Statement of Work

Team IOT

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CMU
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Document Overview

Purpose

The purpose of this document is to describe in detail the work to be done by the Team IOT that consists of 4 students from the Master of Science in Information and Technology – Embedded Software Engineering (MSIT-ESE) program at Carnegie Mellon University, for Bosch Research and Technology Center, Pittsburgh, PA.

Intended Audience

This document is intended for Bosch Research and Technology Center, Team IOT, and the MSIT-ESE advisor, Anthony Lattanze, to have a common ground on what is to be done in the project.

Scope of Document

This document focuses on the development and planning activities of the project, the hardware and software needed to be used in the project, defining the success criteria and scope of the project. The IOT project is being completed by Team IOT as part of the MSIT-ESE program at Carnegie Mellon University.

Project Overview

Project Background

The project titled “Internet Of Things” (IOT) is sponsored by Bosch RTC, Pittsburgh PA. The following text gives a background about the project.
Today with increasing use of computers in our daily life it is easy to imagine a world where physical and virtual objects and humans are seamlessly integrated into a ubiquitous information network. Such a framework would make these objects, their data, and services easily accessible. This vision of hyper-connectivity is often referred to as the Internet of Things (IoT). The general forms of the IoT are machine-to-machine, machine-to-man, and man-to-machine.
Interfaces generally take the form of services that facilitate interactions with, and between objects. These services would be available to facilitate interaction with humans, physical, and virtual objects. Interactions might include query and state change, access to remote devices (e g. sensors) and data while taking into account security, privacy, safety, performance, and other similar quality attribute issues.

IoT has a potential to revolutionize our homes. However, while IoT is an exciting and promising paradigm, there are obstacles to overcome before IOT related ideas can be translated into widely available products and applications for the mass market. A few of these challenges include:

- Standardization: Currently there is a lack of technological standardization in terms of protocols, interfaces, hardware platforms, discovery and announcement of IoT services. The industry is in its infancy and remains fragmented. This is an obstacle for IoT adoption in terms of supporting mass production, device commonality, and a commodity market of products.
- Security and Safety: To successfully deploy IoT it is essential that data confidentiality, non-repudiation, authentication, and similar security issues are addressed satisfactorily depending on the application sensitivity. In addition to protection from internet hacking, remote objects may require additional physical security or the ability to sense tampering or the ability to otherwise detect physical malicious intrusion. Closely coupled with security is the safe operation of objects and

devices in the IoT – especially if objects interact with humans or property in a way that could be hazardous.

- Sensor Data Representation, Fusion, Power, and Prognostication: Each of these present a unique challenge. Representation and format of sensor data is a challenge since network bandwidth remains an issue – especially in timely applications. In situations where heterogeneous sensors are used, fusing data from different sensors of the same type presents a key challenge. Given the proliferation of wireless sensors power management will be an important issue especially with remotely deployed sensors. Real -time adaptive energy aware power management techniques will be essential. Sensor failure is a common issue in embedded systems, but becomes a thorny issue when the consumer of sensor data is significantly separated from the sensor platform. Prognostication techniques to detect failure and degradation of remote sensors are critical to IoT.

This project is an attempt to look for solutions to some of these problems by building an end to end IOT system for a home.

Project Goals

The goal of the team is to perform a product exploration to answer some key questions for product developers in the IoT space.

- This projects goal is to explore IoT infrastructure and protocols for device announcement and service discovery in a house.

- The project is aimed at experimenting with different kinds of “local” and “decentralized” protocols that facilitate the discovery of sensors, actuators, phones, tablets to interact and then communicate between them to perform desired actions. Local Protocols deal with devices who communicate with each other in absence of the Internet. Decentralized protocols mean that there is not centralized point of control in the protocol.

- During the design and implementation of this project certain questions need to be answered on which path to take for the final implementation. This is an important goal of the project as it will give a formal analysis of different approaches to solve the same problem. Listed below are the three major questions identified from the discussions with the client.

  1. What kind of service discovery protocol can be used? Two examples of this can be listed below:
     - Consumer initiated discovery: where the consumer of a service can initiate the discovery of a service like notification or illumination.
     - Producer initiated discovery: where the provider of a service announces periodically about its availability and consumer contacts the provider when the service is needed.

  2. What are the different ways to represent Location and to what granularity is the location should location be represented?

  3. What are the different methods of representing other services offered by nodes in the home? How are these broken down into sub categories?

- After such an end to end system is built it is to be evaluated for certain parameters. These parameters are listed below:

    1. How the system survives in the case of a failure of a node.
    2. Energy consumed by each node thus affecting battery life of nodes.
    3. Response Time of the system. The time it takes for the system to perform the desired task from the point when it received the stimulus to perform the task.
    4. How easy to install is the system

Success Criteria

1. There is a strong rationale behind all the decisions that the team take regarding the architecture of the system. And all this rationale is appropriately documented.
2. The system in place works correctly in the demo.
3. The code that the team delivers is easy to understand and to build upon.

Project Scope

This defines what work is to be done during the course of the project and also tries to define the expected output of the project in the form of describing the final demonstration.

Final Demonstration

The capabilities of the IoT framework of service discovery have to be demonstrated by two scenarios. These scenarios will serve two purposes:

- Exercise the capabilities of discovery of service by nodes and user devices in the home
- Doing some assistive work making life easy for the user

Scenario A:

A guest wants to enter the house of the user. The guest rings the door bell.

The nodes in the home locate the user and deliver a notification to him about a guest present at the door.

The notification will be in the form of light and sound. The responsibility of the notification is upon the node that is delivering the notification. For the purpose of the demonstration the notification for the doorbell will be delivered in two ways.

1. Blinking an LED
2. Creating a sound/having pre recorded audio play near the specific user

Services needed in the scenario:

This scenario will have the nodes use the Self Location service as well as the Location of Users service to determine proximity with the User and then deliver a Notification via the notification service.

Self Location – By this service any node or user device would know its own location. This service is to be stubbed and not to be implemented as a whole.

Location of Users – By this service any node or user device can know the location of a particular user in the house

Notification – By this service any node or user device can notify users in the house. The method by which this notification is delivered is up to a provider of this service. In this scenario it will be delivered in form of light and sound.

Nodes needed in this scenario:

- Doorbell
- Speaker
- Node with Light source (LED bulb)
- User device for location

Scenario B:

When the user enters the house, the home detects the user and starts playing music in the room that the user is in.

Now the user enters another room and the speaker in the new room starts playing the same music from where he left off in the previous room.

In this way if there are two users in different rooms they can listen to different music when as long as they are in different rooms.

The concept of this is where ever the user goes the music follows.

Services needed in the scenario:

This scenario will use the self location service of each node (as described in the previous scenario) and the Location of users service (as described in the previous scenario) to determine the location of a particular user. With this information the proximity of the music playback service provider will be determined and music will be streamed from a music server to a music player. When the user moves to another room the music server now uses the new music player in the other room to play music.

Music Server Service – This service is used as a source of the music stream over the network.

Music Player Service – This service is used as music playback when the source of the music is a music stream over the network. This works with the Music Server Service.

Nodes needed in this scenario:

- One node as Music Server
- Two nodes as Music Player/Speaker
- User Device

Hardware

- The team will try to select off the shelf embedded boards that provide functionalities required in the project and if necessary have some customizations over them.
- The selection process will involve evaluation of different boards and the functionality they offer
- Android phones will be used to communicate with these embedded boards.

Software

- The team will develop the software for the embedded boards to interact with other nodes and the user device in the system
- The team will develop the software for Android OS to interact and configure the nodes in the house.

Architecture

- The team will be eliciting requirements from the client and on the basis of that create an architecture for the system
- This architectural documentation will carry the detailed design and the rationale for building the system

Out of Scope

- Determining the location of a User in a house is not in the scope of this project. This functionality will be stubbed for the purposes of this project. There would be a mechanism where the user himself has to interact with the system to give input about his/her location in the house.
- The ability of the system to let a new node or user device join the home securely such that its information is not exposed to any other entity outside the home and any other issues regarding the security or privacy of the user is not in the scope of the project.

Key Deliverables

The deliverables of the project includes following items.

- Statement of work.
- Architecture design document.
- Sensor boards that we build.
- Framework running on those boards.
- Demonstration of the agreed Scenarios.
- Android application for interacting with the nodes.
- Videos of the demo.
- User guide.

Project Stakeholders and Expectations

There are three major stakeholders for this project. Below is a description of what is expected of each of them.

ESE Team

- Attend weekly meetings with the customer to gather requirements and show the progress of work.
- Have all the deliverables ready on time.
- Apply software engineering principles to this project, and present them in the EOSPs.

Bosch RTC

- Reply to team questions and requests as soon as possible.
- Critical questions that impact the timeline of the project, will be sent via email/ or raised in meetings. If the response to these questions exceeds 2 working days, project delivery could be impacted.
- Review and approve Statement of Work.
- Review and send feedback on deliverables and artifacts sent by the team.
- Deliver the hardware resources (see appendix for hardware details).
- Provide access to the cloud computing platform.
- Decide on the time to have weekly meetings with the Team BIOT.
- Share their travel plans in advance, especially if it could impact their response time to a query

Mentor

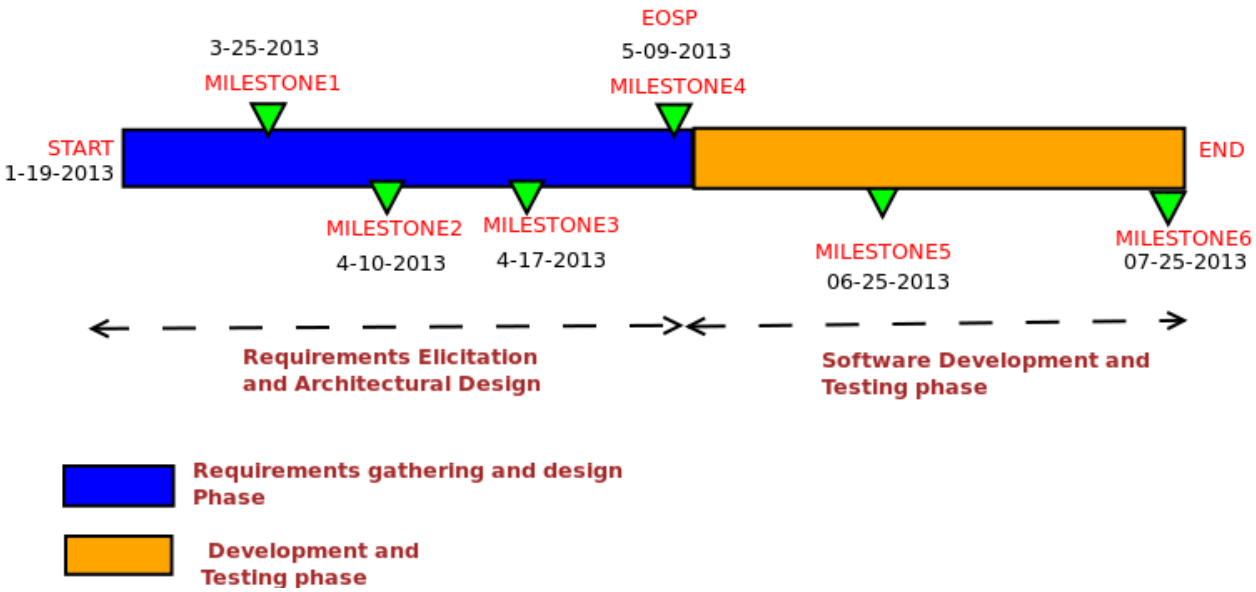
- Attend to team and individual mentor meetings, in order to provide feedback and guidance.
- Reply to team questions and requests as soon as possible.
- Help the team in case of a major problem.

Project Plan

Project Timeline

The project starts on 15th January and ends on the 15th of August.

Below is the project time line that gives an idea of how goals in the project are set in time and when they are supposed to be achieved.



Milestones and Deliverables

Milestones	Due time	Description	Status	Key deliverables
Milestone 1	March 25th	Establishing project scope	In progress	Architectural drivers
			In progress	SOW
			In progress	Project Strategy
Milestone 2	April 10th	Creation of Notional Architecture completed	Not started	Architectural documents which include runtime, physical and code view of the system
Exploration on Hardwares, localization and Hardware Feasibility	March 25th	Exploration of various hard wares for the selected scenarios.	Not started	Report review
ordering the	March27th	Based on the exploration and	Not started	Get the

Hardware		Feasibility test		hardwares
MileStone3	April 17th	Architectural review and Go No Go decision.		Report Review Risk and Trade offs document.
Experimentation with New Hardwares :	April 17th	Need to be discussed	Not started	Experimental results report
Milestone.4	May 9th	Finalize Architecture	Not Started	Architectural Design Document
Milestone.5	June 25th	Deliver basic IOT framework for the Door bell Scenario		Working Demo of Door bell Scenario
Milestone.5	July, 25th	Deliver IOT framework with Advanced Features		May be we may extend to audio streaming in the home.(Need to discuss)

Team Roles

In our context everyone is a software engineer. All other positions need to be filled so that everyone gets the time to lead at different points of time.

Jiahan Wang

Chief scientist: Coordinate the creation and documentation of the experiments and research studies. Coordinate test planning, documentation of the test plan, and test execution.
Support Engineer: Set up and maintain development support tools (development environments, CM, and so forth). Establish and maintain web presence as necessary. Ensure that the ACDM is followed, record deviations from the method, document changes to the ACDM as required. Establish and maintain a defect logging and tracking processes.

Parth Mehta

Requirements Engineer: Act as lead in gathering and documenting functional requirements; Coordinate quality attribute discovery and documentation; Coordinate creation of the Statement of Work (SOW); Serve as customer liaison; Coordinate test planning and execution.

Peng Cheng Tang

Chief Architect: Coordinate creation of the notional architecture and refining it as necessary; Coordinate architectural reviews; capture and document architectural risks and tradeoffs; Coordinate creation and maintenance of architecture documentation.

Chidambaram Bhat

Managing engineer: developer effort, creation and documentation of preliminary and production plans and schedules and project tracking and oversight.

Appendix

Project Dictionary

Node:
Each node is a device that has the IOT framework and must have a CPU, sensor and/or actuator, UDP broadcast capabilities over WiFi. The node is able to communicate to all other nodes and User Devices. A sensor here is something that translates any kind of physical information e.g. the touch of a button to a virtual signal i.e. an electrical signal. An actuator is something that translates virtual information into the physical world. E.g. A light bulb that emits light, a speaker that has audio output.

User:
A user is the person in the house who interacts with the home through a user device.

Authorization node/User devices:
A smart phone or tablet that has the IOT framework and runs the android operating system. Its role is to interact with the user and the home.

Home: A home is referred to the collection of all the nodes and user devices in the house that are

running IoT framework. Nodes that are in two different houses physically are not part of the same logical home.

Service Discovery:

Discovery means the act of finding a service by the node which requires service. For e.g. if a node needs to find the location of the user it gets this information from the node that provides the service of locating the user. This act of locating a service and completing the task desired by using that service is called service discovery.

IoT framework:

IoT defines the protocol by which the nodes and user devices interact in the house. It is a broadcast based communication protocol where each device that has the IOT framework listens to all messages in the particular home. It takes care of delivering messages to other nodes and user devices and interprets messages from other nodes and user devices.

IoT framework will give a common set of API for nodes to communicate with each other.

Having the IoT framework means having the software that implements the protocol defined by the IOT framework.

Message:

Information that is broadcasted through the IOT framework to nodes and user devices are called messages. The exact content of the messages and their structure will be defined in the detailed architecture.

Joining:

Joining in IOT project refers to the time when a node or authorization node first interacts with the home and becomes a part of the logical home.

Service:

Service is the kind of information that a node or user device can provide by interacting with its environment. e.g. Localization, notification, illumination, audio playback, audio stream renderer, audio stream generator

Some services are explained in detail below:

Self Location – By this service any node or user device would know its own location. This service is to be stubbed and not to be implemented as a whole.

Location of Users – By this service any node or user device can know the location of a particular user in the house

Notification – By this service any node or user device can notify users in the house. The method by which this notification is delivered is up to a provider of this service. It could be a notification through light, sound or some other medium.

Service Description:

With each service is associated a service description that gives details of this service. For example notification could have a description of being a notification through sound and notification through light. Furthermore, a sound notification could be elaborated as a mixed with audio player service which could have fixed set of audio tracks or a streaming service from another node of audio input.

Query:

A query operation is an operation by a node to gather information about the environment/user with the help of services provided by other nodes in the home.

Update:

An update operation is an operation which results into the state of a node being changed for e.g. setting time to sound an alarm or some action being taken in the physical word for e.g. playing a sound, or blinking of a light.

Local Protocol:

A local protocol means that the protocol should not be interacting with any devices over the Internet. All communication in the IOT framework should happen within the LAN without any contact with the Internet.

Decentralized Protocol:

A decentralized protocol means there should be no node that “co-ordinates” activities of other nodes nor is any responsible for activities of any other node.

Registration:

The act of registration would involve giving a unique identifier to a node in the home which would serve as a way to address the node in the home. Nodes and user devices shall be registered by a user device before they can become a part of the home