

Multi-Protocol Interoperability Between Distributed Cyber-Physical Systems Towards Industry 4.0 Collaborative Optimization

AUTHORS: Md Sabbir Bin Azad Christophe Danjou

PRESENTED BY:

Md Sabbir Bin Azad

Dept. of Mathematics and Industrial Engineering Polytechnique Montreal Montreal, Canada e-mail: sabbirbinazad@gmail.com

Resume

MD SABBIR BIN AZAD

Proactive self starter with curiosity to learn, research, design and prototype innovative solutions for residential and industrial aspects in the context of Industry 4.0. 5+ years of experience in leading technical projects and full stack development.

EDUCATION

• M.A. Sc. in Industrial Engineering, <i>Polytechnique Montreal</i> , Montreal, QC, Canada	Jan2020-Jul2022
 Research on Industry 4.0. B.Sc. in Electrical & Electronics Engineering, BRAC University, Dhaka, Bangladesh 	Jan2010-Dec2013
Major in Electronics.	
PROFESSIONAL EXPERIENCE	

 Graduate Research Assistant, Polytechnique Montreal, Montreal, QC, Canada 	Jan2020-Jul2022
Research on Industry 4.0.	
Team Lead-Embedded Systems , Btrac Solutions, Dhaka, Bangladesh	Sep2014-Dec2019
Major in Electronics.	

PUBLICATIONS

- Industry 4.0 Digital Transformation Model for Mining Industry Towards Developing the Digital Capabilities and Boosting Profitability
- Real-time Vehicle monitoring for traffic surveillance and adaptive change detection using Raspberry Pi camera module
- 2017 IEEE Region 10 Humanitarian Technology Conference (R10-HTC), 481-484
- Development of electric stove for the smart use of solar photovoltaic energy
- 2014 IEEE Region 10 Humanitarian Technology Conference (R10-HTC)
- Development of electric stove for smart use of Solar Photovoltaic energy with national grid BRAC University



Outline









Chapter3: Research Development



Chapter4: Validation



Chapter5: Conclusion



Chapter6: Future Work



Chapter 1: Introduction

1.1 Background

Industry 4.0, fourth industrial revolution brought about by introduction of IoT and CPSs (Kagermann, Helbig, Hellinger, & Wahlster, 2013), has emerged as a promising approach to provide extensive connectivity in manufacturing environment (Li, Lai, & Poor, 2012)

One of the challenges that arises as a result of this evolution is the growing need for interoperability at various levels of the manufacturing ecosystem (Zeid, Sundaram, Moghaddam, Kamarthi, & Marion, 2019).

1.2 Problem Description

- 1.2.1 Interoperability Challenges
- 1.2.2 Limitations of Existing Interoperable Standards
- 1.2.3 Research Context

The main issue with current interoperable solutions is that there isn't a method that fits well with integration of IoT multi protocols in a gateway and effective full duplex interoperable communication to interconnect the sensors, IIoT devices, and machines and cloud integration for compatible platforms.

A low-cost interoperable IoT system to interconnect IoT objects and heterogenous devices and machines with different access protocols to support interoperability across the small and large-scale enterprises is a must.



Introduction(Cont'd)

1.3 Research Questions

Q1: How can an IoT interoperable system assist structuring any data to interconnect heterogenous devices with different access protocols?

Q2: How can we make this interoperable system cost effective for small and medium enterprises?

1.4 Research Methodology

- **Phase1: Design Protocol Selection Framework**
- Identification of MQTT, CoAP, HTTP, WebSocket and ModbusTCP protocols
- Capabilities and Requirement Analysis
- Conceptual Framework
 Phase2: Develop Interoperable Multiprotocol System
- Build platform in a low-cost Gateway
- Implement full duplex communication between heterogenous systems
- Access multiple database and other platforms Phase3: Validate the Developed Gateway
- Demonstrate with a case study
- Implement on a third-party platform
- Cloud Implementation



Chapter 2: Research Design

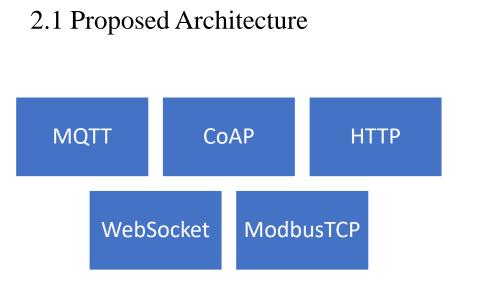


Figure 2.1: Proposed Access Standards for Interoperability

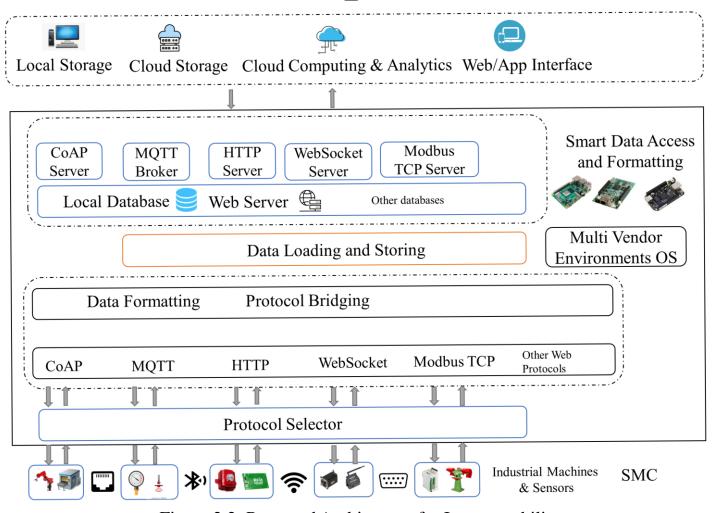


Figure 2.2: Proposed Architecture for Interoperability



Research Design(Cont'd)

2.2 Software Architecture 2.2.1 Set Access Protocols 2.2.2 User Interface

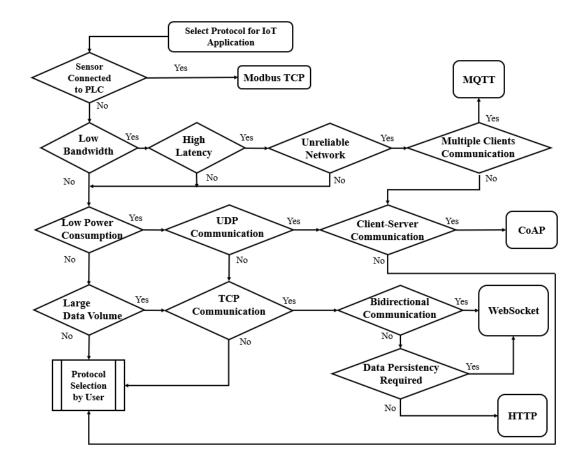


Figure 2.3: Protocol selection block diagram for applicable IoT systems



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Research Design(Cont'd)

2.3 Gateway Architecture

2.3.1 Data Formatting2.3.2 Protocol Bridging2.3.3 Nodes-Gateway Communication2.3.4 Data Process and Storage

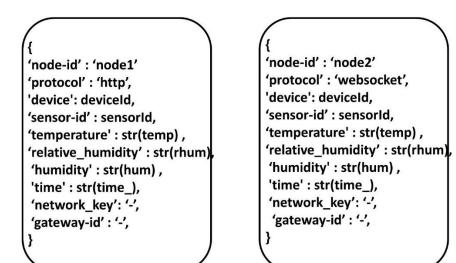


Figure 2.4: Example of systematized data format

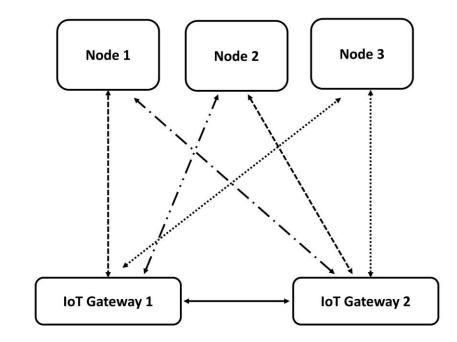


Figure 2.5: Nodes-Gateway Communication



Chapter 3: Research Development

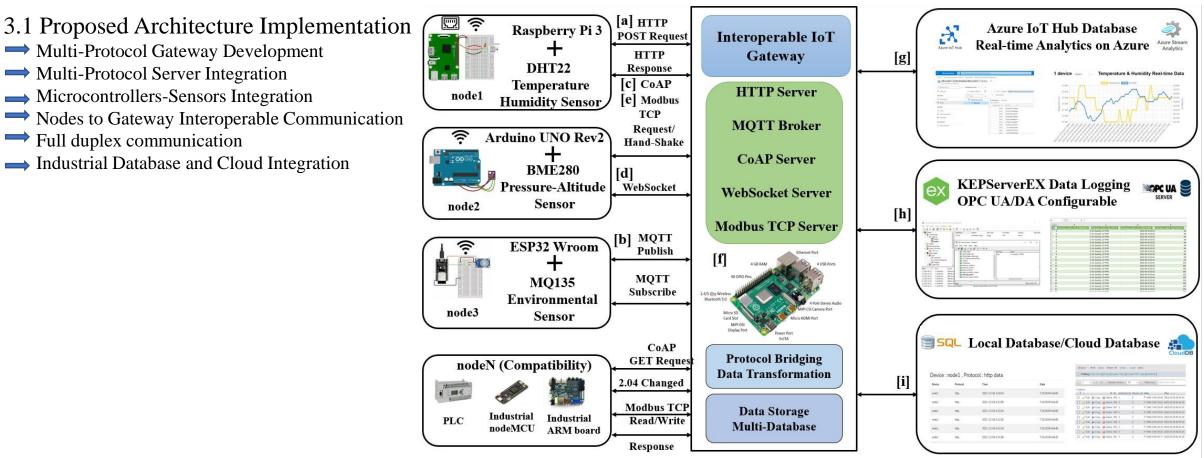


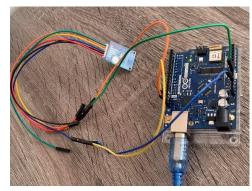
Figure 3.1: Proposed Architecture Implementation Framework, [a]HTTP, [b]MQTT, [c]CoAP, [d]WebSocket, [e]ModbusTCP, [f]Raspberry Pi 4 as Gateway, [g]Azure IoT Hub Database, [h]KepwareServer Data Logging, [i]Local/Cloud Database

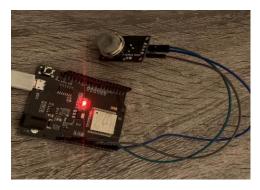


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Research Development(Cont'd)







3.2 Multiple Node-Sensors Integration3.2.1 Raspberry Pi 3 with DHT22 Temperature Humidity Sensor

3.2.2 Arduino UNO Wi-Fi with BMDE280 Pressure Sensor

3.2.3 ESP32 with MQ-135 Air Quality Sensor



Research Development(Cont'd)

3.3 Multiple Nodes-Gateway Communication3.2.1 Communication Protocol Selection for Nodes3.2.2 Data Interpretation Process3.2.3 Data Formatting

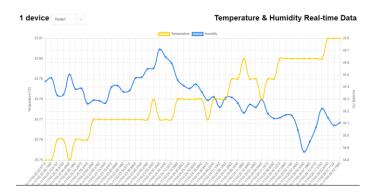
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	Device Name	Data	Select Protocol		
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	node2	Pressure: 1010.79hpa , Approx. Altitude: 20.52meter	Websocket	~	
	node3	Air Quality: 73 PPM	MQTT	~	

Figure 3.2: Gateway receiving data from node1,node2 and node3 over HTTP, WebSocket and MQTT protocol



Research Development(cont'd)

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3.4 Industrial OPC Server and Cloud Integration3.4.1 KepServerEX Data Logging and Communication

3.4.2 Azure IoT Hub Databases

3.4.3 Cloud Databases and Analytics



Chapter 4: Validation(Case Study)

4.1 Case Study

- 4.1.1 ThingsBoard Configuration
- 4.1.2 Gateway Configuration
- 4.1.3 Nodes-Gateway-ThingsBoard Interoperable Communication

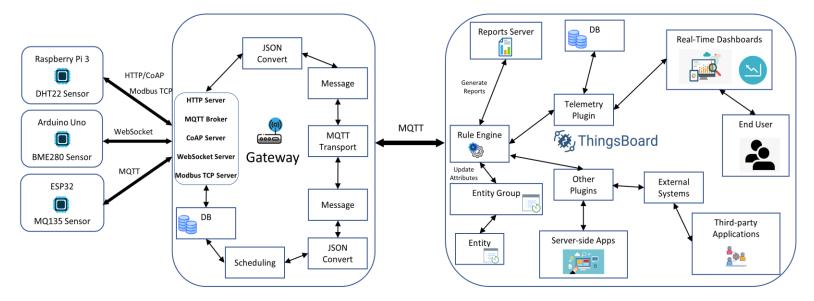


Figure 4.1: Implementation on ThingsBoard Platform



Validation(Cont'd)



4.2.1 Gateway Publishing Data to ThingsBoard

4.2.2 Successful Integration

4.2.3 Real-time Visualization

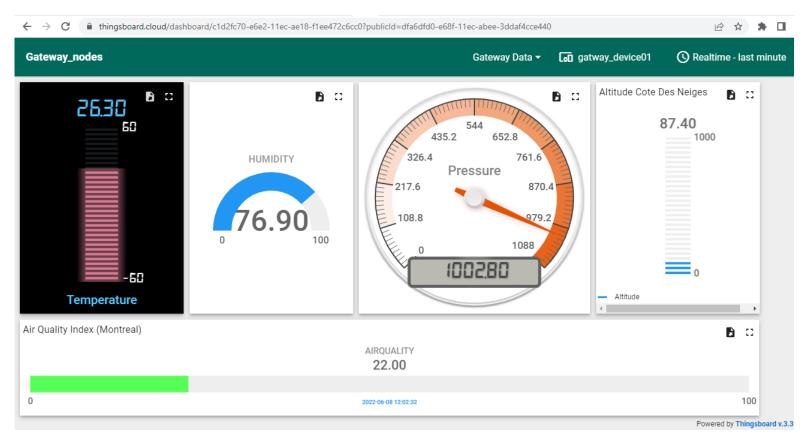


Figure 4.2: Real-time data visualization dashboard on ThingsBoard platform



Chapter 5 and 6: Conclusion and Future Work

5.1 Conclusion

5.1.1 Limitations3.2.2 Common Data Format

3.2.3 Interoperability Management by Middleware Gateway

6.1 Future Work and Recommendation3.2.1 Expanding Supported OPC UA Service3.2.2 IoT Security via IoT Edge Gateway3.2.3 Fog and Edge Computing Paradigm

6.2 Potential Commercial Application6.2.1 Open Protocol Management Controller for SMC6.2.2 Industrial Automation Data Converter



