2 - c_2) - (b_1 - a_1)} & otherwise \end{cases} \tag{48}$$

Where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2}. To compare M_1 and M_1, both the values of $V(M_1 \geq M_2)$ and $V(M_1 \geq M_2)$are needed.

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i $(i = 1,2,3, \ldots\ldots\ldots., k)$ can be defined as :

$$V(M \geq M_1, M_2 \ldots\ldots M_k) = V[(M \geq M_1) \; and \; (M \geq M_1) \; and \ldots\ldots (M \geq M_k)] = min(M \geq M_i), i = 1,2,3, \ldots\ldots\ldots, k. \quad (49)$$

Assuming that:

$$d'(A_i) = min(S_i \geq S_k) \quad (50)$$

For $k = 1,2,3, \ldots\ldots\ldots, n \; ; k \neq i$ The weight vector is given by:

$$W' = ((d'(A_1), d'(A_2) \ldots\ldots d'(A_n))^T \quad (51)$$

Where $A_i \; (i = 1,2,3, \ldots\ldots, n) \; n \; element$

Step 4: via normalization, and we have obtained the weight vectors with respect to the decision criteria:

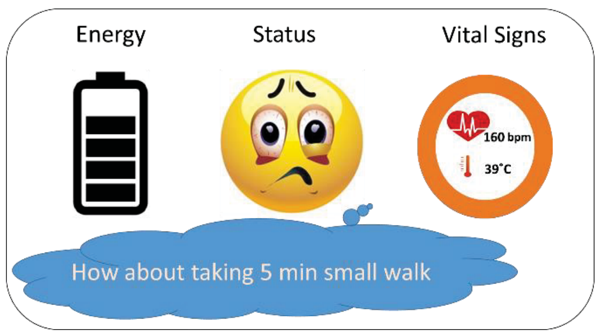
$$W = ((d \; (A_1), d(A_2) \ldots\ldots \mathrm{d}(A_n))^T \quad (52)$$

Where W is a non-fuzzy number that.

9 Appendix B: List of all Survey Questions

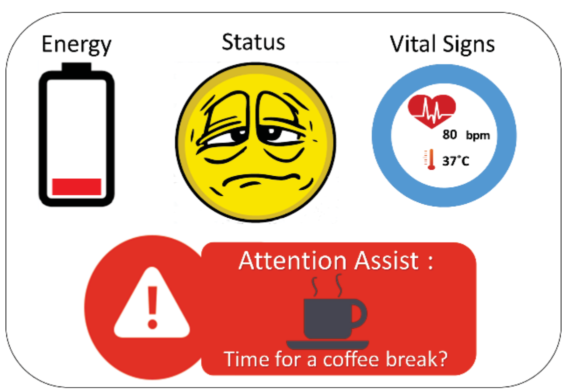
If the application helps you know the facilities on truck stops, restaurants, motels and leisure near you, how do you feel?

If the application does not help you know facilities on truck stops, restaurants, motels and leisure places near you, how do you feel?



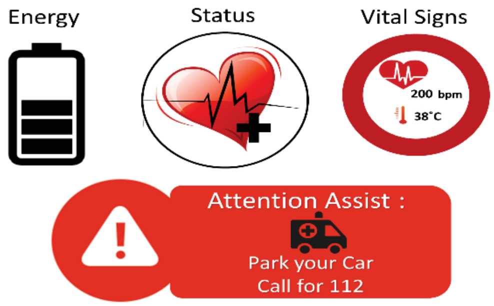
If the application helps you with advices to relax when you are stressed, how do you feel?

If the application does not help you with advice to relax when you are stressed, how do you feel?



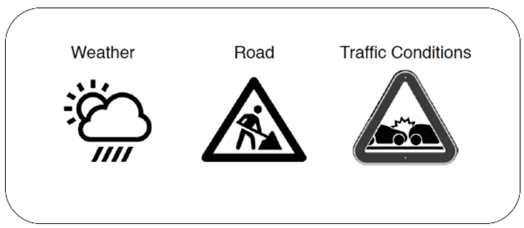
If the application helps alert you when you are sleepy, how do you feel?

If the application does not alert you when you are sleepy, how do you feel?



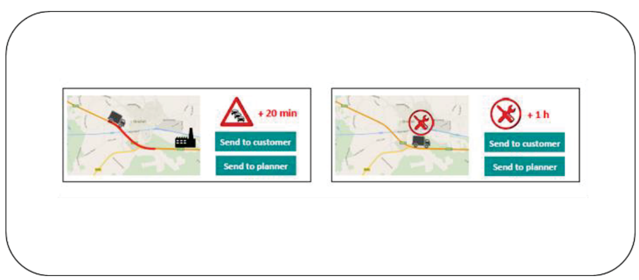
If the application helps alert you and informs nearest medical assistance for help in case of an emergency like heart stroke, how do you feel?

If the application doest not alert you or informs nearest medical assistance for help in case of an emergency like heart stroke, how do you feel?



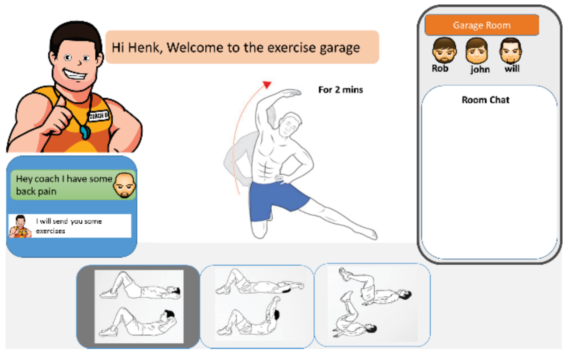
If the application helps to inform you of conditions on the route, how do you feel?

If the application does not help to inform you of conditions on the route, how do you feel?



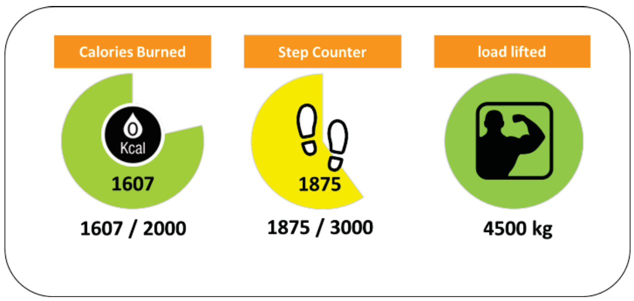
If the application helps to send feedback to the customer or planner, how do you feel?

If the application does not help to send feedback to the customer or planner, how do you feel?



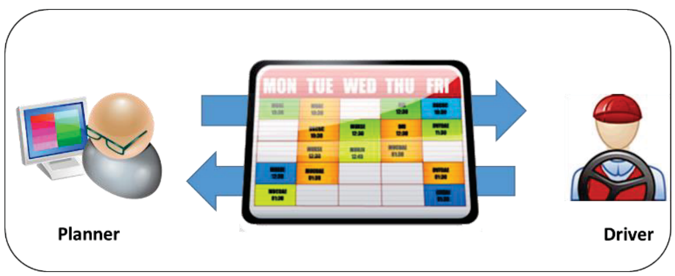
If the application helps you exercise in a group with coach/friends/ or exercise alone, how do you feel?

If the application does not help you exercise with coach/friends/or exercise alone, how do you feel?



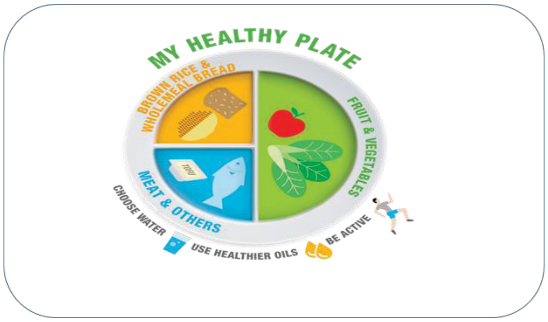
If the application helps monitor your physical activity, how do you feel?

If the application helps monitor your physical activity, how do you feel?



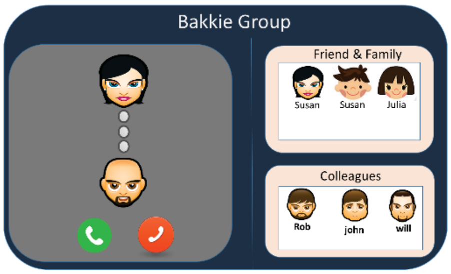
If the application helps schedule task proposal from a planner on a tablet at home or on the road and discuss it with him by giving counter proposals, how do you feel?

If the application does not help schedule task proposal from a planner on a tablet at home or on the road and discuss it with him by giving counter proposals, how do you feel?



If the application helps you to track, suggest healthy nutrition and manage weight by health coaching, how do you feel?

If the application does not help you to track, suggest healthy nutrition and manage weight by health coaching, how do you feel?



If the application helps you talk to colleagues/friends/family via a world wide bakkie, how do you feel?

If the application does not help you talk to my colleagues/friends/family via a world wide bakkie, how do you feel?