

Leveraging Industrial IoT Infrastructure for Remote Sensing and Edge Computing in the Mining Sector

Presented by: Manos Rompogiannakis

Associate Researcher

m.rompogiannakis@pasiphae.hmu.gr

PI: Prof Evangelos Markakis

Pasiphae Laboratory,

Electrical and Computer Engineering Department

Hellenic Mediterranean University (HMU)

emarkakis@hmu.gr



This project has received funding from the European Union's Horizon research and innovation program under Grant Agreement no 101091885

Agenda

- Self-Introduction
- The Mine.io - European Horizon 2020 Project Scope
- The proposed Edge Computing, Remote Sensing, Decentralized Communication System
- Communication Protocols
- Discussion - Benefits of the proposed Solution
- Concluding Remarks
- Challenges – Future Work

Self - Introduction

❖ Who am I?

- Associate Researcher at Pasiphae Laboratory, of Hellenic Mediterranean University (HMU).

❖ Pasiphae Laboratory:

- A research unit of the Electrical and Computer Engineering Department of HMU.
- Specializes in Research and Development of Telecommunication Systems focusing on:
 - Computer & Network Security
 - Emergency Communications & Public Safety
 - Internet of Things (IoT) & Wireless Sensor Networks
 - 5G Networks
 - Data Spaces & Privacy Preserving Technologies
- Participating in many competitive R&D programmes in a European and a national level.

❖ Contact Information:

- m.rompogiannakis@pasiphae.hmu.gr
- emarkakis@hmu.gr

The Mine.io - European Horizon 2020 Project Scope

- ❖ A European project that **researches and innovates** a holistic solution for faster, safer and robust mining sector operations. Mining Digitization with the use of Industry 4.0 (I4.0) technologies:
 - ✓ Internet of Things (IoT)
 - ✓ Artificial Intelligence (AI)
 - ✓ Big Data
 - ✓ Machine-to-Machine communication (M2M)
 - ✓ Cloud Computing

- ❖ The Mine.io project paves the way to new regulations in the mining sector
 - ✓ Electric Vehicles

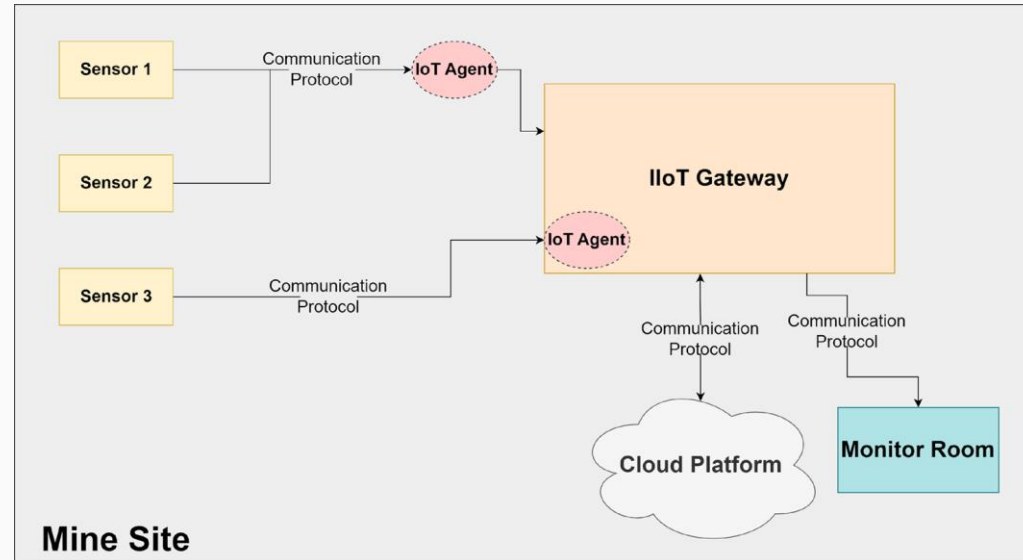
... all these for safer and cleaner environment for the workers, increased productivity of mining operations, reduced environmental footprint.

The Mine.Io - European Horizon 2020 Project Scope

- ❖ Based on the literature review, several IoT-based solutions have been proposed for the mining sector:
 - ✓ Most of them have not been tested in real mining environment
 - ✓ No cloud connection provided
 - ✓ No filtering on the big amount of raw sensor data
- ❖ Our proposed IoT-based solution focuses on the internal architecture of an IIoT Gateway :
 - ✓ Provide edge-to-cloud data transmission with data loss avoidance
 - ✓ Provide AI/ML computation for raw data filtering

The proposed Edge Computing, Remote Sensing, Decentralized Communication System (1/2)

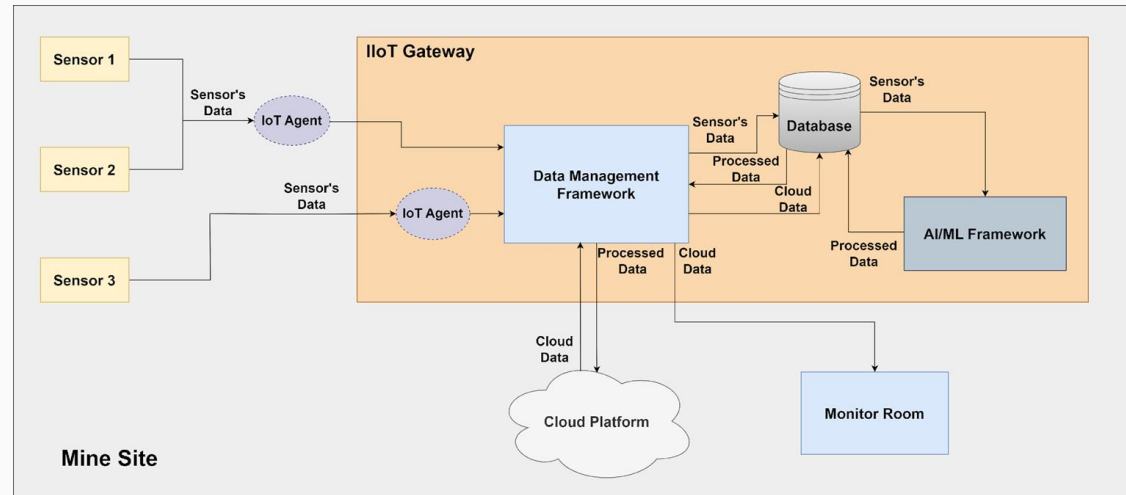
- Data collection from various **IoT devices** and **data sources** deployed in a mine and transfer to the IIoT Gateway.
 - **IoT Agents** (software components) act as intermediates between the sensors and the IIoT Gateway.
 - Open-source **Data Management Framework** creates an IoT ecosystem between sensors and gateway.
 - **Communication protocols** depend on the sensors used in the mine (various supported, such as **MQTT, CoAP, LoRaWAN**)



The proposed Edge Computing, Remote Sensing, Decentralized Communication System (2/2)

- **IIoT Gateway:**

- Supports **flow** of input and output data
- Acts as the **bridge** between the edge (Mine) and the Cloud.
- Receives **Cloud data** and sends it to the **Monitor Room**.
- Contains a local **database** to store the data to avoid data loss
- Supports **lightweight AI/ML computations** through an open-source AI Framework to reduce the amount of transmitted data.



Communication Protocols

- **Short Range Communication Wireless (SRCW) technologies** provide short range communication, use of node repeaters for data transmission
- **Cellular Communications Systems (CCS) technologies** provide low latency with high data rate, suitable for connection between gateway cloud
- **Low Power Wide Area Network (LPWAN) technologies** provide long range communication, low data rate, high penetrating ability

| Protocol / Standard | Category | Latency (ms) | Range (km) | Data Rate (Mbps) | Frequency Band (GHz) |
|---------------------|----------|--------------|------------|------------------|----------------------|
| IEEE 802.11 | SRCW | <10 | 0,1 - 1 | 150 - 600 | 0.9, 2.4, 5 |
| Zigbee | SRCW | 80-130 | 0,1 | 0,02 - 0,25 | 2.4 |
| BLE | SRCW | >7.5 | 0,1 | 1 | 2.4 |
| 5G | CCS | 1 | <5 | 100 - 20000 | 0.45 – 47 |
| 4G | CCS | 200 | <7 | 150 | 0.6-2.5 |
| SigFox | LPWAN | 10-100 | <50 | 0,0001 | <1 |
| LoRa | LPWAN | 10-100 | <15 | 0,0003 - 0,05 | <1 |
| NB-IoT | LPWAN | 1600-10000 | <15 | 0,25 | <1 |
| Weightless | LPWAN | 10-100 | <10 | 0,1 - 16 | <1 |
| LTE-M | LPWAN | 10-15 | <10 | 1 | <1 |

Discussion - Benefits of the proposed Solution

- **Wireless Communication:**
 - Real-time data
 - Monitoring environment conditions, mining equipment and machinery
- **Proposed Communication System:**
 - Bridge between edge and cloud
 - Utilizing a local database to store the data and prevent data loss
 - Support of lightweight AI/ML computations to reduce the amount of data that need to be transferred
 - Collecting and transmitting machine and environmental sensor data from the edge to cloud and back to the monitoring room

Concluding Remarks

- **Conclusions:**
 - Increase safety of workers
 - Proactively detect equipment maintenance necessities and extend its lifespan
 - Reliable communication system due to no data loss
 - Decrease the amount of transferred data

Challenges – Future Work

- **Challenges:**
 - Mines located in isolated areas.
 - Harsh environmental conditions in the mines.
 - Adaptability of the system to the different requirements of the mines
- **Future Work:**
 - Define requirements of a real mine.
 - Develop the IIoT Gateway in a laboratory environment.
 - Provide the IIoT Gateway for testing in a real mine site and evaluate the results.

Thank you for your attention

Q&A

Presented by: **Manos Rompogiannakis**
e-mail: **m.rompogiannakis@pasiphae.hmu.gr**

PI: **Prof Evangelos Markakis**
e-mail: **emarkakis@hmu.gr**

PASIPHAE Laboratory:
<https://pasiphae.eu>



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