A

PROJECT ON

SYSTEM ANALYSIS AND DESIGN OF FALL DETECTION HOME ASSISTIVE TECHNOLOGY.

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Course : Smart Systems

Date : 18/06/2020

INTRODUCTION ON FALL DETECTION

Falls are major risky and abnormal events occurring infrequently to elderly people aged 65 years and above, individuals with leg weakness, balance disorder and also the blind causing premature deaths or possible major injuries, head trauma, paralysis and coma. According to World Health Organization (WHO) age demography, 28% to 35% of world elderly population aged 65 and above encounter falls every year with 424,000 death cases being recorded as result of fall related injuries. Therefore, this ranks falls as second leading cause of death (Santiago, Cotto, Jaimes & Vergara-Laurens, 2017). Fall detection system is defined as assistive device founded on purposed of raising alarm on occurrence of fall event. Fall detection system is crucial for aging-at-home of the elderly whereby in regard to this, various fall-detection solutions have been advanced on basis of sensitivity, accuracy, reliability and specificity requirements for adequate assistive surveillance system that enhances life safety for the aged.

PART 1:

Requirements Identification and Modelling

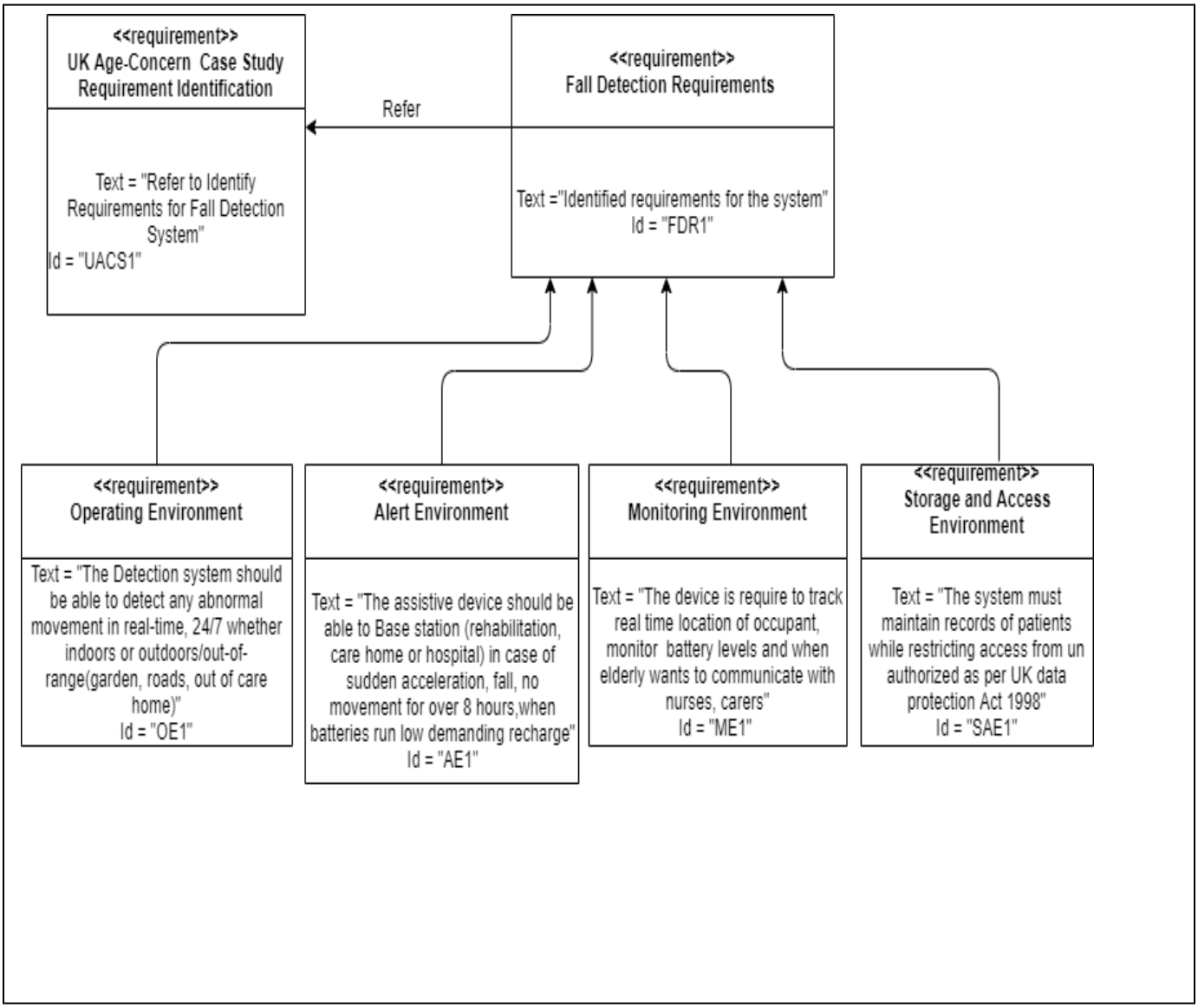
Age Concern in UK Case Study Abstraction

Age Concern care home in Britain houses elderly people with over 60% facing death as result of fall. Current system used is not based on automatic fall detection and alarm creation as residents must press telephone button every morning by 11 o'clock if one is okay, failure a staff member visits the household to identify reason. Pendants requiring manual action are placed in lift to be pressed during emergencies. The system further falls inadequate as it lacks secure and efficient resident data storage. Therefore as management seeks to upgrade to an automatic fall detection system, following requirements have been proposed for the future system. When one experiences a fall, automatic fall detection system should detect and alert for help by activating emergency response structure on its own or be triggered by person. Fall detection system should operate on both indoor and outdoor environment, for example garden be connected to mobile assistive technology. The automation of the detection system should therefore manage behaviors such as false alarms, forgotten pendants stored away, freeing person to venture out of compound. The system should continuously monitor location and movement in real time, evaluate form of movement through intelligent algorithms then activate an alarm if elderly walks out of care home, no movement for over 8 hours or after sudden acceleration and fall. Medical professionals

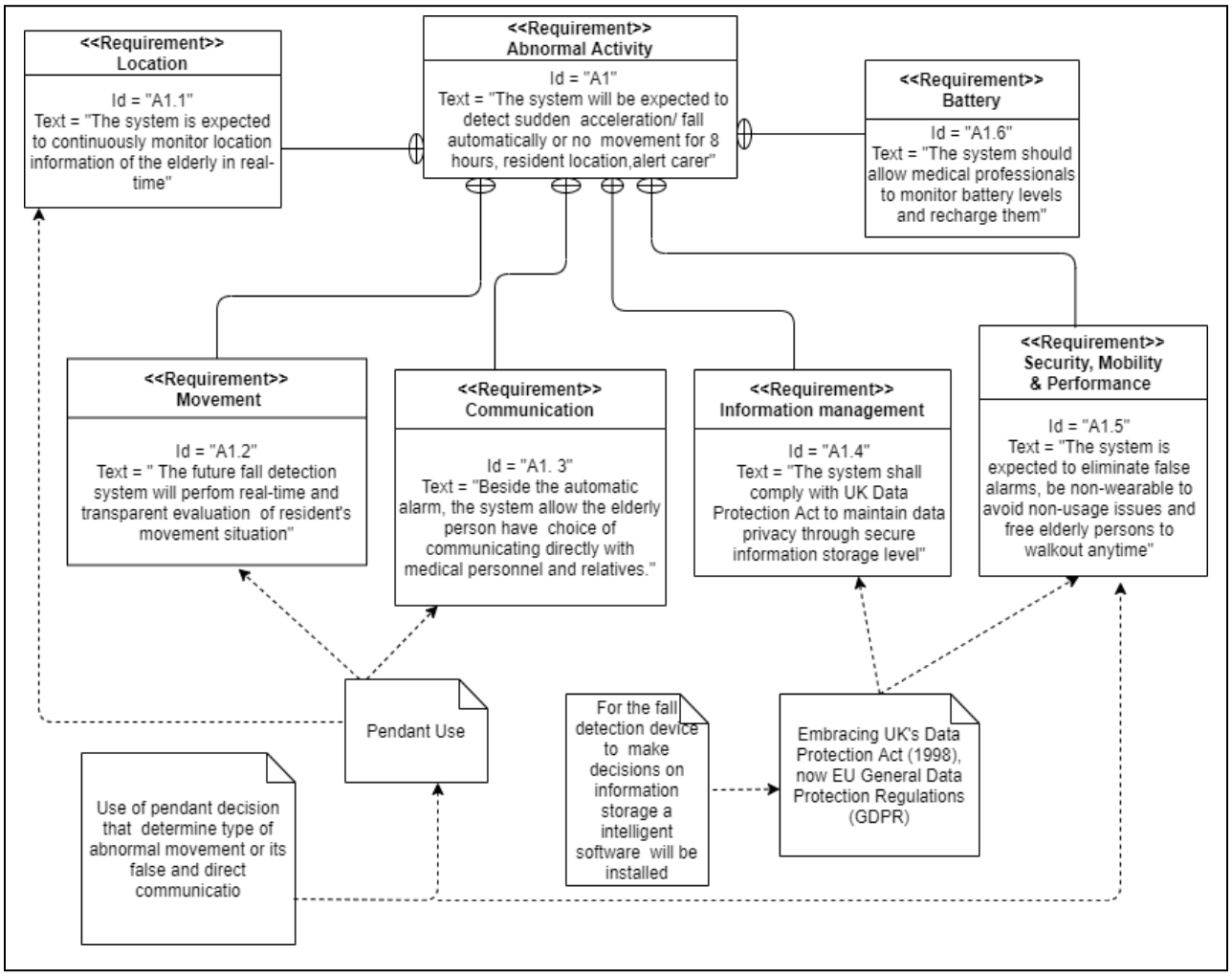
should have access to system, monitor battery levels and recharge the batteries. There should be communication interface between elderly and medical professionals and relatives. Lastly the system is required to host safe information storage repository, accessible by the authorized staff. These requirements are summarized and displayed in below SysML Requirement diagrams.

Produce two SysML Requirements diagrams for the given case study:

SysML Requirements Diagram 1 : High Level



SysML Requirements Diagram 2: Low Level



PART 2

Design and Propose a System Solution for This Case Study

Introduction

This research section aims at presenting extensive review of existing fall detection assistive technologies. Automatic fall detection technologies employed can be assembled into three broad categories as wearable sensor-based systems (WS), non-wearable-based system (NWS) and hybrid-based or fusion systems (FS) (Yacchirema, Puga, Palau & Esteve, 2019). Non-wearable based systems also environmental sensing-based systems involve both vision and ambient-based fall detection systems are placed in subject's surrounding environment such as bathroom, bedroom or garden to detect fall through sensing environment signals that track abnormalities in movement of the subject. NWS include acoustic sensors, cameras, microphones, pressure sensors, thermal sensors and infrared sensors (Ren & Peng, 2019). Wearable-based systems are closely attached to the body to detect when the bearer is experiencing a fall through use of the movement sensors such as gyroscope, barometer, tilt meter, accelerometer and magnetometers fitted in the necklace belt or watch.

i) Literature review of existing assistive technologies.

1. Walabot HOME Fall Alert System

Tel Aviv and San Francisco based Vayyar Imaging, leading company popularly known for its 3D imaging technology launched a Walabot HOME, an automatic health monitoring and fall detection smart home device which is mounted on the wall and uses radar based 3D imaging to monitor occupants' movement without user privacy invasion. Therefore, Walabot HOME non-wearable with neither button, pendant nor cameras but capable of detecting all types of falls, gets assistance for unconscious user as it bears ability to reach for help. Unlike smart watches and pendants, Walabot HOME does not prompt user to charge it. It bears simple installation process, that is; mount on the wall, configure to companion application tailored for iOS or Android device whereby on fall it notifies up to four saved emergency contact's phone via two-way voice for help. The fall alert system work 24×7×365 effortlessly without user intervention, covering whole as per package bought, whether for a single room, multiple rooms or home package. It has 4× accuracy while enhancing control privacy through adoption of advanced motion detection technology hinged on radio wave signals unlike accelerometers and camera images, collecting no

optical data (Walabot.com, 2018). Machine-learning artificial intelligence employed in implementation adapts to changing patterns of homes.

2. Unaliwear's Kanega LTE Watch

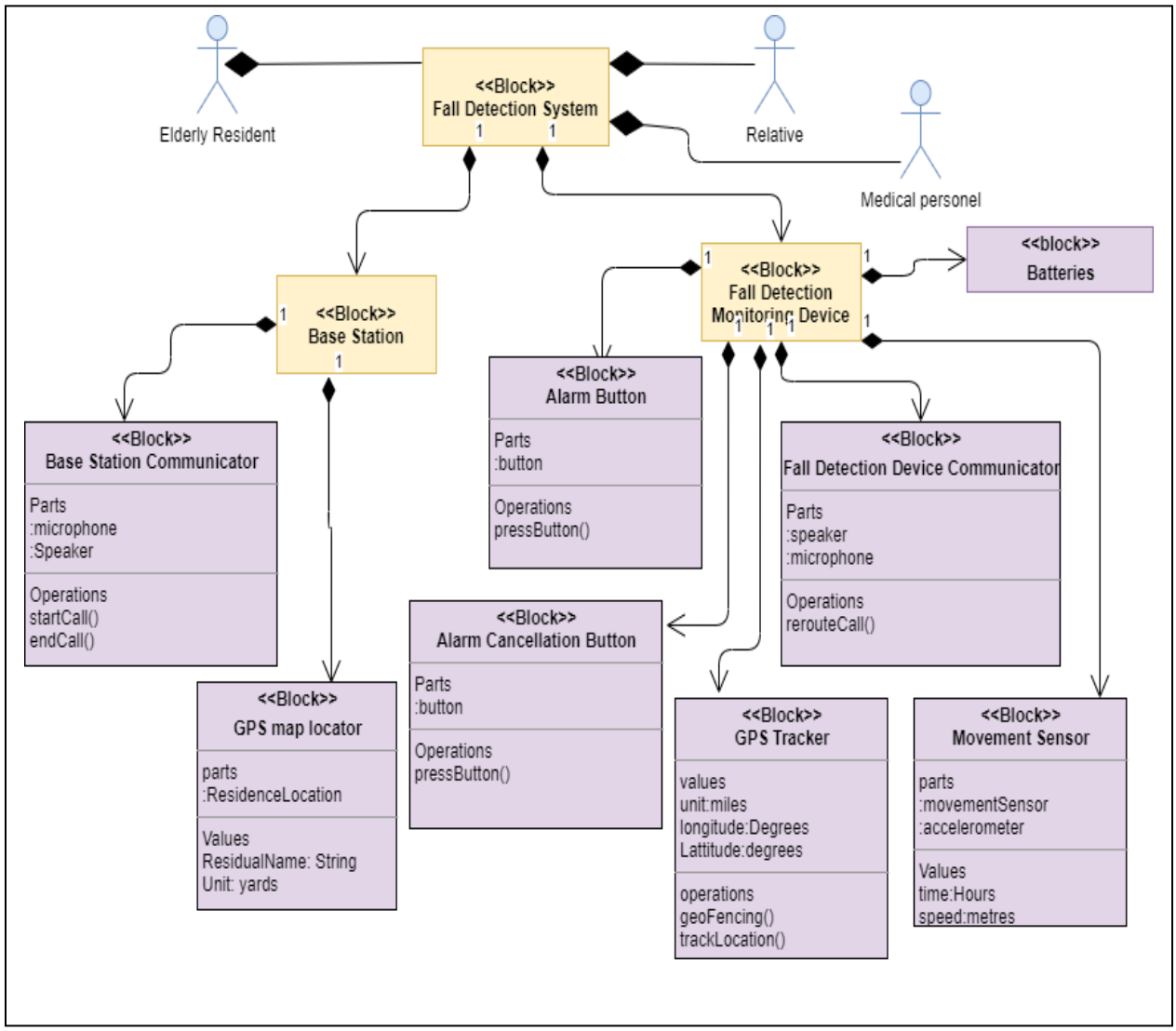
The Unaliwear Company introduced Kanega self-contained and voice-controlled smart watch purposively designed to keep elderly persons safe, active and independent but connected as its not connected a smartphone or home-based system. Its fall detection operations are tied to embedded proprietary technology that detects a fall or abnormal movement insinuating fall automatically then alerts bearer with buzzles while showing emergency message on the screen which on failure to respond to, it automatically beeps and calls emergency response operator. Being a voice controlled device, one can speak directly to device which is capable of responding to short voice commands send. Kanega LTE watch allows one to select person of choice; friend or relative to get connected (Unaliwear.com, 2015). The Kanega Watch offers wearer 24/7 protection for its waterproof feature one take it to shower overnight and on outdoor besides possessing a patented battery system, implying one does not take it off for charging instead, it will automatically remind wear to change low batteries with spare. The watch technology combines WI-FI, cellular, BLE and GPS location assistance since when one is out, the watch can trace where you are and track where you have been. Lastly the watch releases medication reminders through either voice, wrist tap or else a text (John, 2019).

3. FallWatch wearable miniaturized fall detection device

It is a telecommunicating fall detector implemented by Vigilio S.A in France to automatically detect a fall event and reciprocate immediate by contacting health professional nurse or carer for emergency check-up. The device can be worn for duration of up to 30 days, utilizing environmental infra-red sensors at the victim's residence with certain data fusion algorithm for danced reliability. Further, the Vigi'Fall patch device is capable of tracking victim's heartbeat, record and post the information to health services team. Performance trials conducted in hospital, laboratory, domestic and nursing home environments demonstrate over 90% successful and accurate detection using only biosensor. Inclusion of data-fusion software in real environment trials, high success rate is recorded with full elimination of false alerts (Vigilio, 2011).

ii) Designing, creating and explaining two (x2) SysML block diagrams for structure.

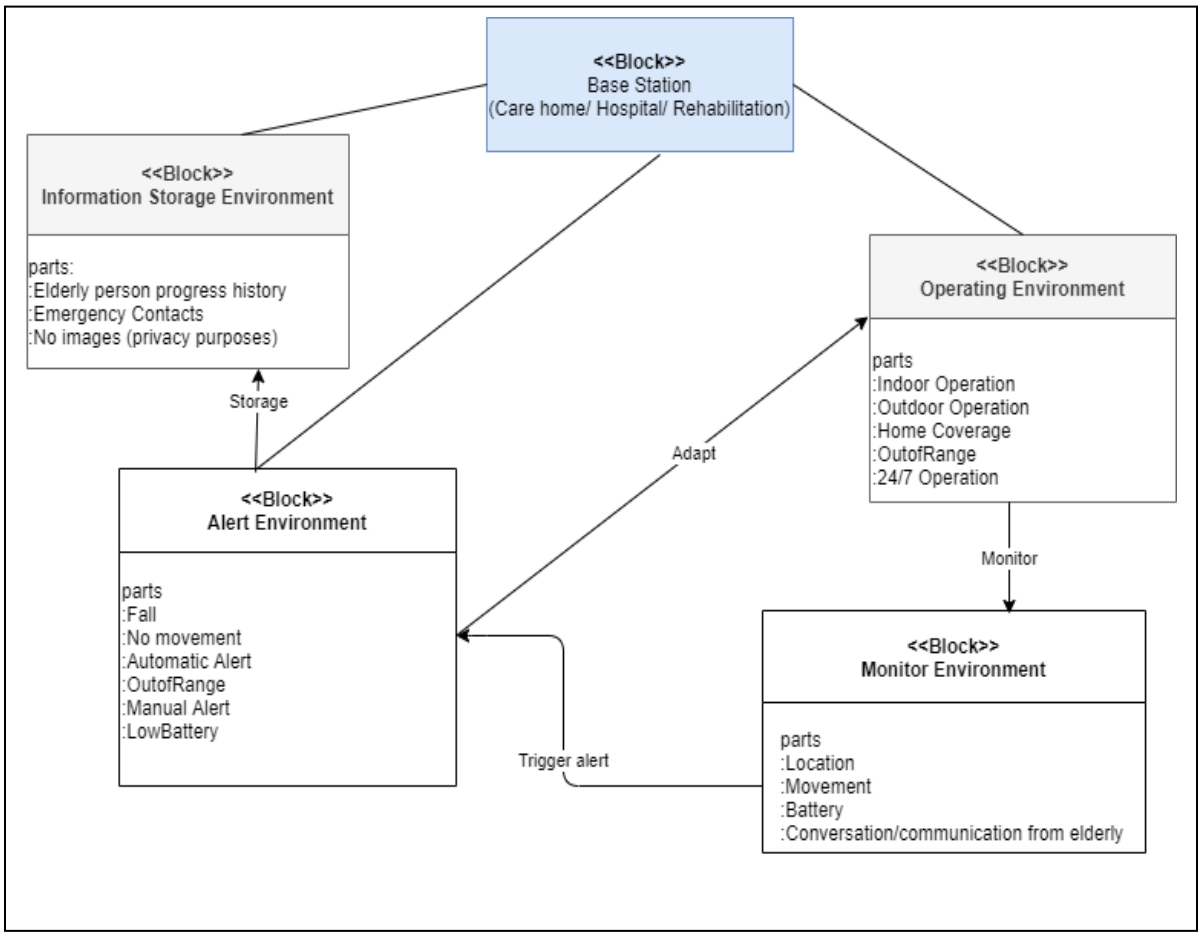
SysML Block Diagram 1



Explanation

Block diagram above gives overall structure for the system. The actors to the fall detection system are three; an elderly lone home occupant, relative and medical personnel representing nurses, carers, medical doctors and therapist. The system structure is further split into two base station (Respondence side) and monitoring device working operations (at the patient's residence). Base station is composed of communicator and GPS map locator while on monitoring and alert side, structure differentiates into device communicator, GPS tracker, Movement sensor Alarm Button, and Alarm Cancellation and Device batteries.

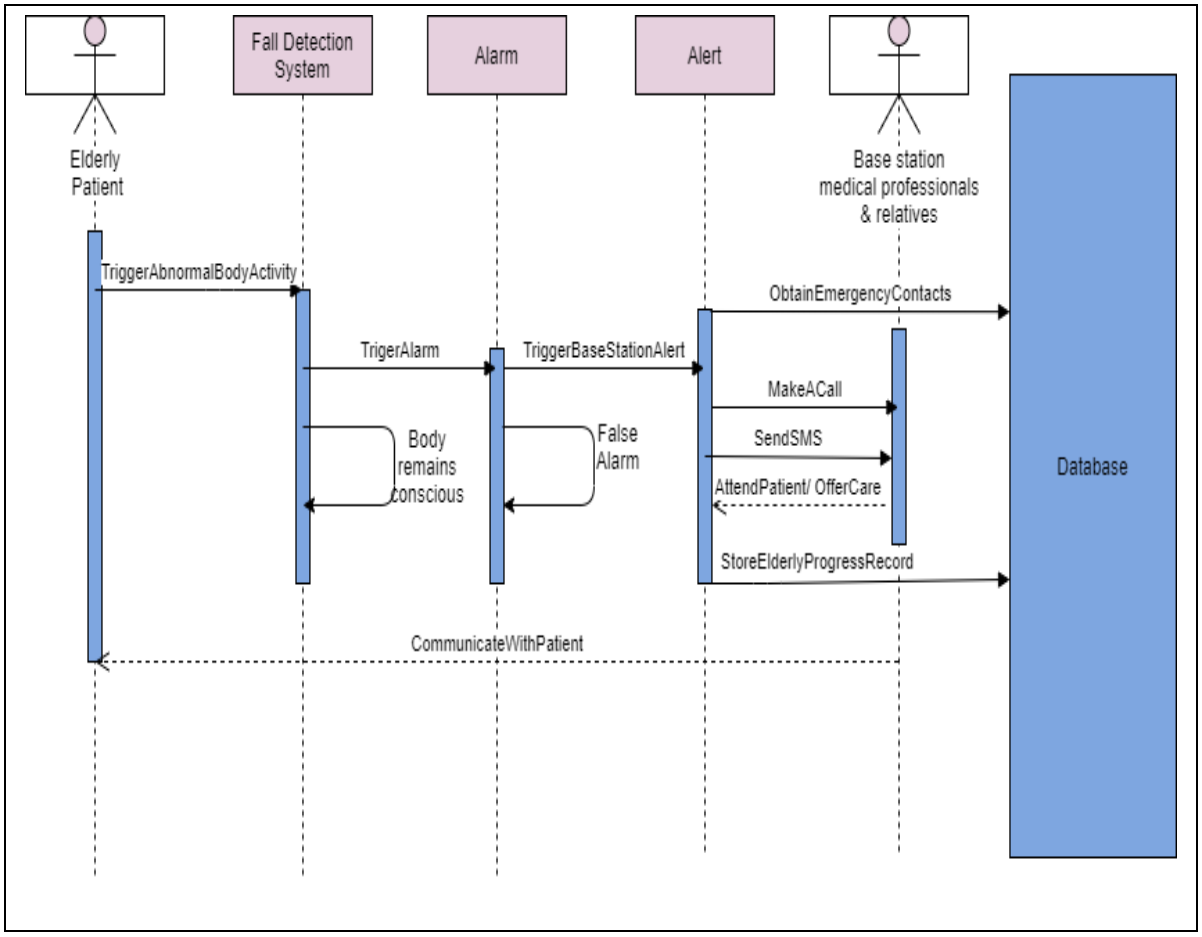
SysML Block Diagram 2



Explanation

Block diagram is a low level abstraction of the proposed fall detection system from Base station viewpoint, giving a breakdown of various environments interacted together. Base station closely interacts with alert, operating and storage environment and indirectly with monitoring environment. Alert Environment is responsible for alerting in case of a fall, no movement detected for long hours, low battery in pendants, through both automatic and manual alert methods. Operating environment covers both indoor, outdoor, entire home coverage and out of range places through 24 hour monitoring. Monitoring environment covers both fall and non-fall movements, location. Battery levels and conversation induced by elderly. Storage interface maintains contacts for responsible care groups and secure data archiving for the elderly.

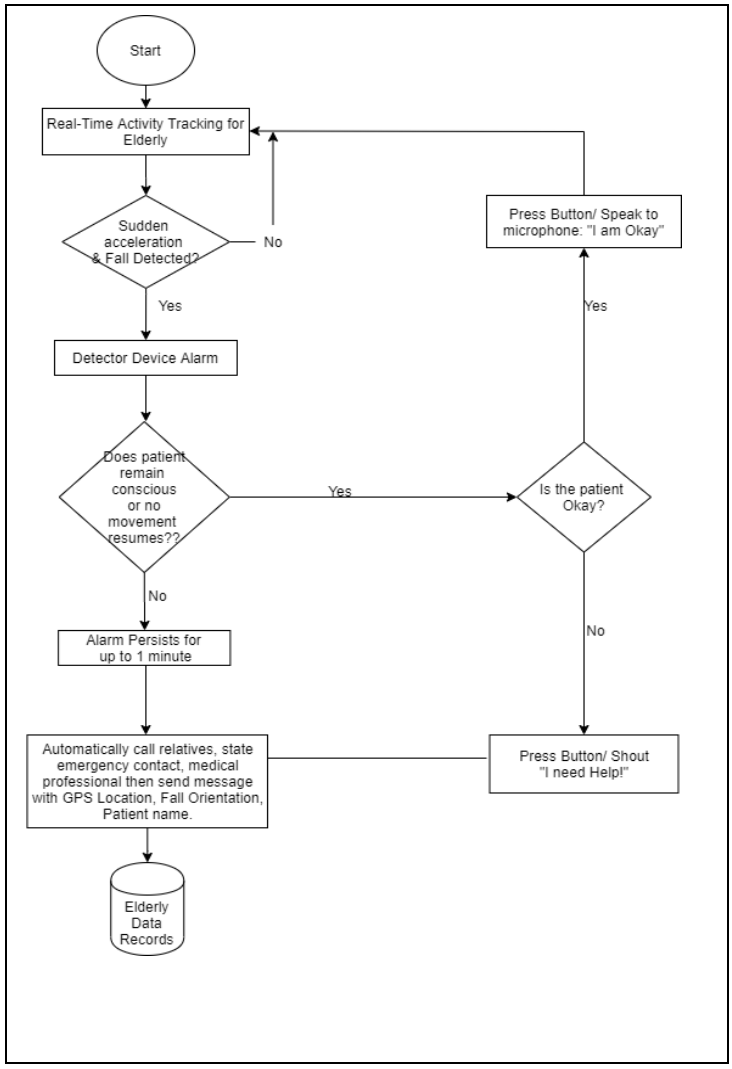
iii) Designing, creating and explaining one (x1) SysML Sequence diagram for behavior.



Explanation

Above is a sequence diagram summarizes behavior for the actors interacting with the fall detection system. An elderly patient initiates the process on encountering an abnormal fall condition detected by the system. If it is a non-fall event, that is body conscious, the process is denied and returned while if body remains unconscious a sounding alarm is activated for 30 seconds, if not responded to after 1 minute, it triggers alert. The system allows patient to designate “false alarm” message, returning back the process. The alert system is prompted to obtain responsible personnel contacts from cloud storage database from which it can make a call to medical professionals and relatives after which it leaves a message indication name and location. Once the situation is assessed and appropriate care granted, all patient data is safely stored. Further the system allows the elderly and medical personnel to communicate at free will unlike when triggered by automatic alarms.

iv) Designing, creating and explaining one (x1) SysML Activity diagram for behavior.



Explanation

Activity diagram addressing on behavior draws the proposed fall detection system solution by tracking an elderly on real-time. On detecting abnormal sudden acceleration or fall it activates device alarm. It further tests if the patients resumes conscious state or not, whereby if no, Alarm persists longer for 1 minute to reach for help from relatives and health personnel. If the user resumes normal movement, the patients is required disseminate a message if he/she is okay, by pressing “I’m okay” or speak into microphone then activity loop returns to start to iterate the process in next abnormal condition.

v) Smart element identification:

Devices are referred to as “smart” due to capability to provide information or service right on demand. Features such as messaging services, web access and real-time applications ascribe to a smart device. The proposed fall detection system is a smart home assistive technology, prove agitated by following elements.

- **Real-time Global Positioning System (GPS) location**
  Tri-axis accelerometer embedded in device with GPS enables it to monitor, locate and raise alert.
- **Sending Shortest Message Service (SMS)**
  Fall detection system auto generates message with name of occupant, location and orientation of fall.
- **Automatic Alarm notification system**
  The device activates alarm automatically that grows louder on timing after which it alerts the medical professional of not controlled in 1 minute.
- **Unobtrusive auto-alerting system**
  The system automatically sends notifications to groups of people responsible for care of the elderly through calls then messages.
- **Real-time movement detection**
  Through intelligent decision trees, the system recognizes falls and discriminates non-falls. Device is fitted with 3D-axis accelerometer responsible for collecting movements of elderly in real time.
- **Real-time (cloud) storage service**
  The proposed system is capable of storing emergency contacts accessible anytime of fall event.
- **24/7 omnipresent system**
  The system monitors all day all night, when indoors, outdoors or out of range
- **Embedding in smartphone and smartwatch**
  These are both wearable devices increasing the mobility of the fall detection system.
- **Automatic voice calls**

The victim speaks to microphone and voice is transmitted through radio waves.

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