Teaching IoT with RIOT

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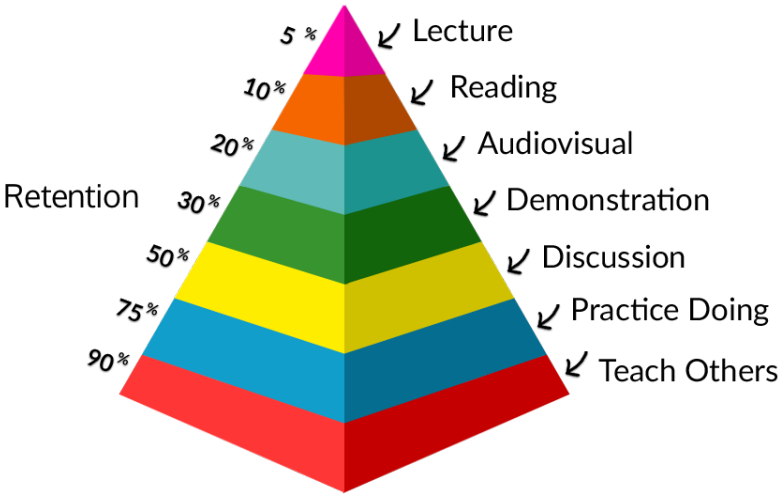
Course Objectives

1. Understand the meaning of digital ubiquity in business
   - Connections, Sensors, Data in industrial scenaria
   - Examine characteristic approaches of pervasive systems and embedded networks
2. Build physical prototypes of smart objects
   - Programming embedded systems using ARM Cortex-M architectures
   - Low-power Long-Range networking technologies
   - Low-power Cryptographic mechanisms
3. Design robust and efficient ICT incorporating smart objects
   - Cloud computing vs Edge Computing
   - Big Data Analytics and Stream Processing
   - Distributed Ledger Technologies
4. Examine essential algorithmic engineering techniques
5. Evaluate performance in real-world deployments
   - Network, Energy, Security

Teaching Approach



Instructor-led Activities

- 14 Lectures of 2-3 hours each
  - Material organized in 5 modules
    1. Designing Applications for the Internet of Things.
    2. Embedded Operating Systems and Hardware Platforms.
    3. Networks, Protocols and Security.
    4. Data, Analysis and Privacy.
    5. Performance Evaluation.
  - First lockdown period: entirely online
  - Second lockdown period: 25% or 50% in classroom
- Material available online:
  - Lecture notes
  - Recordings of entire lectures
  - Scientific publications (about 2 per lecture)

Laboratory Activities

- Laboratories of 3 hours each
  1. Introduction to RIOT
  2. M2M Communications
  3. Low-power Mesh Networking
  4. Performance Evaluation on IOT-Lab
  5. Cloud-based IoT Services on AWS
  6. Low-power Long-Range Networking
- Material
  - All students get an STM Arm Cortex-M development board
  - 4-5 hands-on step-by-step tutorials per laboratory
  - 1-2 short videos presenting independent exercises
  - Video recording of entire instructor-led laboratory
  - Code used during the instructor-led laboratory

Lab: Introduction to RIOT

Lab 1: RIOT

- Tool Chain
- Applications
- Threads
- Timers

Lab: Introduction to RIOT

Lab 1: RIOT

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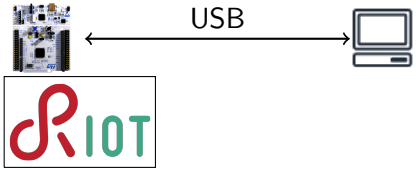
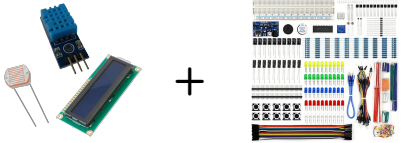
Lab 1: RIOT + STM

- Hardware
- I/O
- RTC
- Power

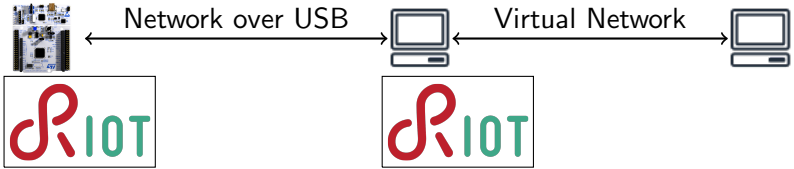




Lab 2: Machine-to-Machine (M2M) communications

Lab 2: M2M

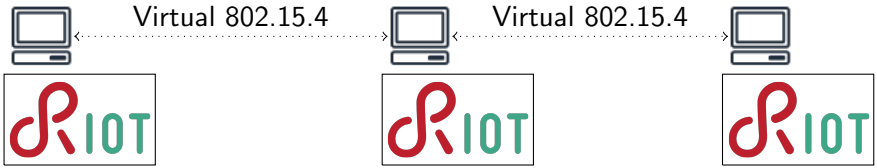
- Networking in RIOT
- MQTT, MQTT-SN
- COAP



Lab 3: Low-Power Wireless Mesh Networks

Lab 3: Mesh Networking

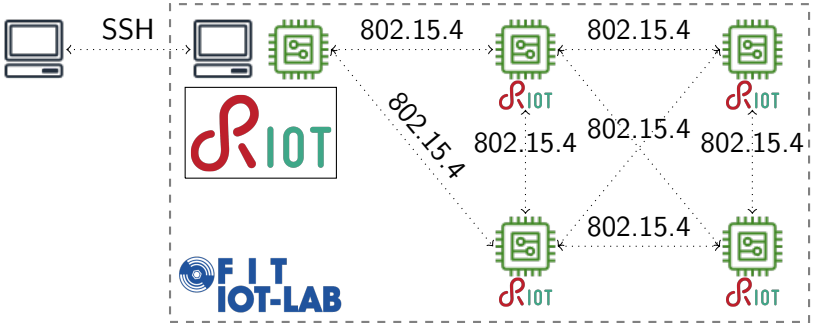
- 802.15.4
- 6LowPAN
- RPL



Lab 4: Experimentation-as-a-Service (IoT-LAB)

Lab 4: IoT-LAB

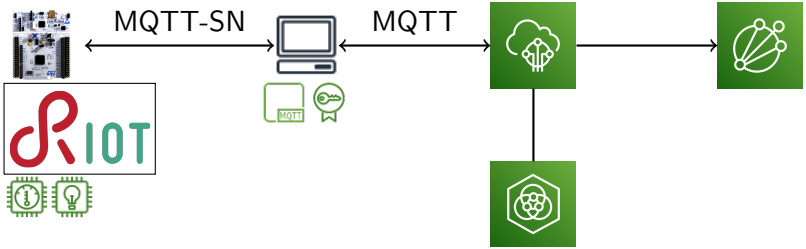
- Provisioning
- IPv6
- RPL



Lab 5: Cloud-based IoT using AWS

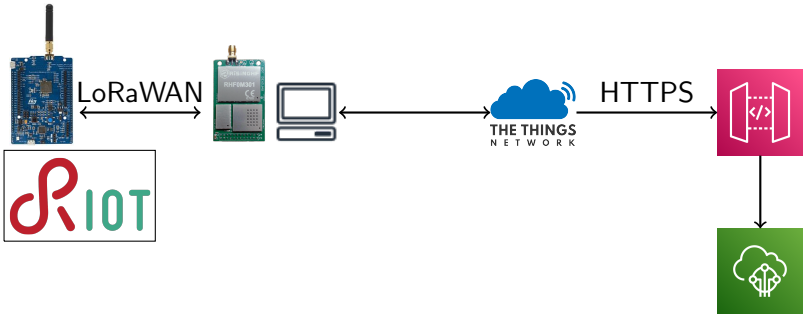
Lab 5: AWS IoT

- IoT Core
- Device Management
- IoT Analytics



Lab 6: Low-Power Long-Range Networks

Lab 6: LPWAN
- LoRaWAN
- TheThingsNetwork



Independent Study

- 3 projects
  - Develop an IoT solution
  - Each project adds up towards the realization of the final system
  - Connected to the modules of study
  - Connected to the laboratory activities
- Each student works independently
- Each project needs to be delivered separately
  - Video-based presentation
  - Blog-based presentation
- Based on soft-deadlines

Group Study

- 1 project
  - Design of an IoT system on a specific thematic area
  - Develop the IoT system
  - Evaluate the IoT system
- Students work in groups
  - Connected to 2 workshops for live problem solving activities
  - 2 check-points during the semester
  - Assisted by 1 assistant from the Faculty of Architecture
  - Assisted by 1 assistant from the Faculty of Information Engineering
- Thematic Areas
  - Smart Museums (2020)
  - Blue Growth (2021)

Conclusions & Future Directions

- Problem-solving Projects
  - Connections with real-world scenaria
  - Organization of students in groups – students of diverse backgrounds
  - Assigning 1+ assistant to each group
  - Development kit
  - Performance Evaluation
  - Develop communication skills: video, blogs
- Instruction-led activities
  - Material available to follow off-line
- Weekly flipped classroom activities
  - Connected to projects
  - Supported by focused workshops