Internet of Things
IO 4041
Final Exam Syllabus

IoT Overview

- Intro of IoT,
- Features of IoT,
- Expectations from IoT with applications
- Enablers of IoT,
- Challenges for smart objects
- embedded systems, application areas of embedded systems, Design principles of IoT architecture, IoT challenges in the light of IoT architecture
- Arduino IDE

Slides + MB Ch1 (Sec 1.1 and Sec 1.2), Ch 2 (2.3, 2,5)

Ch 1

- Areas leading up to smart objects
  - 1.1.1: Embedded systems
  - 1.1.7: Computer Networking
- 1.2: Challenges for smart objects
  - 1.2.1: Node level challenges
  - 1.2.2: Network level challenges

Hardware and Software [Ch 11]

- 11.1: Hardware components:
  - 11.1.1: Communication Device
  - 11.1.2: Microcontroller
  - 11.1.3: Sensors and actuators
  - 11.1.4: Power sources
- 11.2: Software
  - 11.2.1: Operating system
    - 11.2.1.1: Contiki Operating system
- 11.3: Energy Management [only page 138-139]

Communication Mechanisms [Ch 12]

- 12.1: Communication Patterns
  - 12.1.1: One-to-one Communication
  - 12.1.2: One-to-many Communication
  - 12.1.3: Many-to-one Communication
  - 11.1.4: Power sources
- 12.3: IEEE 802.15.4 communication standard
  - 12.3.1: 802.15.4 Addresses
  - 12.3.4: 802.15.4 Frame Format

Application Layer protocols

- Application layer Protocols (overview),
- Request Response vs Publish Subscribe model,
- MQTT: Components, methods, durable and non durable subscription, retaining publication,
- decoupling dimensions of Pub Sub model,
- MQTT packet structure (Fixed header, optional variable length header, optional payload
- Algorithms for encoding decoding of remaining length byte(s),
- Understanding of various MQTT packets of various types such as CONNECT, CONNACK,PUBLISH, PUBACK, SUBSCRIBE, SUBACK

Slides + MQTT V3.1 Protocol Specification document

Application Layer: CoAP

- Overview, features, terminology
- CoAP vs HTTP
- CoAP messages, messaging model, message format

Slides + related concepts from "CoAP specifications RFC 7252"

Section 3: Technical background of the following article (about CoAP, default congestion control, CoCoA congestion control and RPL

Artcile: Analysis of the interplay between RPL and the congestion control strategies for CoAP

Comparative Analysis: CoAP vs MQTT

- Abstract
- Section I: Introduction
- Section III: Part A (CoAP), part B (MQTT)

Research article: Comparative Analysis of IoT Communication Protocols

Transport Layer: General overview

- Overview
- UDP: overview
- TCP: overview, TCP segment size, RTTs and time out, duplicate ACKs, doubling the TO interval, fast retransmit, flow control, congestion control mechanism and its components (slow start, congestion avoidance, fast recovery)

Transport Layer: smart objects

- UDP for smart objects: overview, benefits, drawbacks
- TCP for smart objects: challenging properties
- limiting factors in severe resource constraint for TCP implementation
- A transport layer protocol for WSNs: Reliable Multi-Segment Transport (RMST)
  - Directed diffusion protocol
  - Features
  - No caching and caching modes

Slides + MB Chapter 6 Sec 6.1, Sec 6.2, Sec 6.3, Sec 6.4]

Network Layer

IPv4

- basic idea of classes, subnets, addresses (network, broadcast, valid hosts, subnet mask)
- Fragmentation and reassembly
- NAT [Ch 4: Sec 4.3]

Slides

IPv6

- Overview, key functionalities, changes from IPv4
- Transition from IPv4 to IPv6: tunneling\

Continue on next slide

Ch 6

- 6.1: UDP
  - 6.1.1: best effort datagram delivery
  - 6.1.2: UDP header
- 6.2: TCP
  - 6.2.1: Reliable stream transport
  - 6.2.2: TCP header
  - 6.2.3: TCP options
  - 6.2.4: RTT estimation
  - 6.2.5: Flow control
  - 6.2.6: Congestion Control

Network Layer

IPv6

- Header structure: concept of each field
  - Next header and related extended headers
  - Fragmentation process
- Addressing architecture: unicast (local and global), anycast, multicast

Slides + MB Chapter 15 (Sec 15.1, Sec 15.2, Sec 15.3, Sec 15.10

Ch 15: IPv6

- 15.1: IPv6 for smart object networks
- 15.2: IPv6 packet headers
  - 15.2.1: IPv6 Fixed header
  - 15.2.2: Extended headers
  - 15.2.3 to 15.2.5: hop by hop option header, routing header, fragment header
  - 15.2.7: no next header
- 15.3: IPv6 addressing architecture
  - 15.3.1: notion of unicast, anycast and multicast
  - 15.3.2: IPv6 addresses representation
- 15.10: IPv6 over an IPv4 backbone network

Adoption layer: 6 LoWPAN

- ZigBee, Bluetooth, IEEE 802.11: basic overview
- IEEE 802.15.4 standard
  - overview, characteristics
  - Device types, topologies, header size problem

6LoWPAN adoption layer

- Basic overview, connection with IEEE 802.15.4, route over, mesh under
- Services: Packet fragmentation and reassembly, Header compression. Link layer forwarding with multi-hop
- Supported Headers: A mesh addressing header, The fragment header, and The IPv6 header compression header

Slides + MB Chapter 16 Sec 16.1, Sec 16.2 (till page 237)

Ch 16: 6LoWPAN adoption layer

- 16.1: terminology
- 16.2: 6LoWPAN adoption layer [till page 237]

RPL

- ROLL working group and its objectives
- Routing requirements
- Routing Metrics
- RPL objectives, characteristics, traffic flows
- RPL terminology

- RPL control messages and DODAG formation/construction

- Objective functions, constrains and routing paths

(Slides + MB Chapter 17 +
Research article: RPL in a nutshell: A survey (relevant sections)**)**

Ch 17: RPL routing

- 17.1: Intro
- 17.2: LLN?
- 17.3: routing requirements
- 17.4: routing metrics
- 17.5: objective function
- 17.6: RPL

LPWAN

- LoRa
- LoRaWAN
- Architectural difference between 6LoWPAN and LoRaWAN
- LoRAWAN IPv6 adoption layer specification
- SCHC as an adaption layer for IPv6 over LoRaWAN

(Slides)