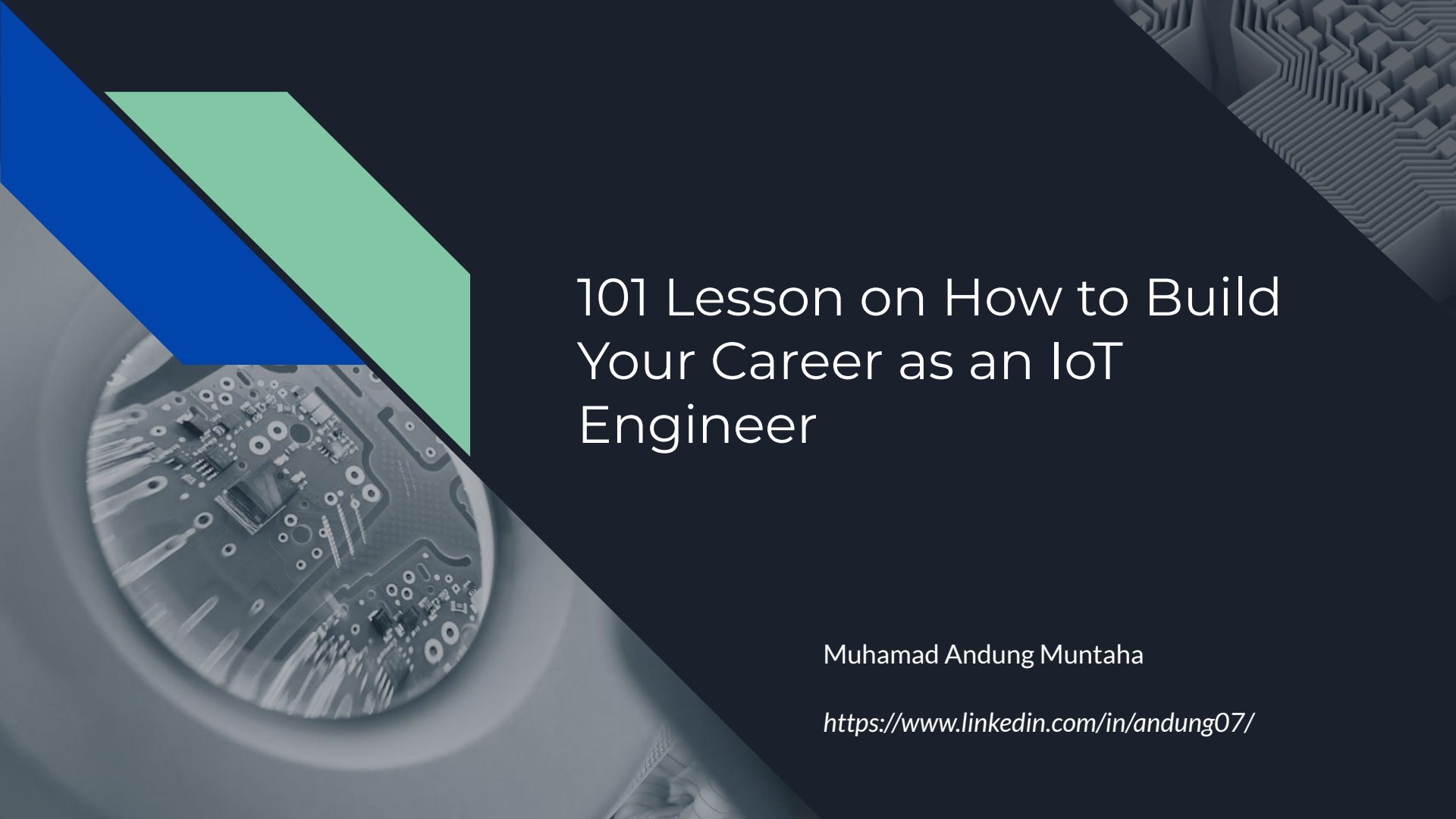

101 Lesson on How to Build Your Career as an IoT Engineer

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Table of Content

Muhamad Andung Muntaha

KTH Royal Institute of Technology
Master of Science - M.Sc, Embedded Systems. Minor: Embedded Software
2017 - 2019

Institut Teknologi Sepuluh Nopember (ITS)
Bachelor of Engineering - B.Eng, Electrical Engineering. Minor: Computer Engineering
2009 - 2013

IT Engineer & Application Developer
Schlumberger · Full-time
Nov 2013 - Jun 2017 · 3 yrs 8 mos
Jakarta, Indonesia

Embedded Software Developer
Self Employed · Part-time
Mar 2018 - Dec 2018 · 10 mos
Stockholm, Sweden

Master Thesis Project
Scania Sverige · Internship
Jan 2019 - Jun 2019 · 6 mos
Södertälje, Stockholm County, Sweden

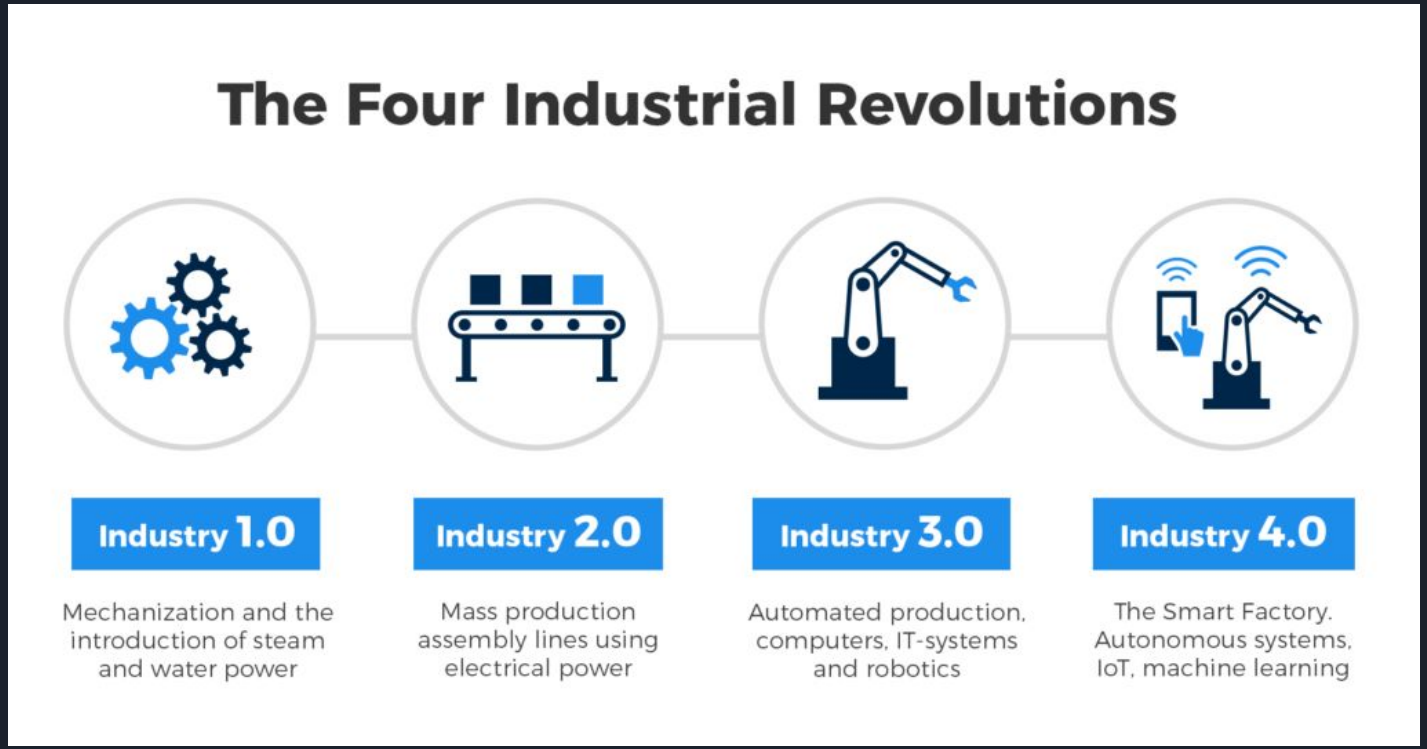
Embedded Software Lead
Nodeflux · Full-time
Aug 2019 - Jun 2020 · 11 mos
Jakarta, Indonesia

Embedded Software Engineer
SoleMetrix · Full-time
Jun 2020 - May 2021 · 1 yr
Singapore

IoT Software Lead
Blue Bird Group · Full-time
May 2021 - Jun 2022 · 1 yr 2 mos
Jakarta, Indonesia

Industrial IoT Software Engineer
Schlumberger · Full-time
Jun 2022 - Present · 6 mos
Jakarta, Indonesia

Industry 4.0



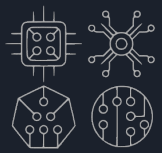
Source: https://kfactory.eu/short-history-of-manufacturing-from-industry-1-0-to-industry-4-0/

THE MATHEMATICS OF INDUSTRY 4.0

automation

conection

cloud computing



internet of things

big data

integrated systems

Source: https://medium.com/@luizcherri/the-mathematics-of-industry-4-0-81904d7bd3cb

Microcontroller Development

I/O, I2C, SPI, etc.

Requirement:

- Response time
- Predictability
- Functionality

Firmware:

- Baremetal
- Real-time Operating Systems
  - Zephyr
  - FreeRTOS
  - UC/OS II
  - RTThread
  - etc

Baremetal vs RTOS

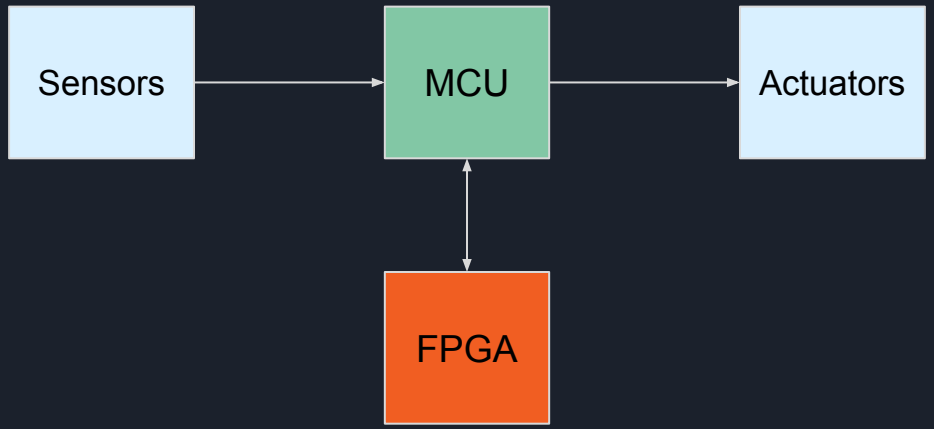
```
void interrupt_cb() {
   // ISR context
}


void main() {

   init()

   while(1) {
    // Mega loop
   }

}
```

```
TASK_DEFINE(TASK_1_NAME, TASK_1_PRIO, TASK_1_STACK_SIZE, task_1_entrypoint)
TASK_DEFINE(TASK_2_NAME, TASK_2_PRIO, TASK_2_STACK_SIZE, task_2_entrypoint)

static void task_1_entrypoint(void* param) {
   while (1) {
       // TASK1 implementation
   }
}

static void task_2_entrypoint(void* param) {
   while (1) {
       // TASK2 implementation
   }
}

void main() {
   runScheduler()
}
```

Baremetal vs RTOS

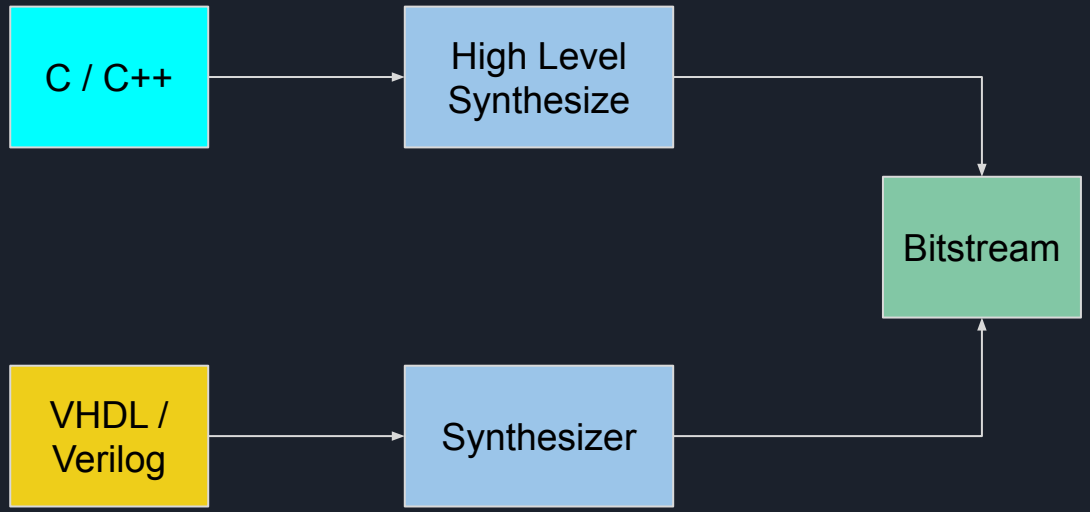
Aspects	Baremetal	RTOS
Hardware control	Full	Medium
Multitask	No	Yes, sort of
Overhead	None	Minimal
Predictability Assurance	Hard	Easy
Maintainability	Medium	Good
Debugging / Tracing	Easy	Medium

Field Programmable Gate Array (FPGA) Development

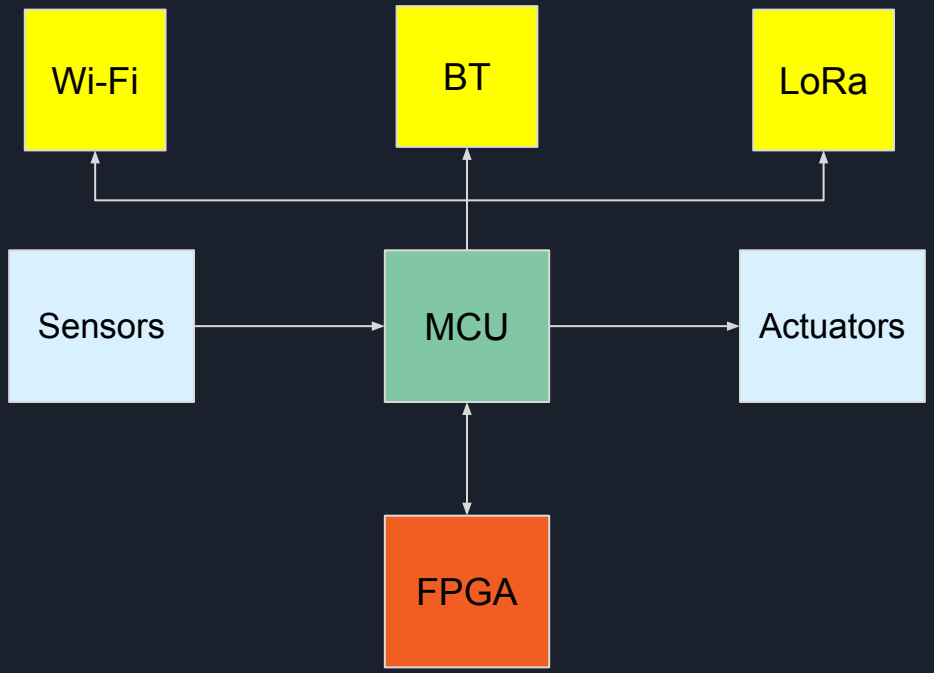


Hardware implementation is faster and truly parallel compared to sequential processing done by a processor

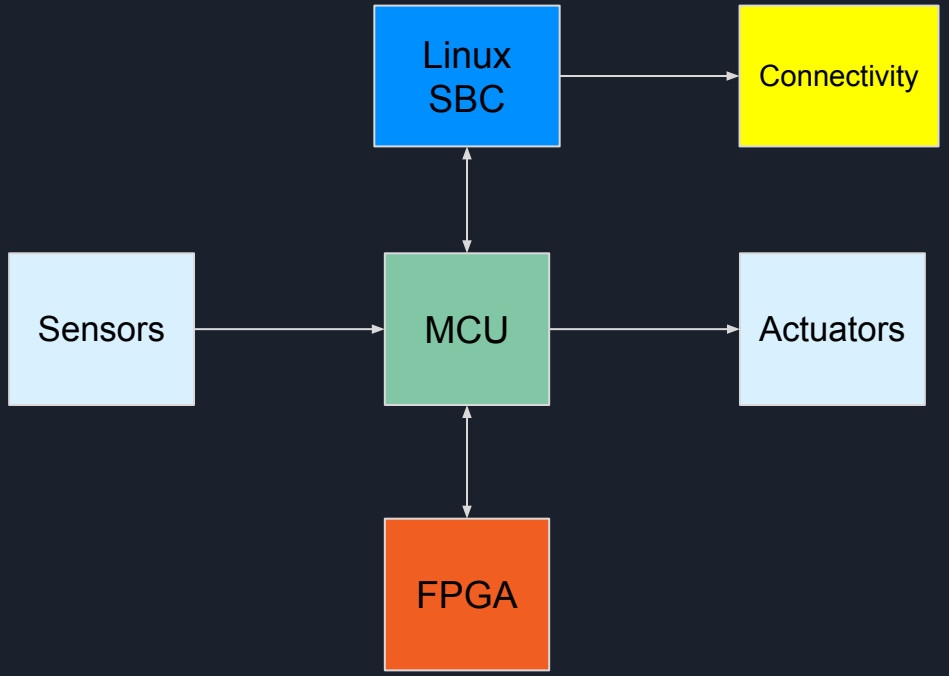
FPGA Development



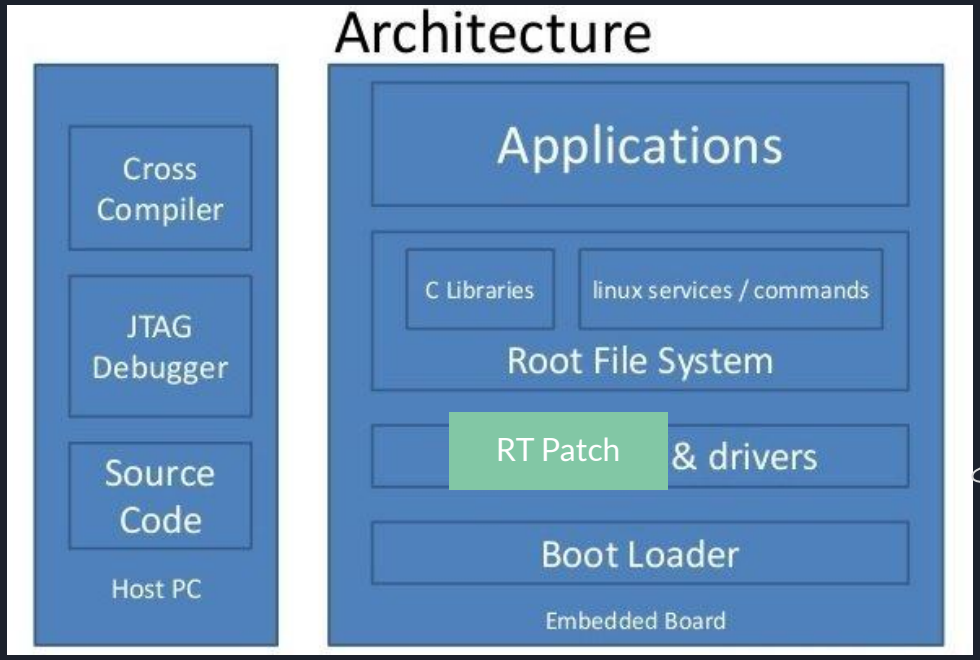
Adding Connectivity



Embedded Linux Development



Embedded Linux Development



- Qt
- Any high level application

- Kernel module
- Device driver

Custom embedded linux OS build system:

- Yocto
- BuildRoot

Source: https://microcontrollerslab.com/embedded-linux/

Embedded Linux Development

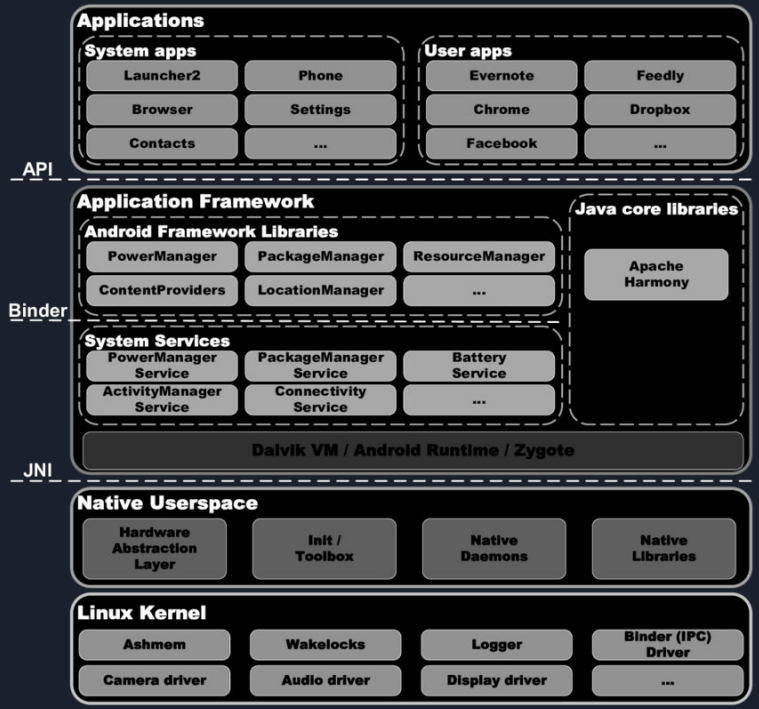
Pros:

- Highly customizable
- High flexibility
- Highly optimized

Cons:

- Portability between different boards
- Dependency hell
- Security patch management
- Not standard development environment

Embedded Android Development

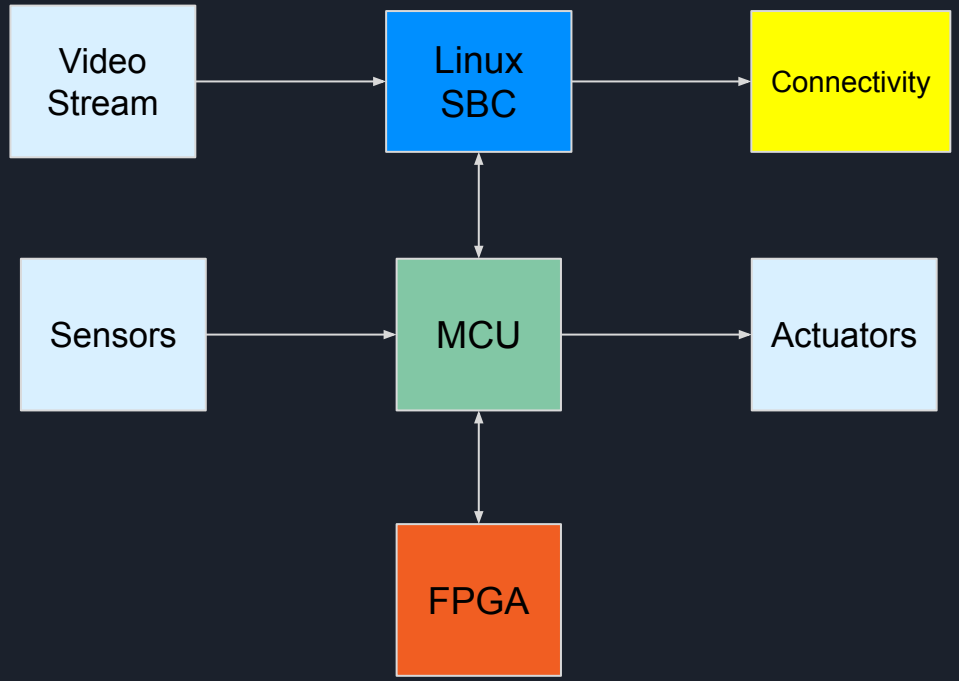


- User apps development
- System apps development
- Interfacing with co-processor
- Radio interface library (RIL)
- Device driver

Android framework gives a standardize development environment, abundance of libraries, and superior portability, which speed up time to market.

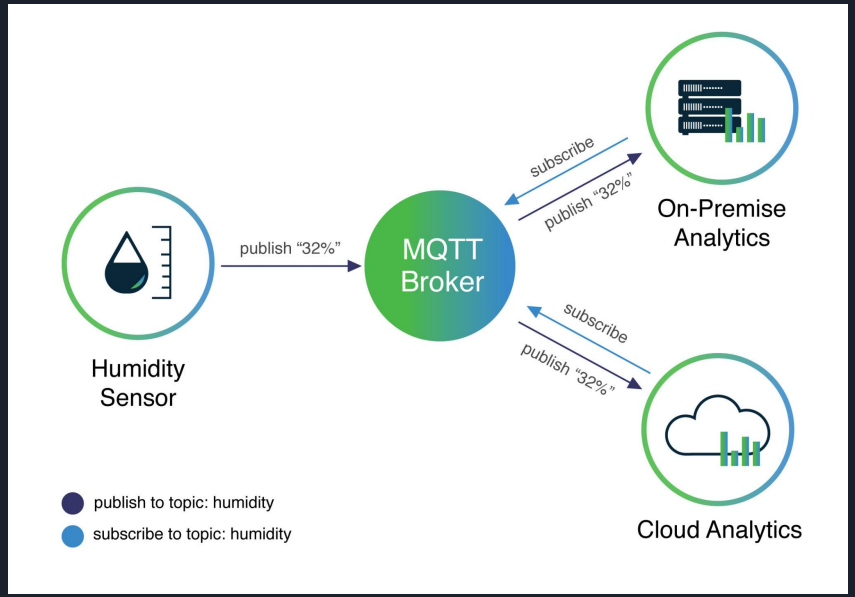
Zhauniarovich, Yury. (2014). Android Security (and Not) Internals.

Embedded AI



- On device inferencing
- Pipeline splitting
- MCU: Tensorflow Lite
- ONNX, Pytorch, Tensorflow, etc.

IoT Communication Pattern



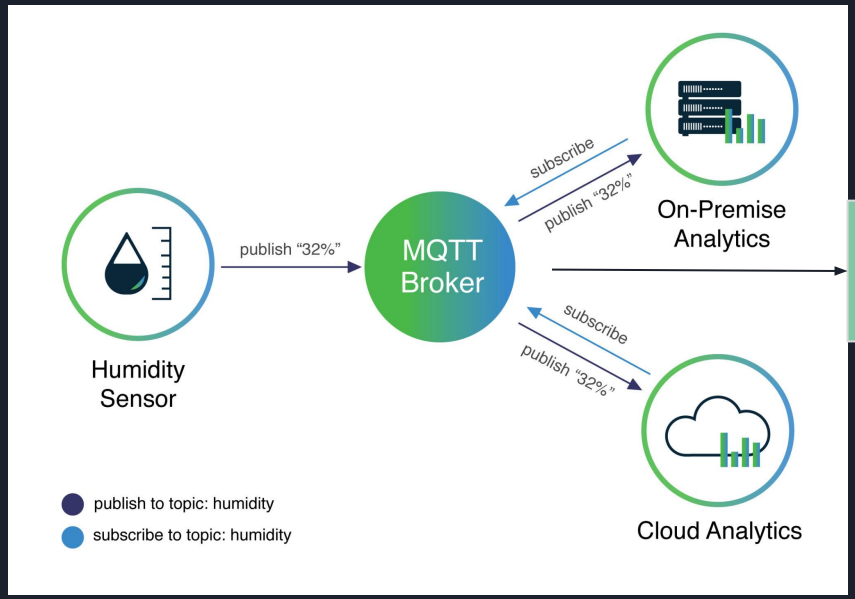
MQTT Advantages over HTTP

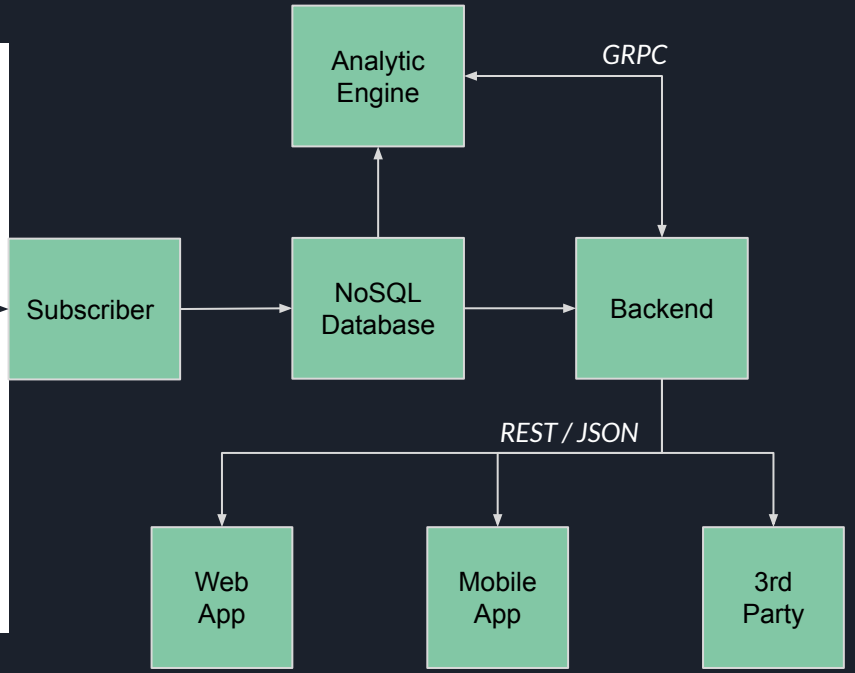
- Smaller packet size
- Persistent connection

Source: https://nusabot.id/alasan-menggunakan-mqtt/

IoT Distributed Systems

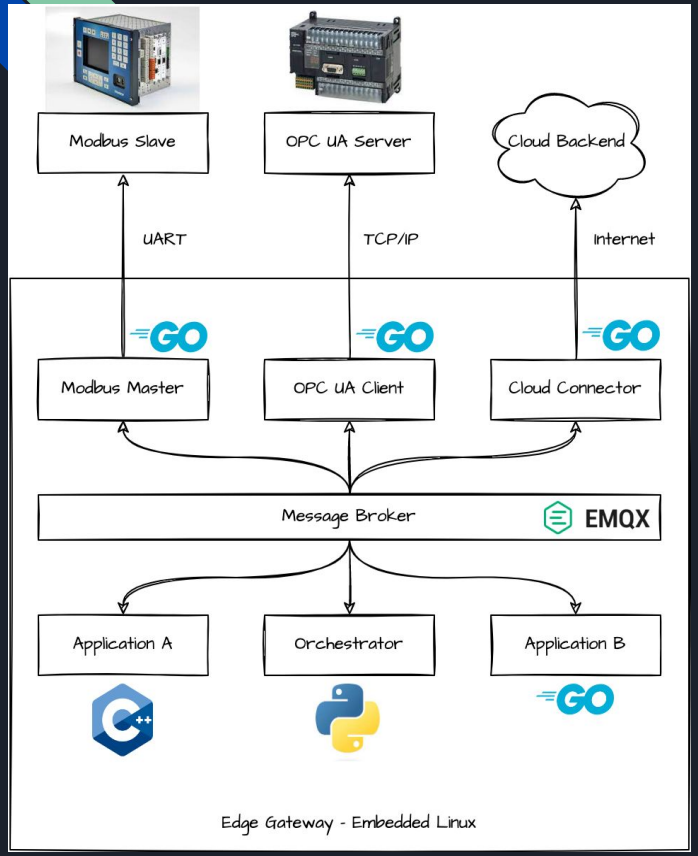
protobuf





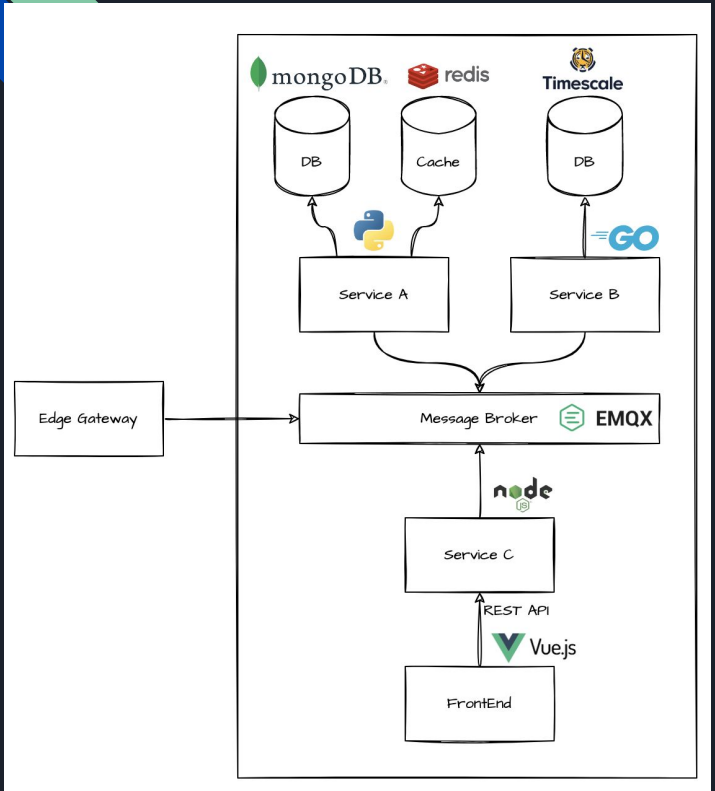
Source: https://nusabot.id/alasan-menggunakan-mqtt/

Industrial IoT Development - Edge



- Implemented as microservices running at the edge.
- Event driven architecture, connected by the message broker.
- System component modules must present as a base.
- Modbus master module and OPC UA client module are responsible in talking to external hardware which use Modbus protocol or OPC UA protocol.
- Cloud connector transfer information to backend and receive instruction from backend.
- Orchestrator module controls which application container that should run, and maintain its health and life cycle.
- Applications can be run concurrently and independently with its own environment.
- Minimum base operating system (embedded linux) run as the host OS which has containerization engine.

Industrial IoT Development - Cloud



- Microservices with event-driven pattern run at the cloud.
- Time series data can be stored in timescale DB.
- Cache can be used to serve commonly fetched data.
- MongoDB can used to store data with flexible schema (NoSQL).
- Service to service communication through message broker.
- REST API to serve data to frontend.
- Services are independent and can be implemented using various language.
- Frontend app can be build using framework such as Vue.js

IoT Device Management

- Collecting heartbeat to gather device status
- Firmware over the air updates
- Software version management
- Configuration management
- Device certificate revocation

IoT Security

The cyber-attack that brought down much of America's internet last week was caused by a new weapon called the Mirai botnet and was likely the largest of its kind in history, experts said.

Unlike other botnets, which are typically made up of computers, the Mirai botnet is largely made up of so-called "internet of things" (IoT) devices such as digital cameras and DVR players.

Because it has so many internet-connected devices to choose from, attacks from Mirai are much larger than what most DDoS attacks could previously achieve. Dyn estimated that the attack had involved "100,000 malicious endpoints", and the company, which is still investigating the attack, said there had been reports of an extraordinary attack strength of 1.2Tbps.

Source: https://www.theguardian.com/technology/2016/oct/24/ddos-attack-dyn-mirai-botnet

IoT Security

- Always use encryption, never communicate in plain
- Utilize Public Key Infrastructure
- Develop with security in mind
- Keep least access principle
- Make sure to change default credential
- Use security hardware if necessary. i.e encryption chip, trusted platform module (TPM)
- Monitor device security regularly (there will always be 0 day vulnerability)

Source: https://whatis.techtarget.com/definition/Confidentiality-integrity-and-availability-CIA

Career Development Advice

Embedded Software Engineer

- C / C++ / Python
- Real time concepts and development
- RTOS
- I2C, SPI, UART, CAN, etc.
- Interpreting schematics
- Hardware level troubleshooting
- TFLite

Embedded Linux / Android Engineer

- C / C++ / Java / Kotlin / Python / Go
- RTPatch (Linux Kernel)
- Device driver development
- Kernel module development
- Shell scripting
- Systemd
- Docker
- Android framework
- Pytorch, Tensorflow, etc.

General Software Engineer

- Go, Python, NodeJS, JavaScript
- Protobuf, GRPC
- REST API development
- Algorithm and data structure
- High availability distributed system
- Scalable distributed system
- Serverless development
- Cloud development (AWS, GCP)
- Application containerization (Docker, Kubernetes)

Be a T-Shaped, versatile engineer. Choose one deep vertical knowledge, but also knows broader context.

Industrial IoT Engineer Job Description

Mission

The IIoT Engineer is responsible for designing and developing software solutions to enable connectivity and control of sensors and actuators at the Edge. The IIoT Engineer draws on a background in Electrical and Computer Engineering and extensive knowledge of communication protocols, messaging systems, embedded Linux and device management.

Responsibilities

- Build prototypes, products and systems suitable for testing, and set up and run lab simulations.
- Develop and maintain high-quality software.
- Stay current with the cutting edge in Internet of Things (IoT) related technologies.
- Share expertise throughout the organization and provide user training for products.
- Evaluate engineering approaches and risks to produce development plans that ensure high-quality, low-cost products and systems.
- Author technical reports, papers, articles, patents and presentations.

Experience & Exposures:

- Embedded Software and IIoT

Instrumentation Engineer Job Description

Responsibilities:

- Design and test electrical, instrumentation and control systems.
- Design and develop PLC programming for acquisition and control system.
- Conduct testing, troubleshooting, root cause analysis and design solution to address issues.
- Collaboration with other development teams.
- Learn Well Service domain knowledge and provide support to field operation
- Draft user manual

Requirements:

- Bachelor's and/or Master's degree in Electrical/Electronics Engineering, Instrumentation & Control System or equivalent.
- Experience with electrical, control and instrumentation in oil and gas.
- Experience with Siemens/NI PLC
- Experience with Networking and communication protocols
- Experience with ATEX/IECEx Certification
- Cybersecurity knowledge in control system would be ideal
- Experienced with C#, .NET, Windows Presentation Foundation (WPF) would be ideal
- The engineer may need to visit field location (offshore rig) to field test/commission the system and interface with other group and field testers.