Preface

From the perspective of the elderly people, in 21st Century technologies and in a rapidly changing world, their needs and characteristics are often not taken into account. Elderly age group is the fastest growing one among developed countries. By the year 2050, about two billion people will be at the age of 60, according to the World Health Organization (WHO), [1], [2].

Although older people need more empathy than technology, technology can help them to have a better and easier life. Recently, startups and companies have focused their attention on the specific needs of the elderly people and the resulting added value. Among all new technologies, here we want to concentrate on ones which help older people during probable falling.

Unfortunately, this is a common problem for the elderly people which may be dangerous in many cases. More than a third of people aged 65 or older are falling each year, and in half of them, there are frequent falls, [3]. Nearly one in every 10 falls leads to serious damage, including hip fractures, legs fractures, and other serious soft tissue damage or head injuries, [4]. For many of elderly people recovery usually takes a long time and they cannot move or walk during this period. This leads to immobility and in continue depression of the elderly person. In older people, fear of falling which cause to reduce self-confidence appears to be a barrier to physical activity in many of them, especially those who have an experience of fall, [5].

The good news is that we solved this problem by means of a new supervisory system which is briefly called IPHSDM (Intelligent Personal Health and Safety Domotic Monitoring). It is a precise and comprehensive system which provides a continuous monitoring, for needy people, with ability of fall events detection and send alert to various optional destinations. It consists of a bracelet (that is worn by elder person), a router or modem (that is connected to internet), and a cloud system to control the device, analysis the received data, and make decision in emergency situations (like send alert or call others). In continue we introduce the whole system by means of use case diagrams, and then we study each part accurately with more details on functions, limitations and connections.

Problem Description

Before we start to explain the problem and general procedure that leads to the solution shown by “Use Case” diagrams, we briefly describe the abbreviations which used here:

SP: Service Provider; the main supervisor who controls the system, analyses situations and makes decision to call related people or emergency centers whenever needed.

MSP: Multi Service Provider; has the duty for control & manage all the single service providers together.

SM: Subject under Monitoring; which in this case can be an elder man or woman or in general anyone who needs to be under care.

SF: Social Forest; including family members, relatives or friends who asked before to be informed about health condition of elder person.

CG: Caregiver; it can be a private nurse or a hospital staff which has the duty of taking care of elder person.

EMS: Emergency Medical Services

Now imagine the condition that an elder person (as the "SM") wears the bracelet (as "Device") in one of his hands and starts to walk around his house. At the other side, there are his nurse (as the Caregiver), his family members, his friends (as the Social Forest), or anyone who wants to care "SM" and so needs to be informed about his current condition, probable falls and his exact location.

Superior Solution

Whatever we need is a bracelet with continuous monitoring from when an elder person wears till the moment he pulls it off for charging the internal battery. The main goal is detection of any fall events during this period and send proper alert to the "Cloud" through the "Gateway" (or "Hub") at the same time.

One important point is the ability of system to recognize difference between a real fall event and a similar movement which is not a real fall like the moments that people bend to pick up something on the ground, otherwise we will receive many wrong alerts during the day and this makes impossible to know when a real fall happens! Fortunately, this problem is solved by using super-sharp sensors and precise falling datasets which enables system to notice fall events accurately. It must be also stated that each pack of this product includes three bracelets to provide a continuous care in case of low battery percentage or losing a bracelet. In continue we introduce different parts of intended solution by means of "Use Case" diagrams and then examine the whole system operation considering each part separately.

Model Description

1-Global Use Case

As you can see in (figure-1), there is a "Use Case" diagram including three packages, "Device" as the bracelet (consists of a raw sensor tile, to which Velcro is added to be able to fasten it to the arm), "Gateway"(or "Hub") as the router or modem, and "Cloud"(as a shared pools of configurable computer system resources and higher-level services that can be rapidly provisioned with minimal management effort, often over the Internet) which here used for data sharing and software applications.

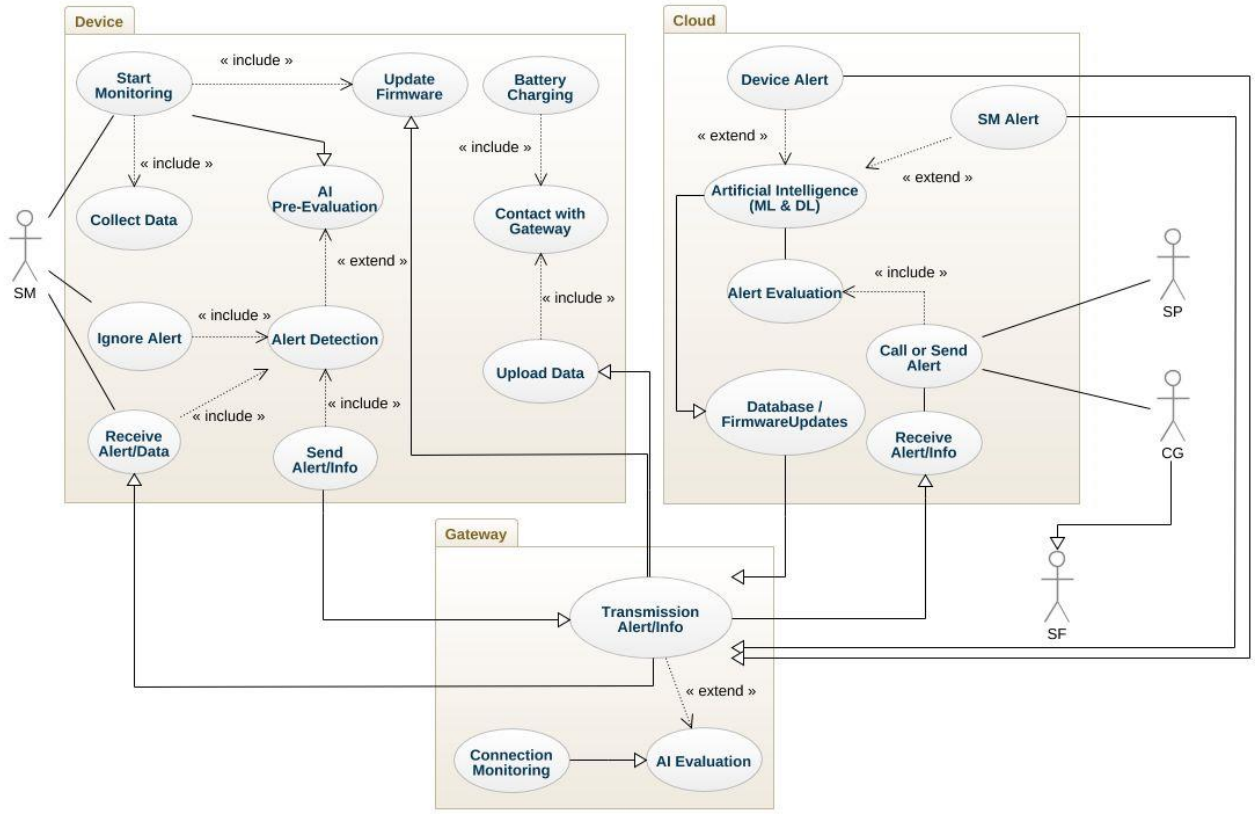

Figure 1- Global Use Case

Now it's the time to take a more precise look in "Use Case" diagrams and study the whole procedure step by step. The procedure will start by monitoring the "SM", however collecting data from surrounding and update the firmware installed before on the device are two prerequisites of this step, and that's why we use "include" link to show their type of connection which is a mandatory dependence here (Figure-2).

Figure 2- Monitoring Process

The collected data will be processed by primary artificial intelligence techniques to detect any suspicious data, and that's why this evaluation could lead to "Alert Detection". The device is designed in such a way that is able to notice if the bracelet is not worn or if the battery charge level is lower than needed amount. In both case it sends an alert signal to the "Cloud", like when a fall event happens. In any of these three cases (fall event, unworn bracelet, and low battery) an alert will made in the bracelet which is shown in "Use Case" diagram by "Alert Detection" in the "Device" package. Now the "SM" will be aware about it and so it's possible for him to ignore the alert, at the same time bracelet sends this alert to the "Cloud" through the "Gateway" and also there is the possibility for "SM" to receive an alert (or pre-packed information) from the main system again through the "Gateway". As you can see all these use cases are linked to the "Alert Detection" by "include" connection, because it's clear that "Alert Detection" is a necessary condition for send, receive or ignore an alert (Figure-3)!

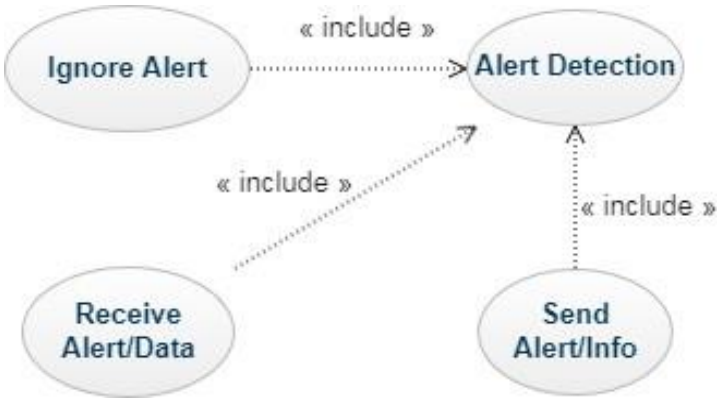

Figure 3- Alert Detection Process

Another remarkable point is about database which used by the bracelet to enables it for detection of real fall events. However it is possible to prepare such information based on previous experiences and fall events that have happened for the elder people and then put the data inside the bracelet, obviously to achieve a high quality performance and to get better results we need to update databases once in a while and it's not possible to do this without make a contact between the "Device" and "Gateway".

Besides as we mentioned before, there is an internal battery inside the bracelet which enables it to work continuously for several days and this connection between the bracelet and router is what we need even for charging the battery.

Accordingly, in both cases (upload new data and charging the internal battery of device), contact between the "Device" and "Gateway" is a mandatory process and that's why we link the related use cases with "include" connection type as it shown before in the "Device" package and here again in (figure-4).

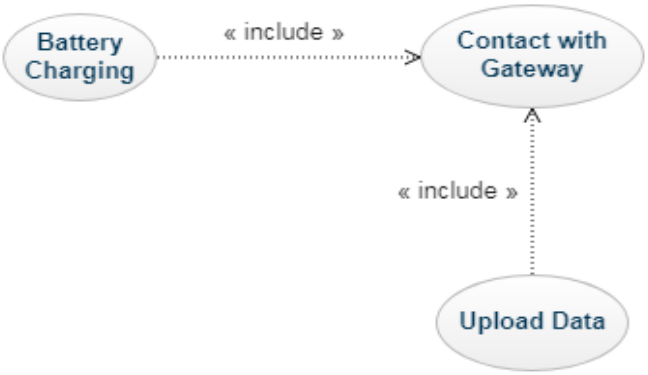

Figure 4- Contact Process

In continue we have “Gateway” or “Hub” package which used for transferring data and alert signals between bracelet and main system. In other words, the “Hub” will be a centralizing device that performs monitoring functions (define what remains on the bracelet, what is sent to the “Hub” and then to the “Cloud”). So, it has been equipped with latest version of “BLE” (Bluetooth Low Energy is a wireless personal area network technology designed and marketed by the Bluetooth Special Interest Group aimed at novel applications in the healthcare, fitness, beacons, security, and home entertainment industries,[3]. Compared to Classic Bluetooth, Bluetooth Low Energy is intended to provide considerably reduced power consumption and cost while maintaining a similar communication range.), and also “Wi-Fi” standards that enables data transfer with highest speed and quality. As you see in (figure-5), each link shows the direction of data transfer between different use cases.

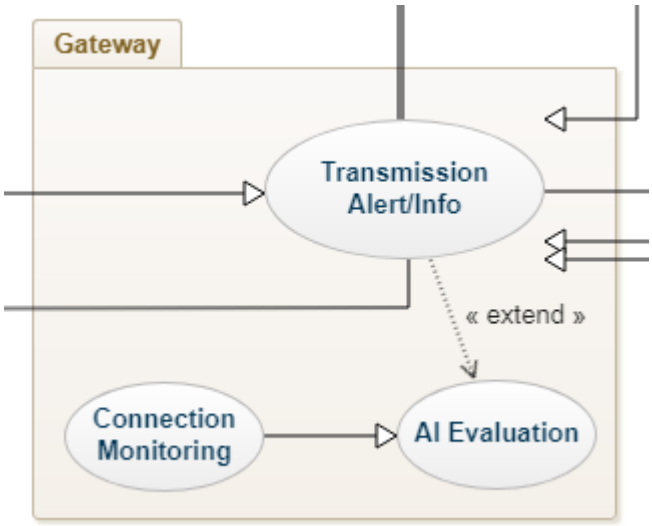

Figure 5- Gateway

The system sends a request to the “Hub” that interprets and executes it, but the “hub" dose not collaborate in the analysis of the sensors. The alert events are generated by the bracelet while the “Hub” has only transmission responsibility and the responsibility for monitoring the status of the “BLE"

network (repeaters, bracelets), and connection to the “Cloud” (provided that the connection to the “Hub” is not lost, in this case it can only have a red “LED” or a non-functioning acoustic signal!). The “Hub” can manage on its own the monitoring of the network(based on the local AI evaluation processes) and generating events related to the network itself (alert): e.g. the “Hub” has no connected devices and sends to the “Cloud” an alert of "devices not connected".

Finally, we study “Cloud” package which plays the role of control system but also with the ability to filter large volume data and delete unwanted parts. Actually, everything that happens on the system, the “Cloud” must record it with the data coming from the “Hub”, generated by it or by the devices. As shown in the “Use Case” diagram after an alert detection, inside the “Cloud” package, in the first step the alert is received through the “Gateway” and then it’s possible to send an alert to various destinations (like “Caregiver”, “Service Provider”, or any members from “Social Forest”) provided that, we evaluate it before. That’s why there is an “Alert Evaluation” use case linked by an “include” to the “Send Alert” use case, because it’s not reasonable to inform others before we reach to a clear conclusion about what happened! This evaluation will be performed through the predefined artificial intelligence approaches.

However, it is possible to complete this evaluation by determining alert type at the same time, which can be a “Device Alert” or a “SM Alert” as shown in the “Use Case” diagram below (figure-6). Unlike the previous links we used for connecting use cases, this time we apply two “extend” link for “Device Alert” and “SM Alert”. That’s because none of these steps is not compulsory and “Alert Evaluation” is done anyway but we consider these steps just as the evolution of main use case’s operations.

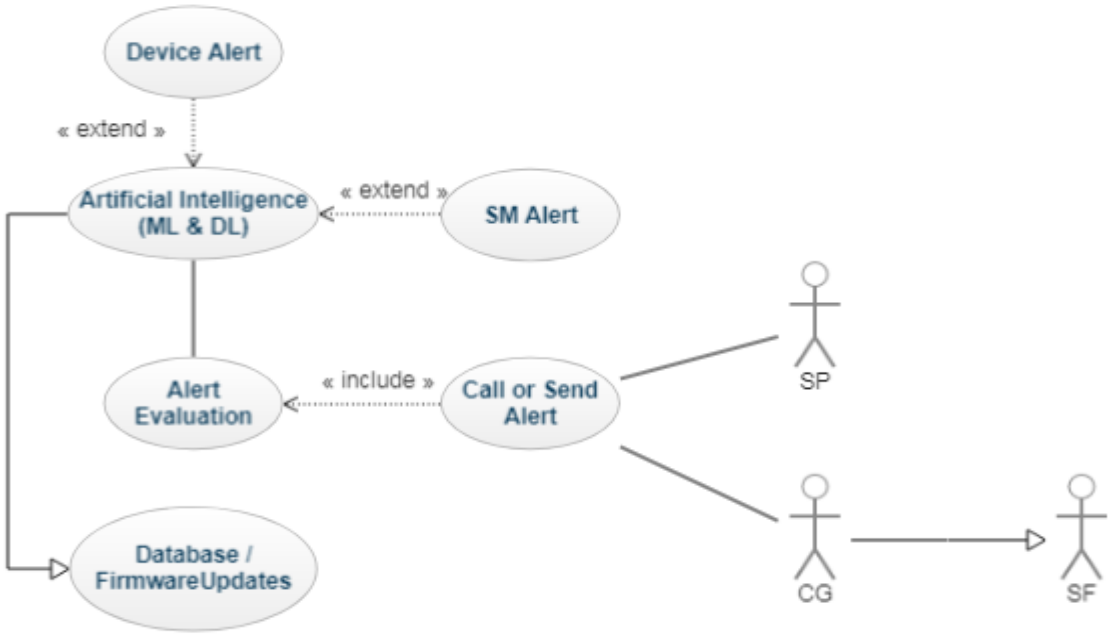

Figure 6- Cloud

2-Service Provider Use Case

Based on what we discussed till now in case of any fall events, inadequate battery charge level, or unworn bracelet an alert signal will be sent to the service provider, so the question is what happened next? Should the service provider calls emergency centers immediately or there are other actions with the higher priority? This is what we want to study now using the service provider package which is shown below (figure-7).

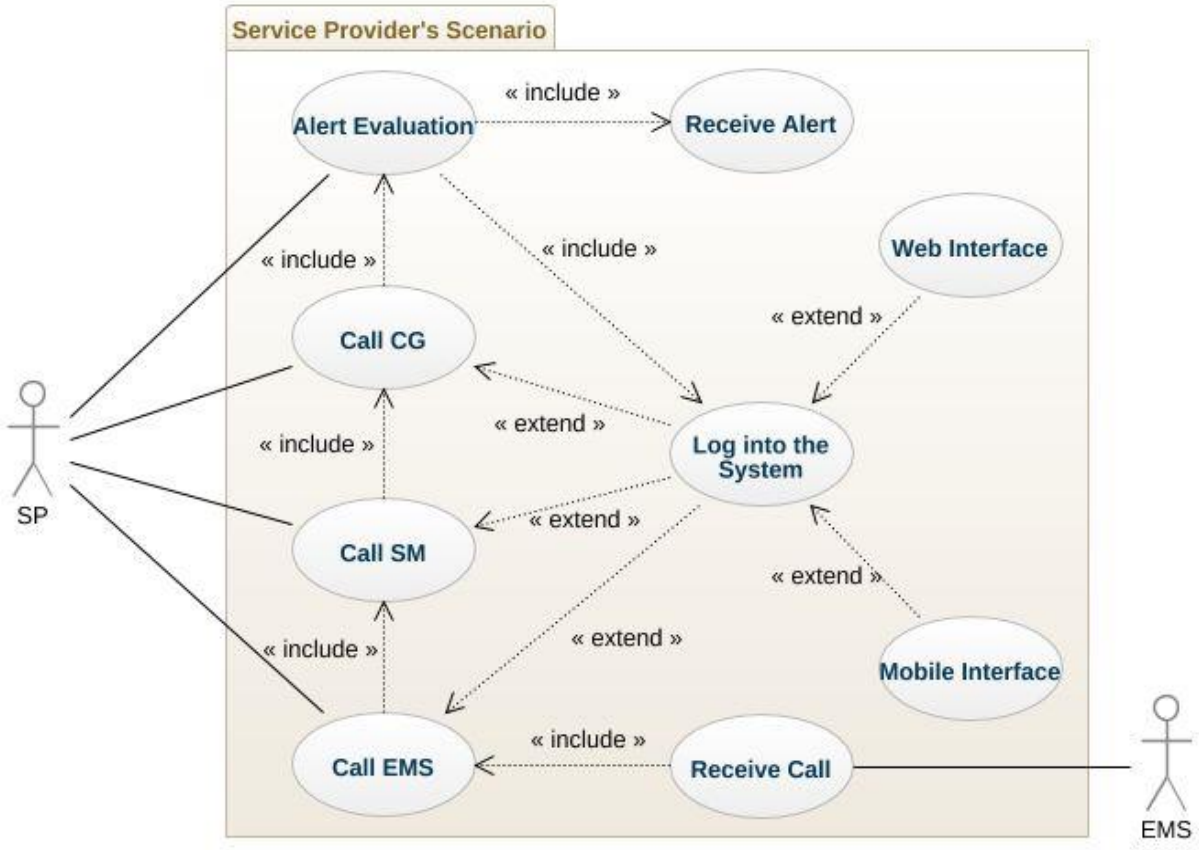

Figure 7- Service Provider's Scenario

As soon as "SP" receives an alert signal from "Cloud", it starts to assess current condition and perform essential activities including make phone calls to nearest hospital or "EMS". Nevertheless, it's clear that calling emergency centers could not be the first thing to do because before we insure about what happened and, also about the type of alert it is not reasonable to call "EMS".

For instance, consider the situation that bracelet works with low battery percentage or as another example imagine an old person who puts his bracelet off for some seconds to wash his hands and then he forgets to wear it again! In both cases the bracelet will send an alert to "Cloud" which after

a few moments received by "SP" too, but obviously it is not reasonable to immediately call "EMS"! Otherwise there will exist many unnecessary calls every time which leads to waste of time and money!

For this reason and to minimize the error percentage, the best idea is considering "Call SM", "Call CG" and "Alert Evaluation" before making any calls to emergency centers or hospitals. This is what is displayed in (figure-8) by using "include" links between mentioned use cases.

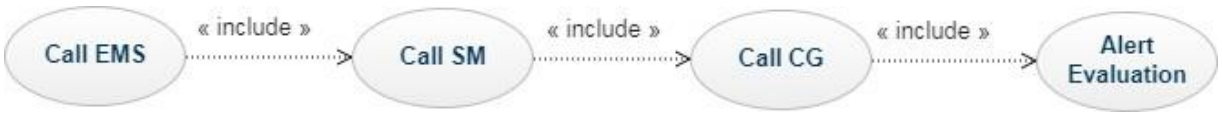

Figure 8- Calling "EMS" Procedure

In next step after that service provider makes a call to person under monitoring, the caregiver or "EMS", it is possible (but not necessary) to extend this process for access to the system through the specific web or mobile interfaces and assess the recorded information, while for evaluation of received alert service provider needs to login into the system, cause clearly it is not possible to do "Alert Evaluation" without check the systems information! It depicted in (figure-9) by using "extend" links for "Call SM", "Call EMS" & "Call CG", and by using "include" link for "Alert Evaluation" use case.

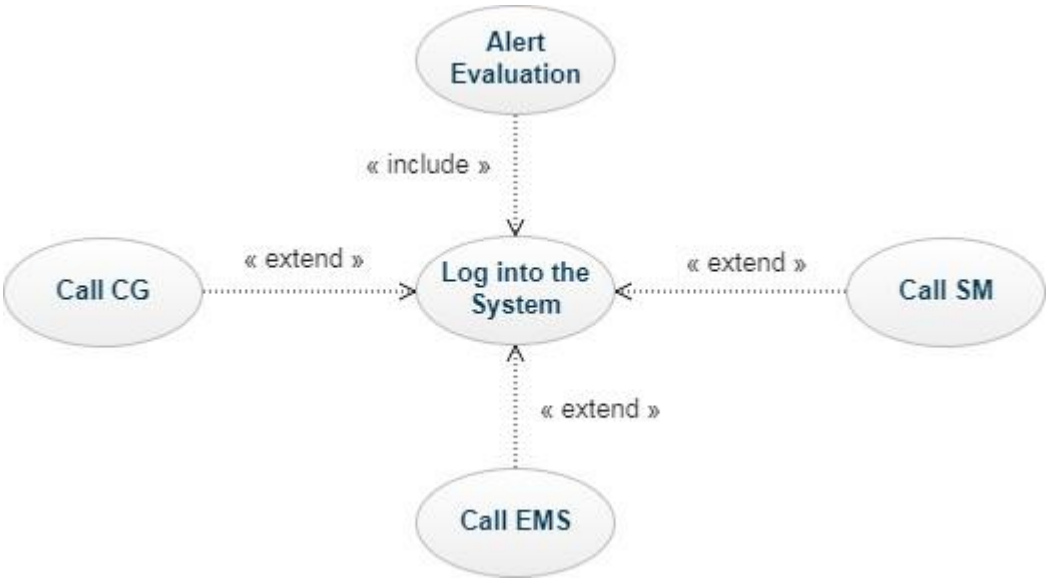

Figure 9- Login Process

Development & Prerequisites

3- Infrastructure Provider Use Case

Till now we studied the whole needed procedure to understand how the monitoring system works for a single user like an old man or woman. We have reviewed all that happens from start to end, from the moment of occurrence of first fall event till when the service provider gets involved and takes different actions to solve the problems in the best and of course lowest cost way.

Now we want to talk about when we face with a group of elder people not necessarily with the same profile and location. They could be in different ages and have various physical properties, but all need the same thing which is a continuous and reliable protection.

As a result, we need to develop our system to provide the desirable protection on a wider scale with higher number of customers and of course service providers! This is what illustrated in (figure-10) as “Infrastructure Providers Scenario”.

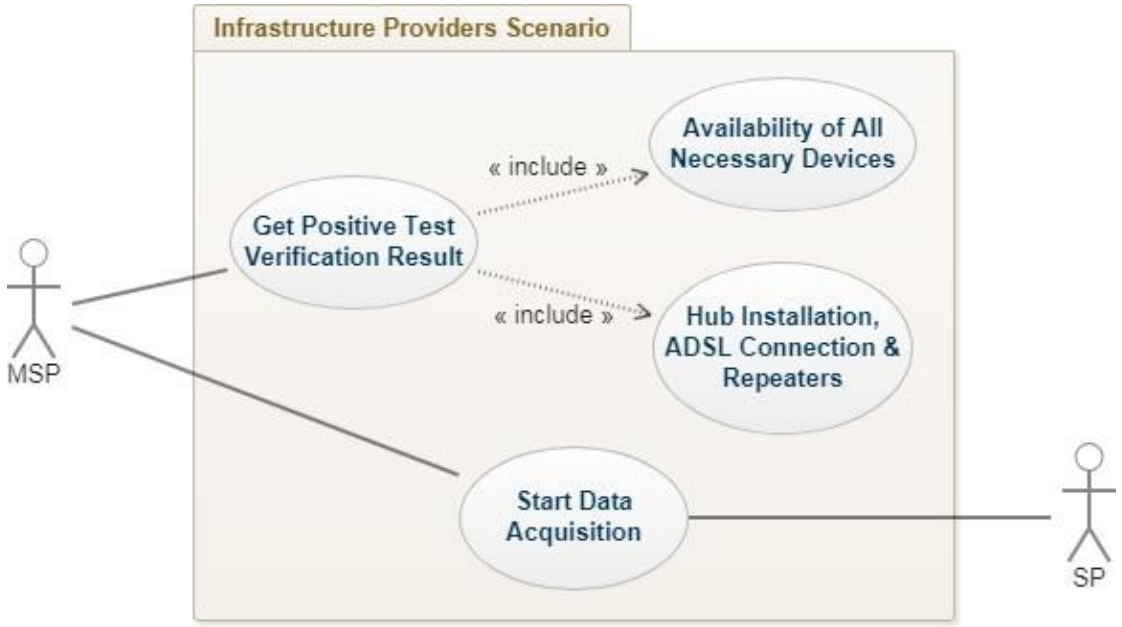

Figure 10- Infrastructure Provider Scenario

As shown in the picture above, each service provider is in contact with “MSP” to transfer information bilaterally that is specified by “Start Data Acquisition” use case. In the next step “MSP” starts to examine individual operation of all service providers to detect any probable fault or problem and this is depicted in the above picture as “Get Positive Verification Result” use case.

However, there are two prerequisites to get a positive result and insure that everything works well. At first, the “MSP” needs to check the availability of all necessary devices including bracelets, routers, cables, and any related hardware that used in operation cycle.

In next level, it is important to check the required software platforms and communications including “Hub” installation, ADSL connection (or any other types like Ethernet), and repeaters performance (an electronic device that receives a signal and retransmits it, more precisely they are used to extend transmissions so that the signal can cover longer distances or be received on the other side of an obstruction). These steps are shown in the “Infrastructure Providers Scenario” by using two “include” links which apply for obligatory use cases.

References:

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[2] URL:http://www.un.org/en/sections/issues-depth/ageing/index.html

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[4] Bradley SM. Falls in older adults. *Mt Sinai J Med.* 2011 Jul-Aug;78(4):590-5. PMID: 21748747

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[6] URL:https://blog.bluetooth.com/bluetooth-low-energy