IOT1 - Internet of Things (IOT) on Microcontrollers

Building low-power IOT devices using standard microcontrollers

Objectives

- Introduce the IoT ecosystem
- Learn how to deploy an local open source IoT Platform
- Describe the most used IoT Edge to Cloud Protocols (MQTT, MQTT-SN and CoAP)
- Explore particularly heinous IoT focused attacks and security provisions at each level of stack (physical devices, communication systems and networks)
- Learn how to configure the LwIP (with MQTT), FreeRTOS and MbedTLS for an STM32 IoT application
- Understand the architecture of the Amazon FreeRTOS IOT libraries

Labs will be conducted on STM32-based boards connected through WiFi or Ethernet to a private cloud server

Prerequisites

- Familiarity with C concepts and programming targeting the embedded world
- Basic knowledge of embedded processors
- Basic knowledge of multi-task scheduling
- Basic Concepts of Cryptography
- Basic knowledge of STM32 microcontrollers

Course environment

- Convenient course material
- Example code, labs and solutions
- ARM-based target board (STM32)
- Access to a private cloud server

Target Audience

- Any embedded systems engineer or technician with the above prerequisites.

Course Outline

First Day

Introduction to IoT

- IoT potential
- IoT Architecture and Core IoT Modules
- Functional blocks of an IoT solution
- The Essentials for Building IoT platform
- Cloud Providers

Exercise: Install and configure an open-source IoT platform

LwIP introduction

- Overview
- Buffer and memory management

- LwIP configuration options
- Network interfaces
- MAC and IP address settings
- IP processing
- UDP processing
- TCP processing
- Interfacing the stack
- Application Program Interface (API)
- Standalone
- Netconn and BSD socket library

MQTT Protocol

- Publish-subscribe
- Architecture details
- Packet structure
- Communication formats

Exercise: Connect and publish CPU temperature
Exercise: GPIO control over MQTT

Second Day

MQTT-SN

- Architecture and topology
- Transparent and aggregating gateways
- Gateway advertisement and discovery
- Differences between MQTT and MQTT-SN

Constrained Application Protocol

- CoAP architecture details
- CoAP Messaging Formats

IoT Security

- IoT cyber attacks
- Physical and hardware security
  - Key management and trusted platform modules
  - Processor and memory space
  - Storage security
  - Physical security
- Cryptography
  - Symmetric cryptography
  - Asymmetric cryptography
  - Cryptographic hash (authentication and signing)
  - Public Key Infrastructure
  - Network Stack “ Transport Layer Security
- Best practices

MbedTLS Introduction

- Encryption/Decryption module
- Hashing Module
- RNG module
- SSL / TLS communication module
- TCP / IP communication module

- X.509 module

Exercise: Two-way SSL connection using TLS with MbedTLS

Third Day

Amazon FreeRTOS

- Amazon FreeRTOS Architecture
- FreeRTOS Kernel Fundamentals Overview
- Amazon FreeRTOS Libraries
- Amazon FreeRTOS Console

Amazon FreeRTOS Libraries

- Porting Libraries
- Application Libraries
- Common Libraries
  - Atomic Operations
  - Linear Containers
  - Logging
  - Static Memory
  - Task Pool
- Configuring the Amazon FreeRTOS Libraries
- Bluetooth Low Energy
- AWS IoT Device Defender
- AWS IoT Device Shadow
- AWS IoT Greengrass
- MQTT (v2.0.0 and v1.0.0)
- HTTPS
- Over-The-Air (OTA) Agent
- Public Key Cryptography Standard (PKCS) #11
- Secure Sockets
- Transport Layer Security (TLS)
- Wi-Fi

Amazon FreeRTOS Porting

- Porting FreeRTOS Kernel
- Wi-Fi
- TCP/IP
- Secure Sockets
- PKCS #11
- TLS
- MQTT
- HTTPS
- OTA
- BLE