ME5100

IoT Cloud and Device Security Management (DRAFT)

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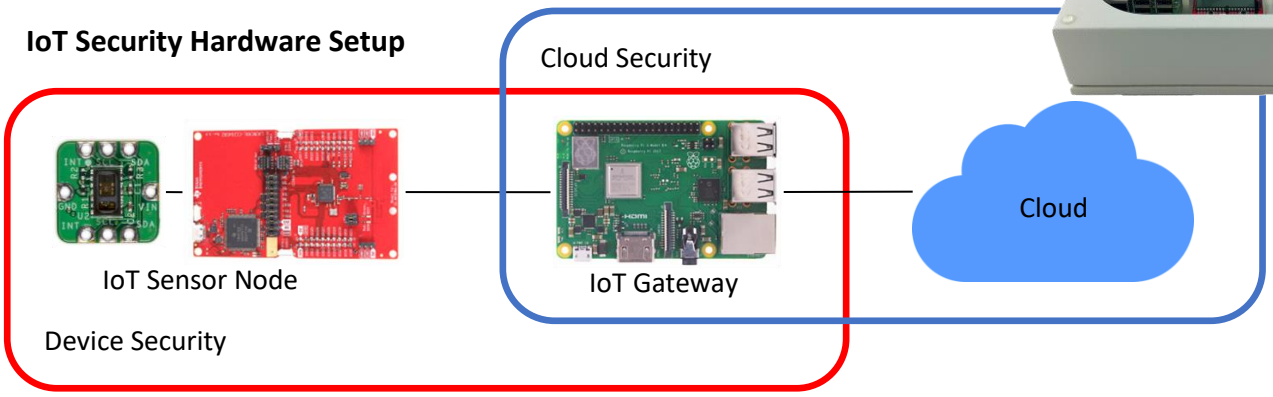
Teaching slides

- Editable Microsoft® PowerPoint® slides
- Covers 40+ hours of classroom sessions

Training kit

- IoT development kit: gateway & Sensor Node
- Lab sheets (MS Word) and model answers
- Problem-based learning assignments
- Covers 18 hours of lab sessions

IoT Security Hardware Setup



Target university subject	Target year of study	Prerequisite(s)
IoT Device and Security Management IoT Cloud and Device Security Privacy and Security in IoT	3rd year to final year undergraduates	Introduction to IoT C Programming Embedded System Programming

The ME5100 serves as a ready-to-teach package in the area of Internet-of-Things (IoT) focusing on device and security management of an IoT system.

Learning Outcomes

Students would be able to:

- Describe various IoT cloud technologies that support IoT applications
- Configure and manage the IoT applications using cloud technologies
- Understand the challenges of cloud and security management when deploying IoT applications
- Deploy cryptography in IoT after understanding the theoretical background of cryptography algorithms
- Implement security features into IoT applications
- Gain practical exposure to application of advanced cryptosystem in IoT context

Benefits of the ME5100 courseware

- Demonstrate implementation of end-to-end IoT network security, from sensor node to cloud.
- Learn and implement Public and Secret Key cryptography (encryption, description and data integrity) such as PKC, ECC, AES, SHA-3 and HMAC.
- Advanced cryptosystem implementation such as NTRU and PRESENT for resource-constraint IoT device.
- Manage IoT cloud server performance and server security using MQTT, Grafana and InfluxDB.
- Industry relevant case studies on IoT security challenges.

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Teaching Slides

(PN: ME5100-100)

Editable slides, covering 40+ hours of teaching for one full semester are provided. The slides cover the following topics:

Overview of Internet-of-Things (IoT) System
Introduction to the architecture of an IoT system. Applications of IoT and future trend. IoT building blocks and enabling technologies. Common IoT software and hardware architecture.

Communication Management using MQTT and MQTT-SN
This will cover MQTT protocol in detail and includes all the functionalities of MQTT broker. In addition to that, it includes MQTT performance monitoring and also understanding the limitation of MQTT.

IoT-Gateway Architecture
This will cover various IoT-Gateway Architecture and the potential roles of an IoT-Gateway. This includes the importance of having remote kill switch in Sensor Node and IoT-Gateway.

Cloud Server and Security Management.
Server management, not limited to performance monitoring. This includes firewall configuration and secure log analysis to identify potential attack.

Security Challenges for IoT Applications.
Security problems faced by IoT applications. Overview of potential attack scenario. Security target to be achieved in common IoT applications (e.g., data confidentiality, integrity, authenticity and privacy preservation).

Public and Secret Key Cryptography
Differences between public and secret key cryptography.
Public Key: Mathematical background for Public Key Cryptography (PKC). Using PKC for encryption/decryption, key exchange and digital signature. Overview of RSA and Elliptic Curve Cryptography (ECC).
Secret Key: Block ciphers for encryption/decryption. Cryptographic hash function for integrity check and authentication (HMAC). Overview of AES and SHA-3.

Privacy Preserving Computation in IoT
Data processing in encrypted domain. Partial homomorphic encryption: Paillier and ElGamal Cryptosystem. Overview of application scenario.

Implementing Security in IoT System
Overview of TLS/SSL protocol. The importance of efficient code for cryptography algorithms. Efficient implementation of RSA. Overview of side channel attack (simple power analysis) and its countermeasure.

Case Studies:

i) Comparing various IoT architectures against its application scenario (gateway vs gateway-less architecture)
ii) Security issues with wearable devices and its countermeasures
iii) Privacy preserving smart metering system in household area
iv) Secure machine-to-machine (M2M) communication for smart manufacturing

Training Kit

(PN: ME5100-200)

IoT Development Kit:

<u>IoT Gateway</u> - Raspberry Pi 3B+ (1 unit):

High performance, quad-core CPU (64-bit SoC ARM® Cortex®-A53 at 1.4GHz) to support complex data aggregation in a low power package.

Integrated Wi-Fi®, Bluetooth® Low Energy support.

1GB SDRAM and 8GB SD Card memory simplifies configuration and increases scalability.

The Development kit

<u>IoT Sensor Node</u>

Sensor Node Controller with add-on BT module (1 unit):

Ultra-low-power (ULP) FRAM-based microcontroller (MCU) platform, including on-board emulation for programming, debugging and energy measurements. This device features LCD support with an integrated 10-bit ADC as well as embedded FRAM (Ferroelectric Random Access Memory), a non-volatile memory known for its ultra-low power, high endurance and high speed write access.

Heart-rate sensor

Sensor board - Heart-rate and Pulse-Oximetry Monitor (1 unit):
A low power, optical heart-rate monitor complete with integrated red and IR LEDs for applications such as Wearables, Heart-rate monitor and Pulse oximeter.

Software

Code Composer Studio Software Development Kit (SDK).

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Accessories

The following accessories are provided with the training kit.

Item	Quantity
16GB MicroSD Card with NOOBS OS	1
5.1V, 2.5A Power Supply	1
Micro USB Cables	1
Jumper wire bundle	1

Lab Sheets

The training kit includes eight lab sheets in editable format. Each lab requires 2-3 hours to complete. Model answers are provided with all lab sheets. The required instruments for the labs are listed below.

Lab Sheet

1. **MQTT connection management**
   Setting up MQTT Mosquitto Broker using Docker. Learn how to use MQTT Mosquitto for topic management and user access control. Demonstrate sensor node hijacking.
2. **IoT Data Storage and Visualization using Grafana and InfluxDB**
   Setting up Grafana and InfluxDB using Docker. Learn how to insert data into InfluxDB and to visualize data in InfluxDB using Grafana. Understand the danger of exposing InfluxDB connection to the Internet
3. **From Sensor Node to Cloud**
   Setup of IoT-Gateway to Cloud, lean how to process MQTT data and insert into InfluxDB. Learn how to control the insertion process using MQTT and the issue of malicious IoT Devices / Sensor Nodes
4. **Secure communication between sensor nodes and gateway: encryption and decryption**
   Learn the techniques to implement AES-256 on MSP430 microcontroller (sensor node). Experiment on protecting the confidentiality of sensor data communicated from the sensor node to gateway device (Raspberry Pi).
5. **Achieving integrity check for sensor data through SHA-3 hash function**
   Learn the techniques to implement SHA-3 hash function in microcontroller and the techniques to provide integrity check on data communicated between sensor node and gateway device.
6. **Secure data aggregation (privacy preserving) in sensor nodes and gateway: partial homomorphic encryption**
   Learn the techniques to implement Paillier cryptosystem in gateway device and how to provide privacy preserving computation in IoT application
7. **Authenticating sensor node and sensor data through RSA**
   Learn the techniques to implement modular exponentiation for RSA encryption and the techniques to implement digital signature through RSA
8. **Implement NTRU in Microcontroller**
   Learn the techniques to implement NTRU public key cryptosytem in microcontroller and the technique to speed up the computation of polynomial multiplication for NTRU

Problem-Based Assignments

The problem-based assignments below allow students to enhance their problem-solving skills.

1. **End-to-End IoT System with Secure Communication**
   First part: Develop an IoT system to monitor the heart rate (MAX30102) using MQTT and cloud solution.
   Second part: Secure the sensor data through PRESENT lightweight block cipher.
   Third part: Improve the encryption and hash speed through various implementation techniques.

2. **Optimizing the Implementation of NTRU Public Key Encryption in Sensor Node**
   First Part: Develop the firmware to monitor the heart rate (MAX30102) using MSP430 microcontroller as sensor node.
   Second Part: Encrypt the sensor data through PRESENT lightweight block cipher. Secure the encryption key for PRESENT using RSA public key cryptography.
   Third Part: Improve the execution speed of RSA through various implementation techniques

Training Kit Hardware Specifications

General	
Warranty	:1 year

Ordering Information

Description	Package	Product Number
Teaching Slides	1 user license	ME5100-100
Training Kit	1 set training kit	ME5100-200
Teaching Slides + Training Kit	1 user license (slides) + 1 set training kit	ME5100-300
Instruments	Where applicable	Purchase separately from Keysight or its distributor

Training courses related to subject matter are available on request. Visit dreamcatcher.asia for details.

For more information or enquiries:

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Updated on 5 Nov 2019