Digital Twin Coffee Room Application – Kahvibotti

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Background: DIGI2 –project at 2023-2025

- Our research was done as a part of DIGI2 project, funded by the European Regional Development Fund and the Regional Council of Satakunta

- Goal: New kind of experimental environment and co-creation methods for the joint use of Satakunta business life and developer organisations that produce technology concepts

- Google: "Tuni Digi2"

- https://www.tuni.fi/en/research/practical-applications-digital-twins-satakunta-region

The research - Kahvibotti

- Basic Idea: **Remote sensing system for coffee machine status**
- Digital Twin - approach
- Focus on 'non-smart' devices
  - IoT can influence user decisions and encourage energy-efficient behavior
- Mixed-methods approach
  - Prototype IoT-enabled home appliance
  - Real-time operational data
  - Interaction monitored through usage statistics and feedback
- Objective: evaluate influence of IoT feedback on user decision-making
  - Observe trends towards energy-efficient practices

**Results offer insights into role of IoT in promoting sustainable living and energy efficiency.**

The research questions:

RQ1: What are the challenges and technical limitations of retrofitting existing household appliances with IoT capabilities for energy monitoring and saving?

- Technical Limitations and challenges
- Compatibility with existing hardware and software
- Integration with existing energy monitoring systems
- Cost of retrofitting
- Reliability and security of IoT devices

- RQ2: How does real-time feedback on energy consumption from IoT devices affect user behavior?

Results – System diagram
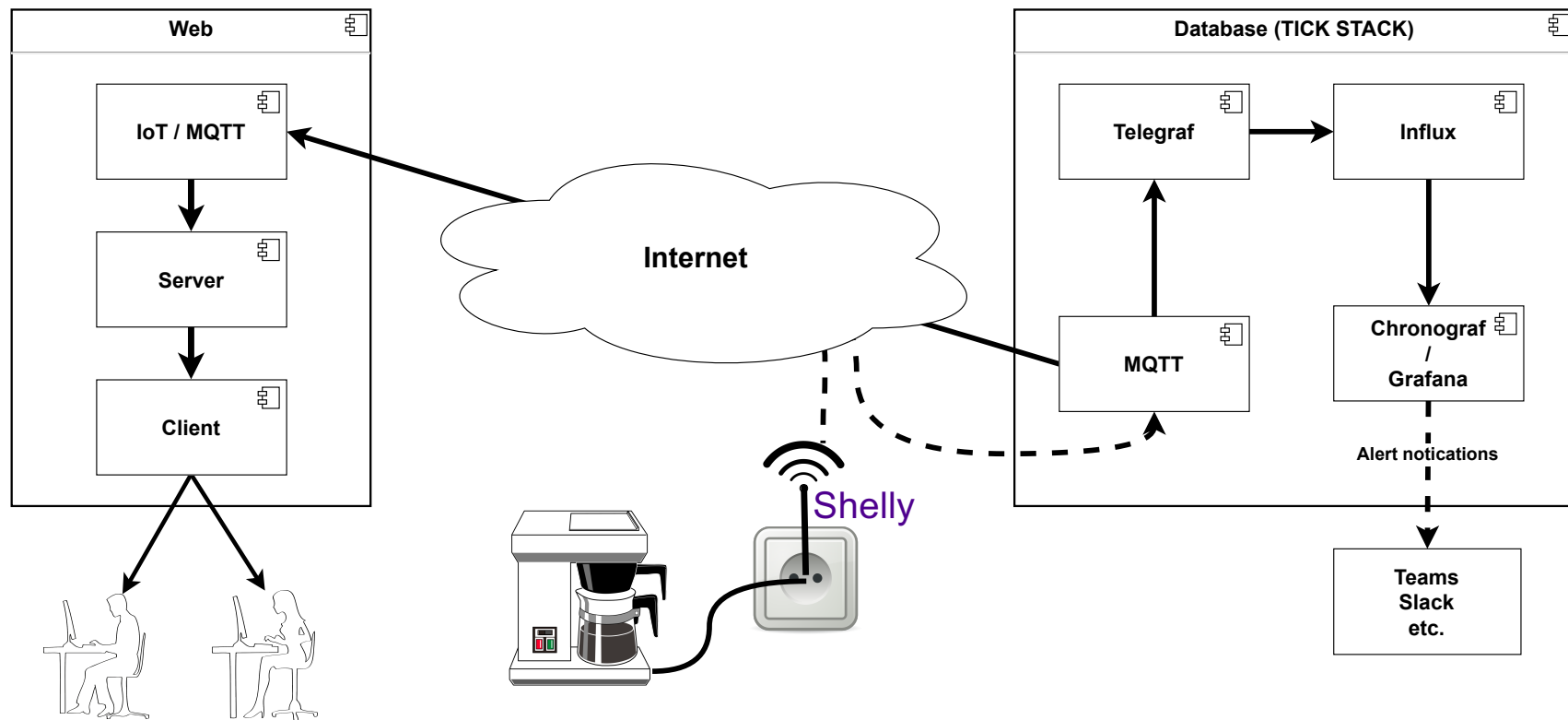
Results – System diagram

Client software communicates through GraphQL interface of server software

- Server software receives data from IoT/MQTT component
- IoT/MQTT component subscribes to topics of original MQTT message broker
- MQTT topics can be subscribed using wild card characters
- Easy to add more coffee machines to system

Data collection utilizes Docker Compose script

- Used for bootstrapping Telegraf, InfluxDB, Chronograf, and Kapacitor (TICK Stack)
- Bundled with additional services such as Grafana and MQTT
- InfluxDB and TICK Stack chosen for ability to easily implement simple dashboards

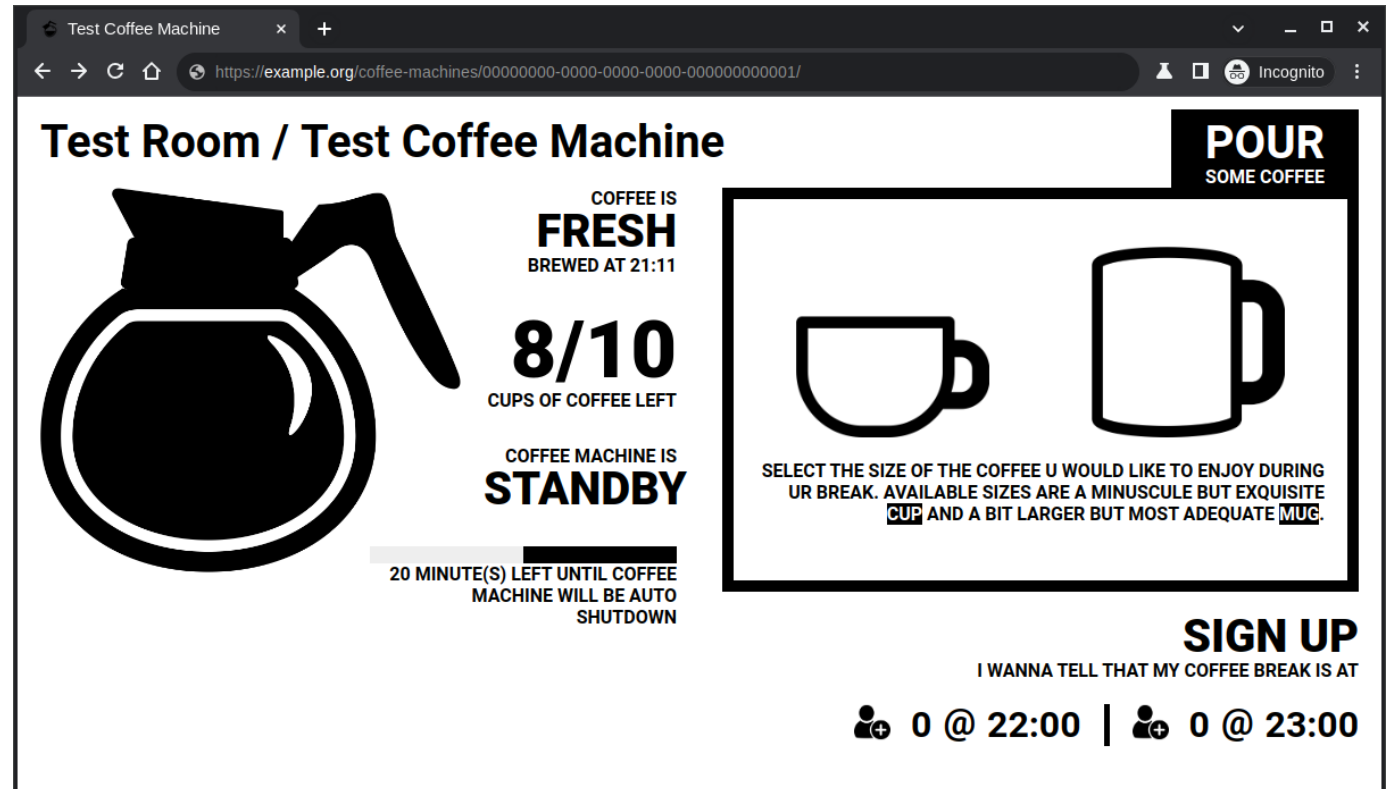MQTT message broker service is most important component

- Supports two way communication for advanced DT applications
- Only one way communication utilized in this use case

Fully automatic
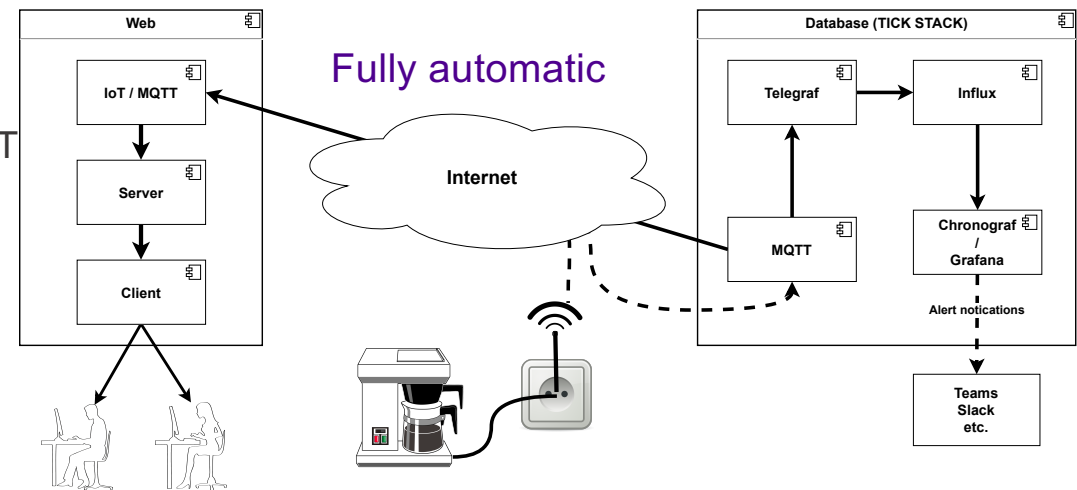
Results - web client

Features:

- Coffee machine status display
- Displays estimated amount of remaining coffee
- Enrollment for Upcoming Hours
- Interactive user input function
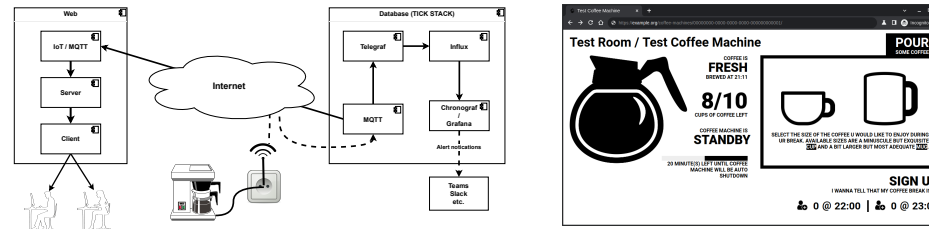- Reporting Coffee Consumption

Teams messages

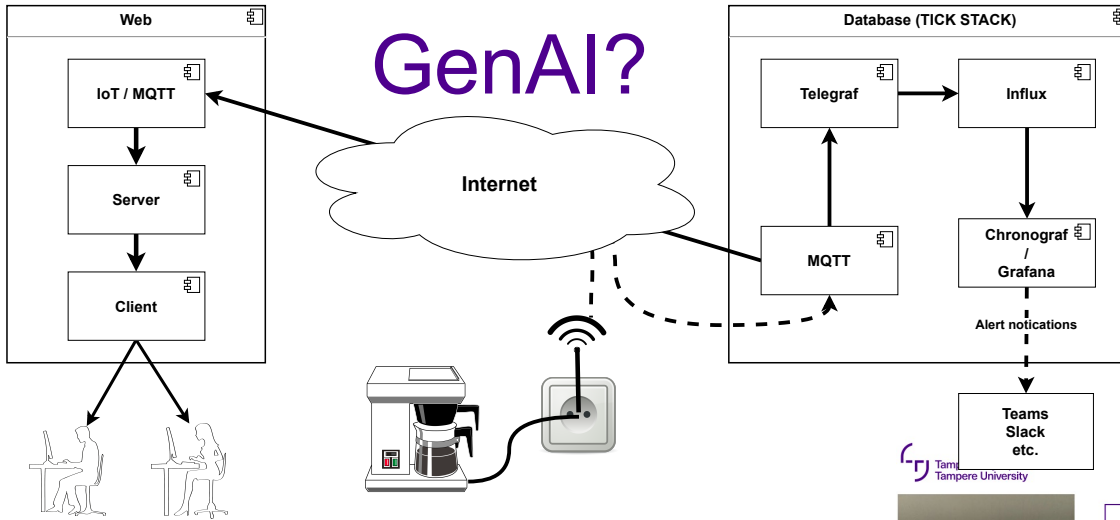- Brewing
- Automatic off
- Manual switch off

Summary

- In technical(RQ1) – The system is working
  - Energy meter measure
  - Data was collected
  - The collected data are used to suply information.
  - Real-time energy consumption information from IoT device.
- Social research (RQ2)
  - This need more research: Questionnaire? Interviews?

Backend system is ready for system expansion…

Future research

GenAI?

Web
- IoT / MQTT
- Server
- Client

Internet

Database (TICK STACK)
- Telegraf → Influx
- MQTT
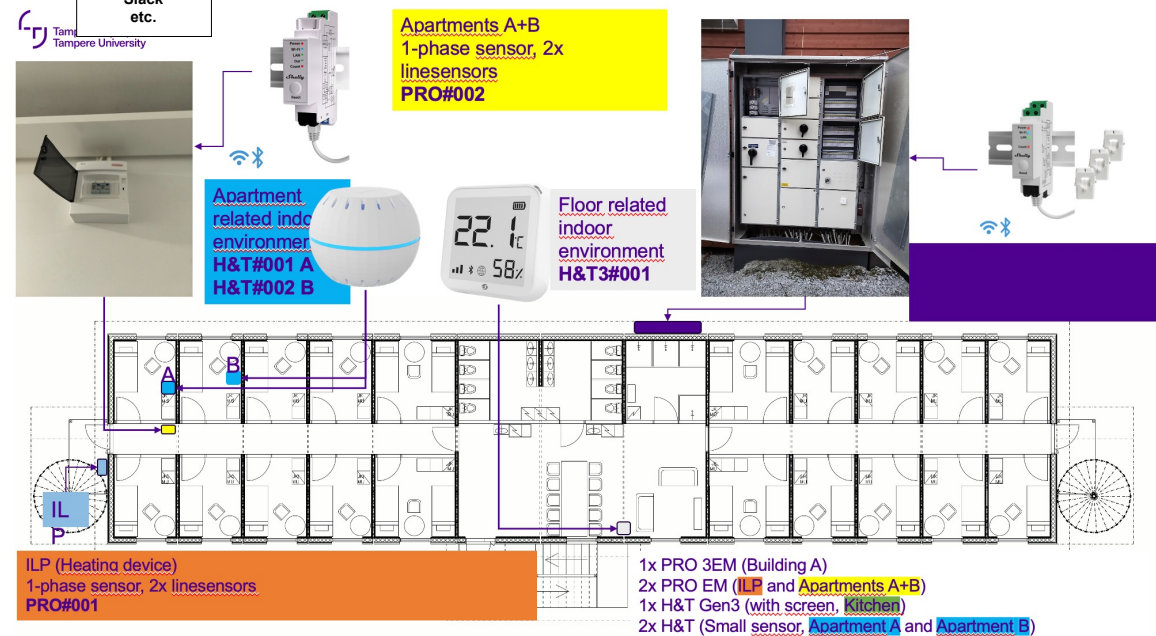- Influx → Chronograf / Grafana

Alert notications

Teams
Slack
etc.

Possibilties of Generative AI and LLMs
- GenAI for analysis
- GenAI for messages
- Other possibilities

Real-time energy consumption

Testing environment extension
- Energy measurement of rental apartments
- Several different sensor devices
- Mainly energy measuring

Apartments A+B
1-phase sensor, 2x linesensors
PRO#002

Apartment related indoor environment
H&T#001 A
H&T#002 B

Floor related indoor environment
H&T3#001

22.1 °c
58%

A
B

ILP

ILP (Heating device)
1-phase sensor, 2x linesensors
PRO#001

1x PRO 3EM (Building A)
2x PRO EM (ILP and Apartments A+B)
1x H&T Gen3 (with screen, Kitchen)
2x H&T (Small sensor, Apartment A and Apartment B)

Thank you – Questions?