Project Acronym: MEDIS

Project Title: A Methodology for the Formation of Highly Qualified Engineers at Masters Level in the Design and Development of Advanced Industrial Informatics Systems

Contract Number: 544490-TEMPUS-1-2013-1-ES-TEMPUS-JPCR

Starting date: 01/12/2013 **Ending date:** 30/11/2016

Deliverable Number: 2.2

Title of the Deliverable: Mobile Devices as Remote Monitoring and Control Systems for Embedded Applications – Learning Activities

Task/WP related to the Deliverable:

Type (Internal or Restricted or Public): Internal

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Contractual Date of Delivery to the CEC: 31-03-2014

Actual Date of Delivery to the CEC: 31-03-2014

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Context

WP 2	
WPLeader	Mälardalen University (MDU)
Task 2.2	
Task Leader	MDU
Dependencies	
Starting date	
Release date	

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History

Version	**Date**	**Author**	**Comments**
01	18/02/2014	Huseyin Aysan, Radu Dobrin, Sasikumar Punnekkat	Initial draft
1.0	20/03/2014	Radu Dobrin, Sasikumar Punnekkat	Revised Draft
1.1	31/03/2014	Radu Dobrin, Sasikumar Punnekkat	Final Draft

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1 Executive summary

This deliverable describes the learning activities proposed to implement the module of "Mobile Devices as Remote Monitoring and Control Systems for Embedded Applications".

This module is structured into 6 lectures and 4 labs, so that the teams are provided with necessary knowledge and possibilities to practice towards learning the fundamentals of programming mobile devices to remotely monitor and control embedded systems. The module is concluded with a seminar where the teams present the outcome of the learning activities.

In this deliverable, the structure of the module, the pre-requisites, the learning activities and the schedule are provided.

2 Introduction

The developed methodology is mainly based on problem based learning (PBL) and other accepted active learning techniques with the deliberate intention of creating the realistic working environment which the student will experience in his future career. This model is based on the educational goals proposed by the Accreditation Board for Engineering and Technology (ABET) [1]. The general aims of the approach are:

- To guarantee that the student has a knowledge about the fundamentals of the specialization.
- To encourage the students to work as part of a team in solving industrial problems.
- To encourage students to apply practical skills in order to improve their problem solving abilities in the situations they will meet in their working environment.
- Due to the rapid advances in this area, to develop the capacity to adapt to any new computer based systems that may appear in the future.

Taking into account this methodology, all the learning activities are driven around a reference project. The specification, design, implementation and validation of the course "mobile devices as remote monitoring and control systems for embedded applications" are taught using the liquid tank application and different mobile devices bridged over communication infrastructures based on Ethernet, WI-FI or Bluetooth protocols. The size and complexity of this system is adequate to support the explanation of the essential concepts.

3 Pre-requisites

These are the pre-requisites for this module:

- Basic C programming
- Basic web programming
- Basic knowledge in computer networks

4 The reference project

The specification, design, implementation and validation of remote monitoring and control systems are taught using the liquid tank application together with a communication infrastructure, as well as mobile devices to be used as remote controllers.

The communication infrastructure consists of modules that provide Ethernet, WIFI and Bluetooth connectivity.

The liquid tank application is a closed loop system in which the temperature of the liquid in the tank is regulated at a reference temperature using an analog temperature sensor, a digital over-temperature sensor, and a heating element.

The amount of liquid in the tank is regulated using an analog level sensor, a digital overflow sensor, a pump and an electronically controlled solenoid valve.

Figure 1 shows a diagram of the sensors and the actuators used in the tank application.

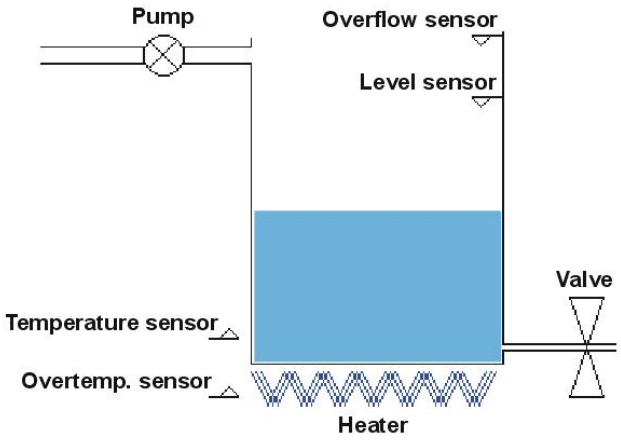

Figure 1 Diagram of the scale model.

Specifications of the sensor data and the signals to drive the actuators are given below:

Signal	**Direction**	**Type**	**Values/Range**
Valve	Output	Digital	TTL, “0” -> closed, “1” -> open
Pump	Output	Analog	linear, -5v = 0%, 5v = 100%
Heater	Output	Digital	TTL, “0” -> off, “1” -> on
Overheat	Input	Digital	TTL, “0” -> Overheat!
Overflow	Input	Digital	TTL, “0” -> Overflow!
Liquid temperature	Analog	Input	linear, -5v = 0º, 5v = 100º
Liquid level	Analog	Input	linear, -5v = 0 liters, 5v = 8000 liters

The sensors and actuators can be connected to a personal computer (PC) using a Data Acquisition (DAQ) module such as National Instruments USB-6008 DAQ (Figure 2), or any Arduino microcontroller board that is equipped with USB connectivity. If this method is used, then the Ethernet, WIFI and Bluetooth connectivity of the PC can be used as the communication infrastructure.

Alternatively, these signals can be directly connected to a simple microcontroller module that has built in Ethernet, WiFi or Bluetooth module, such as the “WiFi DipCortex” board which has a built in WiFi module (Figure 3). Other examples are “Arduino Yún” (for both WiFi and

Ethernet) and “Arduino BT” (for Bluetooth). As a last option any basic microcontroller board can be used together with add-on boards that provide WiFi, Ethernet or Bluetooth connectivity.

Figure 2 National Instruments USB-6008 DAQ

Figure 3. WiFi DipCortex Board

5 Learning activities

This module is structured into the following learning activities in the form of lectures, seminars, labs, and miniprojects, and implemented according to the schedule proposed in Table 1.

- Lectures: basic knowledge in the lecture topic is presented, and pointers to references to attain deeper knowledge are provided.
- Labs: students work in teams of two to four students to practice the theoretical knowledge provided in the corresponding lectures.

- Seminars: the student teams present the outcomes of their work, as well as submit a minor written report.
- Miniprojects: dedicated to planning, design and development of the control system of the educational liquids tank. The mini-project is performed by teams of 4 students during 2 hours. Weekly, the mini-project is advanced progressively

6 Lectures and learning outcomes

In this section, we propose the structure of the lectures.

6.1 Chapter 1 – Fundamentals of Remote Monitoring and Control

This lecture will give an introduction to the fundamentals of remote monitoring and control of embedded systems as well as the liquid tank system which will be used throughout the course.

At the end of the lecture, the students will be able to:

- explain the working principles of the liquid tank system
- understand the principles interfacing the liquid tank to a PC or a microcontroller board equipped with communication modules
- understand the different kinds of architectures that can be used for remote monitoring and control, such as
    - direct communication
    - communication through a web based application using a client-server approach

6.2 Chapter 2 – IDE

There are several manufacturers that develop mobile platforms and various mobile operating systems that are used in these platforms. This lecture will give an overview of a number of integrated development environments (IDEs) for developing apps that will be deployed on the most common operating systems, i.e. IOS and Android.

At the end of the lecture, the students will be able to:

- explain the basic steps of developing apps using the dedicated IDEs for IOS and Android platforms
- explain the basic steps of developing apps for both IOS and Android platforms using cross platform development tools, such as Titanium or PhoneGap

6.3 Chapter 3 – Basic app development

This lecture will cover practical aspects of developing a basic app in one of the platforms using an example. The main feature of the app will be inter-device communication using Bluetooth and WiFi.

At the end of the lecture, the students will be able to:

- start developing simple apps with inter-device communication functionality for IOS and Android platforms using their dedicated IDEs or a cross platform development tool.

6.4 Chapter 4 – Graphical user interface (GUI)

This lecture will cover the basics for designing a functional and intuitive graphical user interface. It will provide knowledge on the programming of GUI controls as well as addressing the limited bandwidth issues that can occur while dealing with media streaming.

At the end of the lecture, the students will be able to:

- perform an analysis of project specification with respect to GUI requirements and design a GUI for the project
- start programming the GUI controls
- understand the basics of encoding/decoding of media streams

6.5 Chapter 5 – Security

This lecture will cover the security related issues that a system connected to the internet might experience, suggest solutions and discuss the role based access control approach.

At the end of the lecture, the students will be able to:

- understand the basics of security related issues
- start implementing a simple roled based access control to their projects

6.6 Chapter 6 – Reliability

This lecture will be on reliability of embedded systems and usage of fault tolerance and testing for dependable systems design. It will also cover the synchronization issues that can occur with multiple accesses during remote monitoring and control of these systems.

At the end of the lecture, the students will be able to:

- perform a simple reliability analysis using the project specification suggest a design for fault tolerance
- understand the synchronization issues of multiple accesses
- understand the basic testing methodologies

6.7 Chapter 7 – Research findings

This chapter will focus on the research question that emerged during the coursework. It will conclude with a a final seminar consisting of presentations given by the project teams on their implementations and findings throughout the course, specifically emphasizing on the remote control aspects in conjunction with the security and reliability aspects. Students will also be asked to hand in their reports and their codes at this time.

7 Schedule

The course is implemented over a duration of 15 weeks according to the Table below

Week	Type	Topic
1 – Introduction		
1	Lecture	Fundamentals of Remote Monitoring and Control
1	Seminar	Research of Remote Monitoring and Control
1	Laboratory	Lab introduction - Liquid tank system I
1	Miniproject	Presentation of project goals

2	Lecture	Lab introduction - Liquid tank system
2	Seminar	Research of mobile communication
2	Laboratory	Lab introduction - Liquid tank system II
2	Miniproject	Control systems and mobile devices
2 – IDE		
3	Lecture	Dedicated IDE's for IOS and Android
3	Seminar	IDE for mobile devices
3	Laboratory	IDE introduction - instalation and usability
3	Miniproject	Desgin and structuring of control application
4	Lecture	Cross-platform developement tools (Titanium, PhoneGap, etc)
4	Seminar	State of the Art on development tools
4	Lab	Basic app development !
4	Miniproject	Testing of mobile apps and I/O address mapping
3 – Basic App Development		
5	Lecture	Inter-device communication 1
5	Seminar	Research inter-device communication
5	Lab	Basic app development II
5	Miniproject	Implement basic control logic
6	Lecture	Inter-device communication 1
6	Seminar	Research synchronisation in distributed systems.
6	Lab	GUI development and implementaion
6	Miniproject	Implement complex control logic
4 – Graphical User Interface (GUI)		
7	Lecture	Grapghical User Interface (GUI) I
7	Seminar	Structure of code for GUII
7	Lab	GUI development and implementation II
7	Miniproject	Add control logic to GUI
8	Lecture	Overview of micro-controller programming
8	Seminar	Propose structure of code implementing wireless communication on micro-controller
8	Lab	Implement wireless communication with the micro-controller
8	Miniproject	Mapping of physical I/O to mobile devices
5 – Security		
9	Lecture	Security in mobile communication
9	Seminar	Research application areas of secure wireless communication
9	Lab	Access controll and synchronization mechanisms I
9	Miniproject	Build a library of functions to secure access
10	Lecture	Security and control
10	Seminar	Research on secure control systems
10	Lab	Access controll and synchronization mechanisms II
10	Miniproject	Secure sending and receiving of messages.
6 – Reliability		
11	Lecture	Reliability in mobilie communication
11	Seminar	Research methods of reliability
11	Lab	Implement reliable communication
11	Miniproject	Simple distributed reliable control application
12	Lecture	Fault tolerance
12	Seminar	Research one fault tolerance for mobile devices
12	Lab	Implement fault tolerant communication
12	Miniproject	Add synchronous data transfer to distributed application.
13	Lecture	Testing of reliable mobile applications
13	Seminar	Research on testing of mobile communcation
13	Laboratory	Testing approaches for mobile communication
13	Miniproject	Determine latency of trafic in miniproject.
7 – Research findings		
14	Lecture	Research on dependable mobile communication 1
14	Seminar	Research on app controled ES
14	Laboratory	App control framework
14	Miniproject	Add hierarchical supervisory control of distributed control application.
15	Lecture	Research on dependable mobile communication 2
15	Seminar	Research on reliable communication for embedded control systems

15	Laboratory	Final project demonstration
15	Miniproject	Presentation of the project(s)

Table 1

8 References

[1] ABET. 2012. Criteria for accrediting engineering programs. Retrieved 03-21-12 from http://www.abet.org/DisplayTemplates/DocsHandbook.aspx?id=3143.