Course Takeaways

(and inputs for your Portfolio ...)

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1. IoT network characteristics and specificities

Hint : *List the major peculiarities of IoT physical networks. If needed, you can take the case of Low-Power Wireless Personal Area Networks (LP-WPAN) that we considered during the course and explain how they differ from conventional computer networks and what are the specific constraints that they are subject to.*

Response: According to the course, IoT networks (also called LLN - Low-Power and Lossy Networks) are composed of nodes with strict limits in terms of power, energy and processing resources. The links, typically wireless, present considerable losses with a significant variability of the delivery rate. TD2 shows us these constraints through the study of the 6LoWPAN.

2. Rationale for adopting an IPv6 based architecture to support the communications of an IoT system or use case

Hint : *List the main benefits of adopting an IP based architecture in an IoT system, up the connected object (e.g. sensor, etc.).*

Response: Relevance of IPv6 for IoT: The course shows that even if the design of custom IoT networks is sometimes necessary, the use of Internet technologies is preferable because:

- Internet protocols are already standardized
- Developing new protocols is risky and expensive
- For long-lived objects, Internet protocols remain relevant
- IPv6 allows end-to-end security These points were illustrated in TD1

3. IPv6 basics

Hint : First, from the experiments and traffic captures that you did during TD1, describe the different IPv6 initialisation steps that a host goes through, when switched on. Explain the rationale of the different steps, and the messages (with the types of IPv6 addresses) that are used to complete these steps. Then, derive some of the requirements of IPv6 (in terms of transmission capabilities of the physical network, and host availability) and enrich them with some other important characteristics of IPv6.

Réponse: The initialization of an IPv6 node follows a precise process observed during TD1. First, the node automatically configures its link-local address based on its MAC address. It then checks that this address is not duplicated via the DAD mechanism. The node discovers its neighbors thanks to the Router Solicitation and Router Advertisement messages. The latter also allow to configure global IPv6 addresses. This process requires multicast support and sufficient bandwidth.

4. IPv6 adaptation and extensions in order to enable its use atop a physical IoT network

Hint :Without delving into the details, and relying on the experiment that you undertook during TD2, list the main additions, adjustments and optimizations of IPv6 that were defined for an application in the context of an IoT network.

Response : To operate on constrained IoT networks, IPv6 requires major adaptations studied in TD2. The 6LoWPAN layer compresses IPv6 headers to reduce their size. It also manages packet fragmentation adapted to small frames. The RPL protocol optimizes routing for mesh topologies typical of IoT. These mechanisms allow IPv6 to be used despite the constraints of IoT networks.

5. The IETF IPv6 based stack for IoT

Hint :Depict the protocol tack proposed by the IETF for IoT and then briefly describe the main network functions performed by the new layers. Also, provide a few words to describe the proposed application level protocols.

Response : The IETF stack for IoT is based on IPv6 with specific adaptations. The physical layer uses IEEE 802.15.4, optimized for low power. 6LoWPAN adapts IPv6 to constraints. RPL handles mesh routing. At the application level, CoAP provides REST services tailored to constrained devices, while MQTT implements an efficient publish/subscribe model.

6. Existing IPv6 based network technologies for IoT

Hint : List the existing IoT network technologies that are using IPv6 and their associated vertical(s) (application domain(s))

Response : Several IoT technologies already leverage IPv6. Thread uses it for home automation, providing a robust and secure solution. Industrial networks use 6LoWPAN/RPL for reliability. Adaptations of IPv6 also exist for Bluetooth Low Energy and IoT cellular networks (NB-IoT). These implementations demonstrate the viability of IPv6 for various IoT use cases.

7. Is an IPv6 based stack relevant for your semester project ?

Hint : After briefly describing your semester project, elaborate very shortly on the relevance of adopting IPv6 in your semester project.

Response : For the effort control project using a smartwatch and an electric bike, the adoption of IPv6 is not strictly necessary in the current architecture. The system is mainly based on:

- An API communication with the smartwatch
- A React/JavaScript web application
- A local communication with the ESP32

However, IPv6 could become relevant in an evolutionary perspective:

Enable a direct and secure connection between the watch and the ESP32
Facilitate large-scale deployment (e.g.: fleet of connected bikes)
Enable interoperability with other IoT equipment (heart monitors, environmental sensors)
Standardize communications for future integration with intelligent transport systems

However, the implementation of IPv6 would represent an additional complexity not justified by the current needs of the project.

8. IoT and sustainability (Optional, even if recommended)

Hint : After watching the presentation referred below,

1. cite one of the United Nations' sustainable development goals, and briefly explain how IoT can help in achieving it ?
2. What are the main guidelines promoted by the presenter to design a sustainable IoT device/product?

Title : The IoT and the two sides of Sustainability, 2023
Presenter : Carlo Boano, University of Graz, Austria

link to video : https://www.youtube.com/live/Sf70-Nb_hNI
Abstract : IoT systems are often portrayed as a key driver for sustainability and as an essential technology to achieve many of the seventeen United Nations' sustainable development goals by 2030. Among others, IoT systems can help improving health and well-being, building smart cities, promoting a responsible production and consumption, increasing awareness and visibility into energy and resource usage, as well as facilitating access to clean energy. At the same time, sustainability is often not a concern during the design of an IoT system: several IoT gadgets are unnecessary, many IoT products become quickly obsolete, and poorly-performing IoT devices are quickly dismissed. As a result, IoT hardware often ends up as e-waste into landfill after a very short lifespan, which is worrying considering the magnitude of IoT devices expected in the next decade. In this talk, I will illustrate this paradox with concrete examples and highlight the need to maximize the usability and lifetime of IoT systems, presenting technical solutions that could help in this regard

Response :

One of the UN Sustainable Development Goals and the role of IoT:
Drinking water management is a crucial goal mentioned in the presentation. IoT can help by:

- Monitoring large-scale water distribution networks
- Detecting leaks in real time
- Avoiding the waste of drinking water
- The presenter mentions pilot projects using LoRa technology to monitor pipelines in rural areas.

Key guidelines for designing a sustainable IoT device:

- Design truly useful products that meet societal needs
- Facilitate recycling by allowing the separation of components
- Integrate over-the-air (OTA) update mechanisms
- Ensure robustness against RF interference by using adaptive protocols
- Avoid reliance on cloud services that may disappear
- Reduce the use of additional gateways by using cross-technology communication (CTC)
- Preference battery-free devices with energy harvesting when possible