UNIVERSITY OF CAMBRIDGE

Towards Distributed and Protocol-Independent IoT automation in Smart Spaces

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Smart spaces

- **myriad of interconnected IoT devices**
- **different protocol standards for different requirements**
- **plethora of automated functions for heterogeneous IoT applications**

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requires adequate management for smooth automated operation

Current automation approach: BMS

- Building Management System
- Centralised automation
- IP-dependent

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Management

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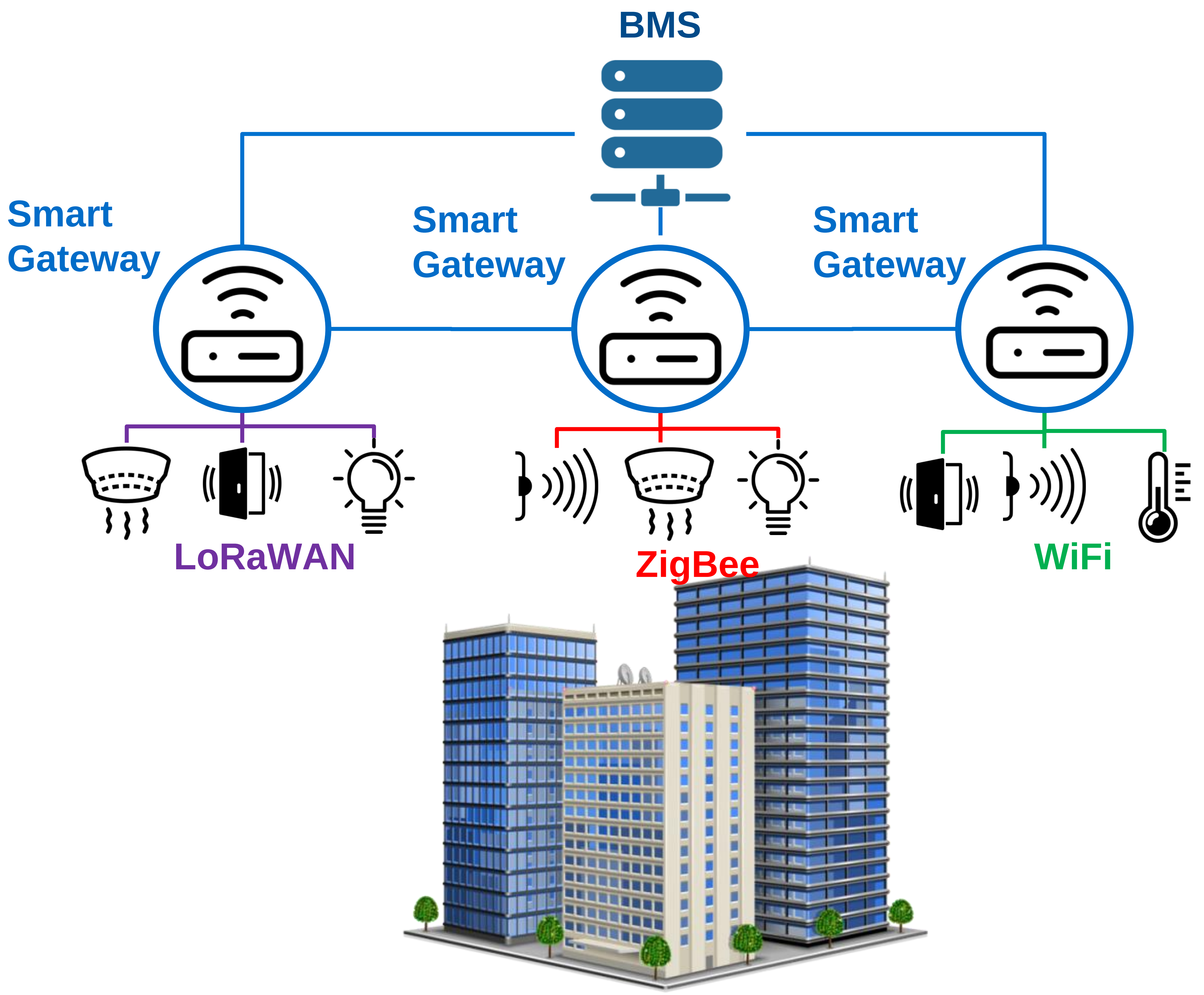
Drawbacks:

- **Single point of failure**
- **Slow:** all non-IP sensors/actuators traffic goes through a central IP network for application support
- **Privacy concerns:** can potentially track every building user

https://www.pngwing.com/en/free-png-pxuoh
https://www.epdtonthenet.net/article/128817/Sensors-link-up-for-smart-building-automation.aspx

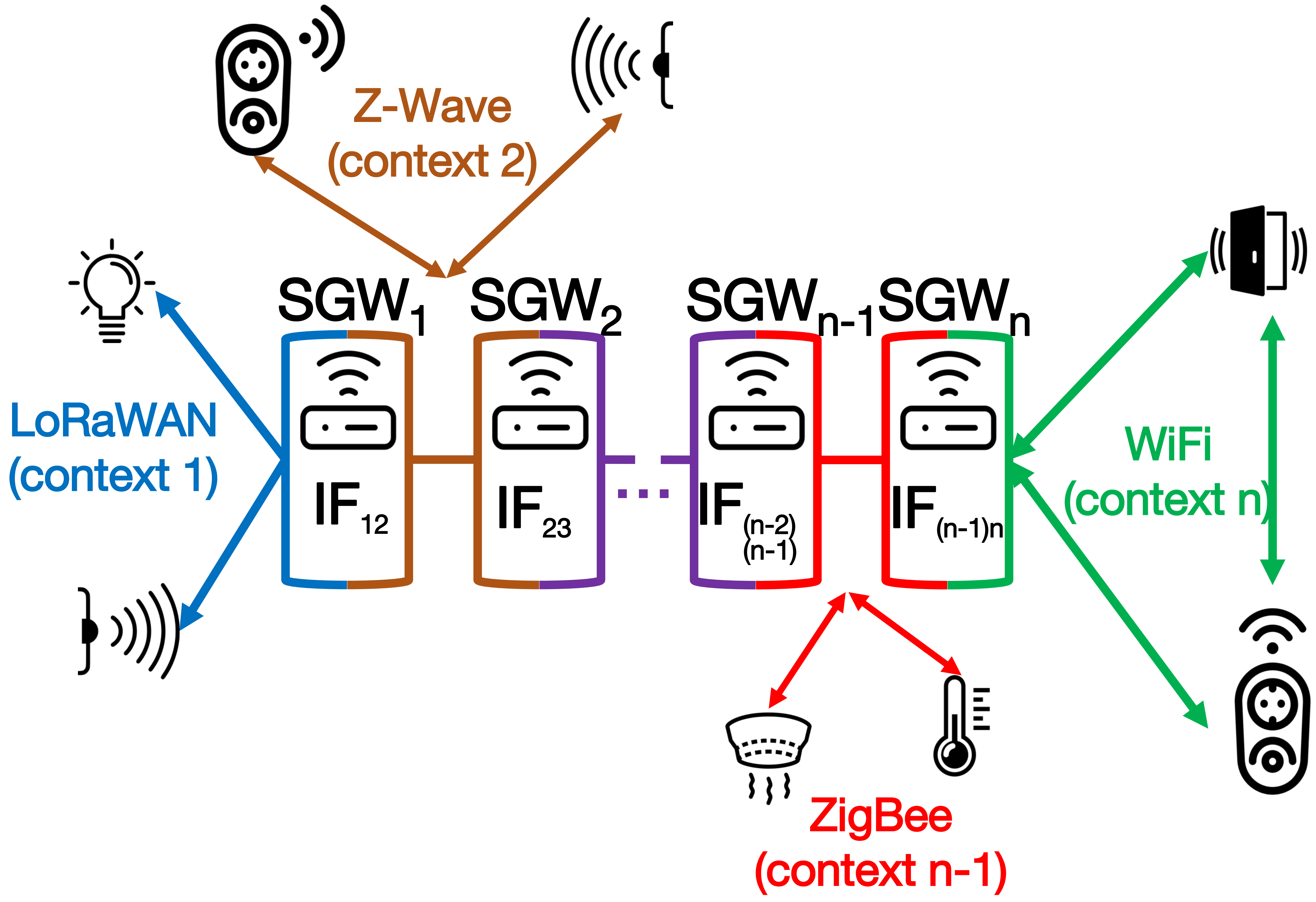
Alternative: decentralised automation

- More robust, fast and secure
- Offload control functions to a hierarchy of networked units:
  - separate control of different IoT sensors
  - enforcement of automation workflows distributed across the architecture
  - dealing with sensitive sensor data locally



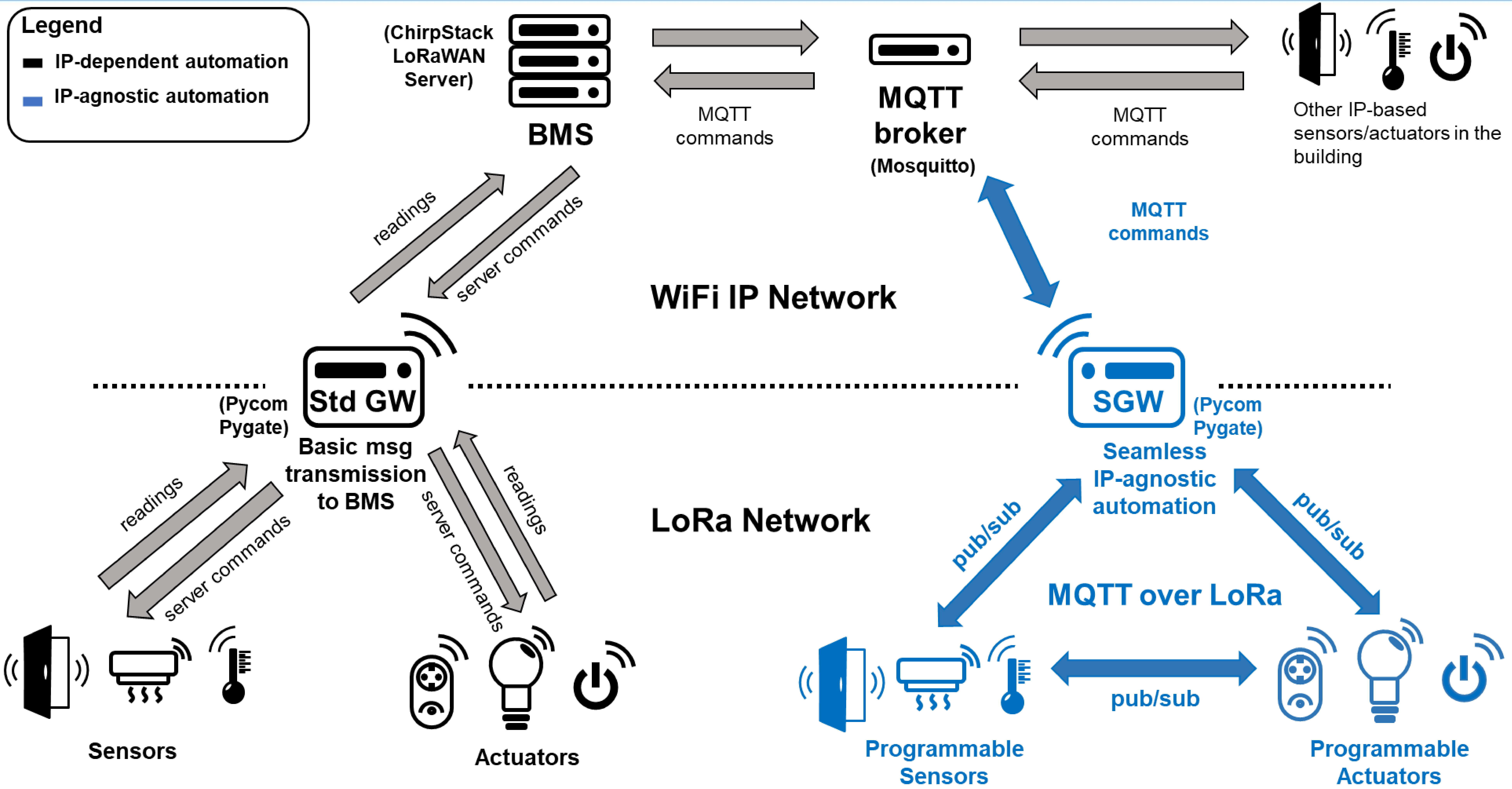
Protocol-independent IoT interoperation model

- Inspired by Plutarch architecture*
- **Contexts**: group of IoT devices within the same protocol
- **Distributed Smart Gateways (SGWs)**
  - **Interstitial function (IF):** inter-context mapping for seamless application provision
  - IP-agnostic interoperation between contexts
  - local automation logic
  - inter-context QoS, sensitive/redundant data filtering



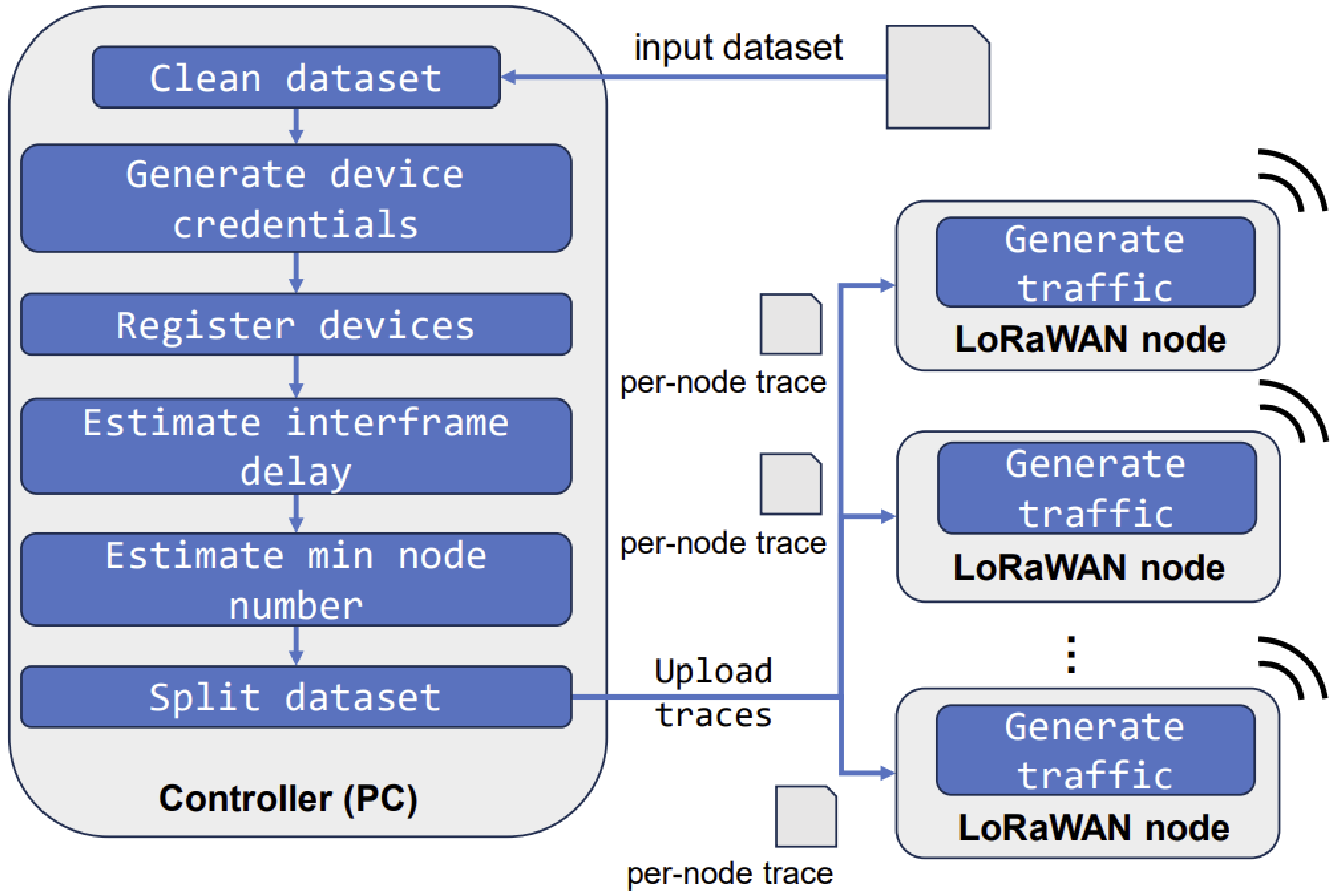
(*)Jon Crowcroft, Steven Hand, Richard Mortier, Timothy Roscoe, and Andrew Warfield. 2003. Plutarch: an argument for network pluralism. SIGCOMM Comput. Commun. Rev. 33, 4 (October 2003), 258–266. DOI:https://doi.org/10.1145/972426.944763

Implementation



Tools for large-scale evaluation

LoRaWAN traffic generator:



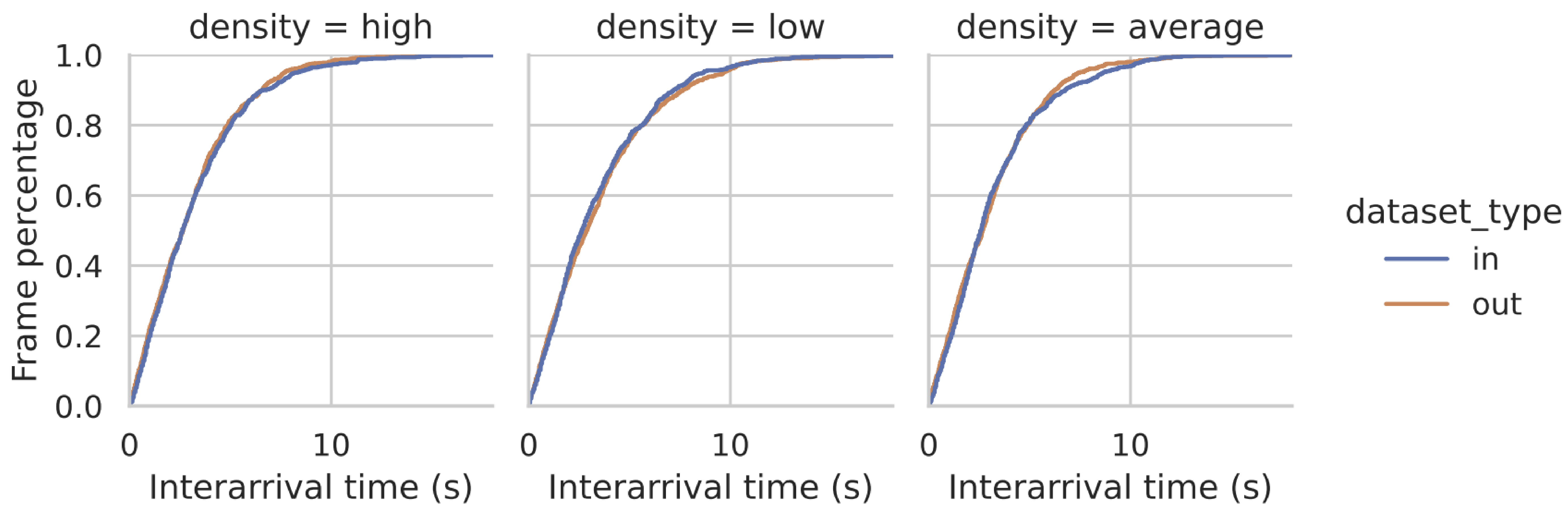
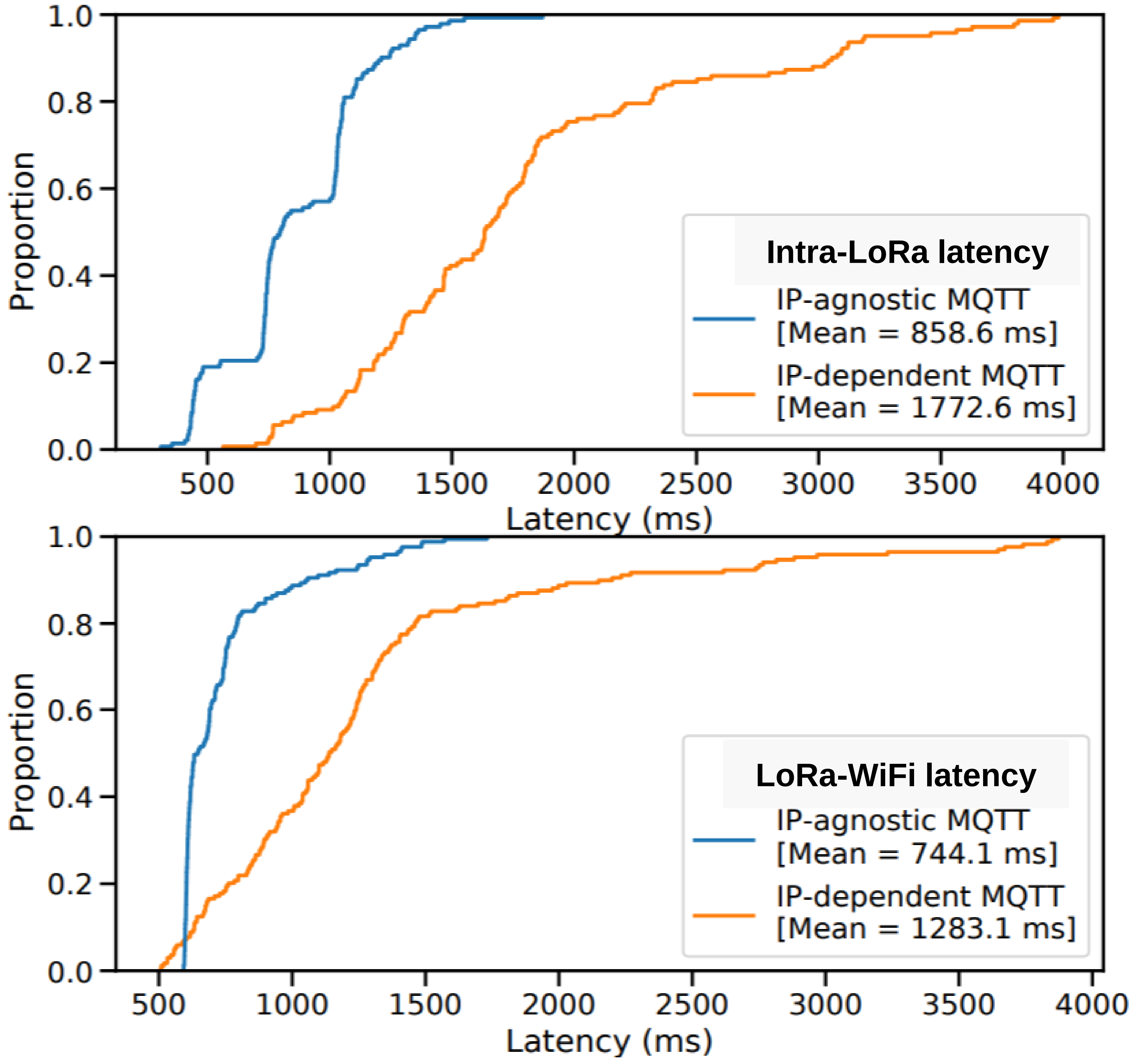


Figure: Comparison of interarrival time distribution between initial and reproduced LoRaWAN datasets

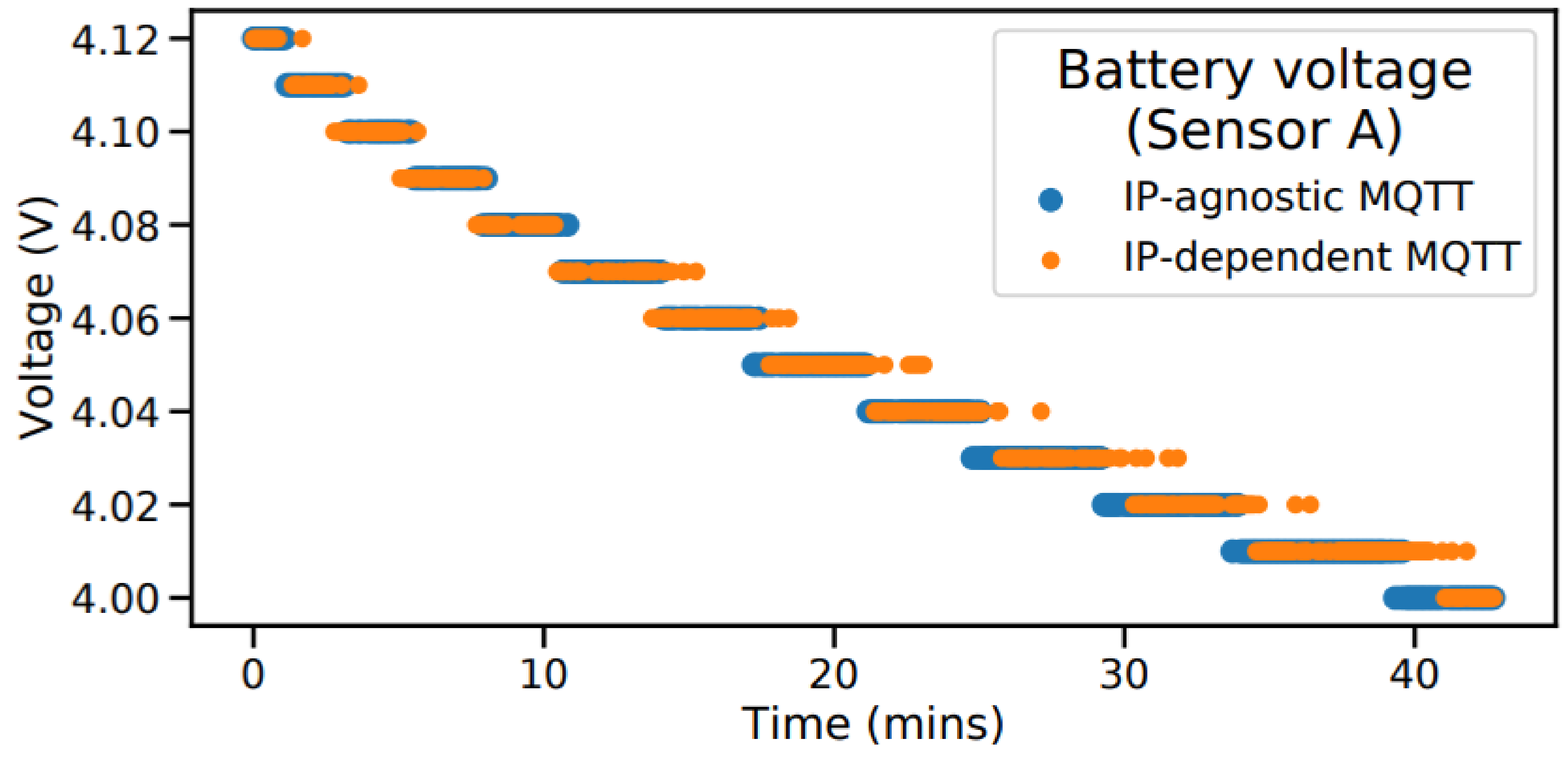
- **Real-time LoRaWAN traffic generation**
- **Model dense urban traffic loads with minimum number of nodes**: ~10 nodes for 400 active devices
- Need to comply with regional regulations (1% duty cycle) and hardware limitations
- **reproducibility precision > 90%**

Comparison with centralised IP-dependent automation

<u>Latency over power consumption</u> *(published in ACM HotNets'21)*



- MQTT automation over LoRaWAN and WiFi contexts
- Up to two times reduced application interoperation latency
- Improved service responsiveness over the same device power consumption



Further work

- Large-scale realistic eval using the developed LoRaWAN traffic generator
- Precise quantitative comparison against the legacy approaches for IoT automation: latency, robustness, power consumption
- Dissertation writeup

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