Comparative Performance Analysis of Empirical Propagation Models for LoRaWAN 868MHz in an Urban Scenario.

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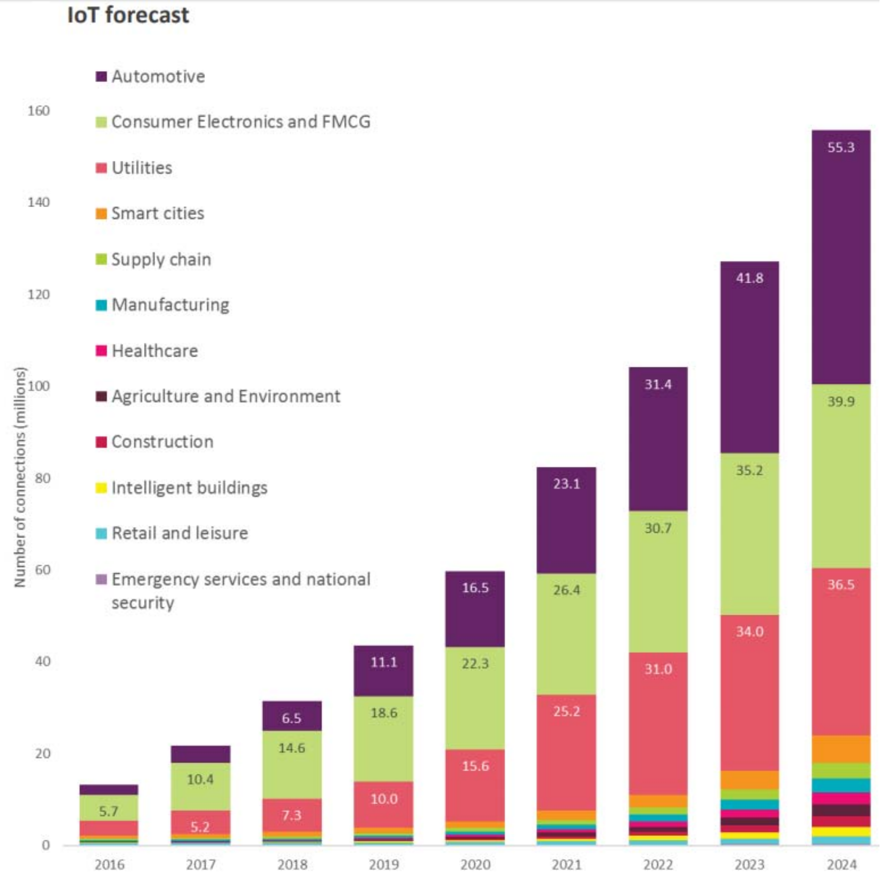
Research Background and Motivations

- The Internet of Things (IoT): A network of everyday consumer devices and other physical objects that are connected to the Internet to provide new services.
- IoT is set to enable large numbers of previously unconnected devices to communicate and share data with one another.



Source: Cambridge Consultants IoT forecast for Ofcom

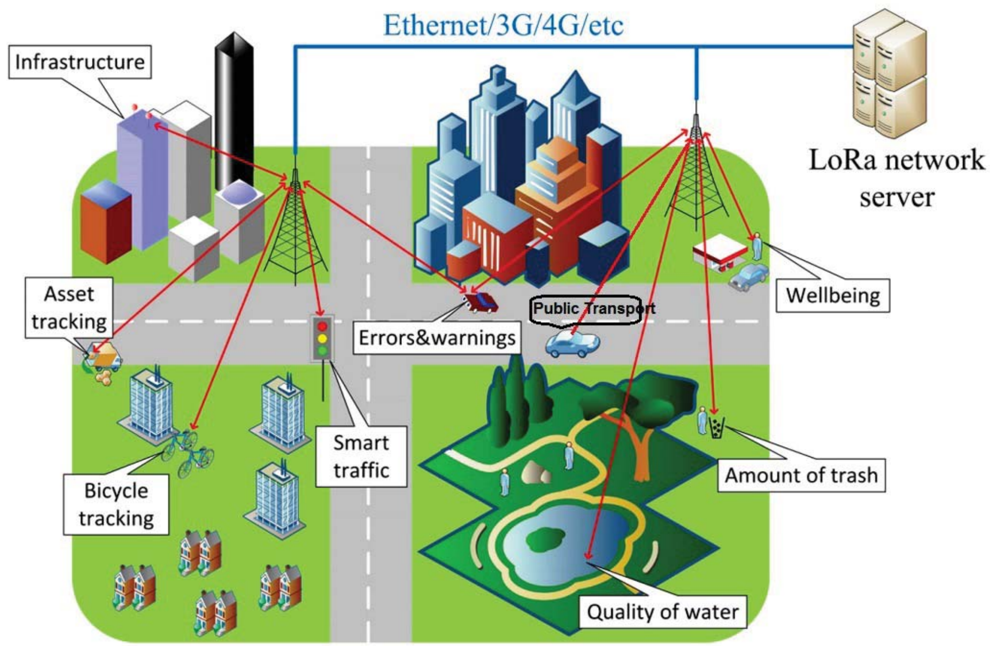
Research Background and Motivations

- LoRa is technology for wide area networks designed to be deployed in the 868MHz band in Europe, which is exempt from licensing.
- LoRaWAN defines the communication protocol and network architecture, while LoRa is a physical layer that enables communication over the long range.
- Anyone is permitted to roll-out LoRaWAN networks, so we can expect public, private, or enterprise deployments, etc.
- IoT for smart cities has triggered multiple studies to analyse LoRaWAN coverage and deployment in an urban scenarios.
- In the existing literature, real-world measurement is the main tool so far used to study LoRaWAN coverage and deployment in the city environments.

Research Background and Motivations

- Empirical propagation models can be vital planning and deployment tools for LoRaWAN networks as they depend less on terrain data and are faster to execute.

- There is little work regarding the use of standard propagation models to assess the propagation performance of LoRaWAN networks.



Research Challenges

Some unique features of LoRaWAN IoT which make the operation and propagation in the city environment a challenging task include:

- **Wireless channel:** During the RF propagation, the signal undergoes Path loss, shadowing, multipath fading, etc,. especially in an urban environment.
- **Wireless link quality:** Quality of link is subject to wireless channel and adversely affected by the devices (transmitter/receiver) location.
- **City environment:** Propagation models are built and validated for specific propagation environment, eg,. city, but city environment changes so fast.

Research Challenges

- **Practical LoRaWAN IoT deployment and tools:** Currently, most LoRaWAN deployment and performance assessment is based on measurements.There are few simulation tools with LoRaWAN protocol.

- **Empirical/geometric models for LoRaWAN IoT deployment:** These tools are vital for planning practical IoT deployment, but are either less accurate or expensive to use.

Main Work 1 - What did we do?

1.Modelling RF propagation into ns3 LoRaWAN simulator.

2.Simulated LoRaWAN 868 MHz in the city of Glasgow.Used models:

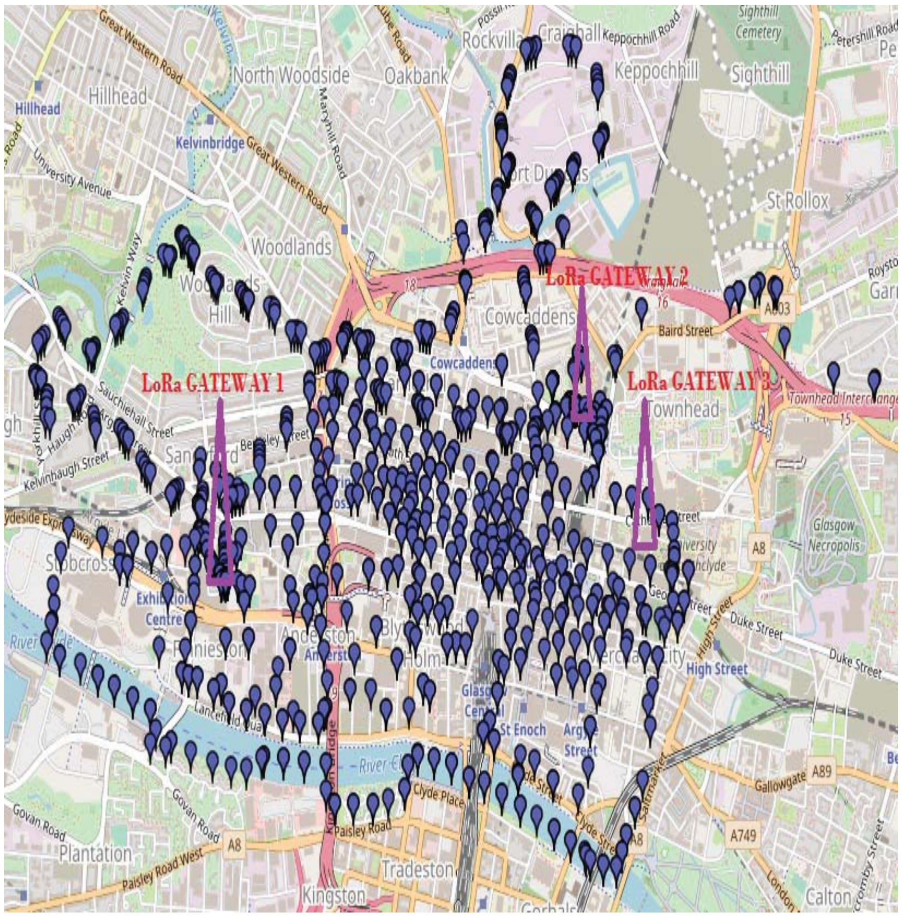
- **Okumura-Hata Model**
- **COST-231 Hata Propagation Model**
- **COST-231 Walfish-Ikegami**

3.Measured real-world data in the city of Glasgow.

4.Analysis of the real-world data measured in Glasgow city for LoRaWAN propagation performance.

5.Critical analysis of three empirical models and the measurements to evaluate the models'accuracy.

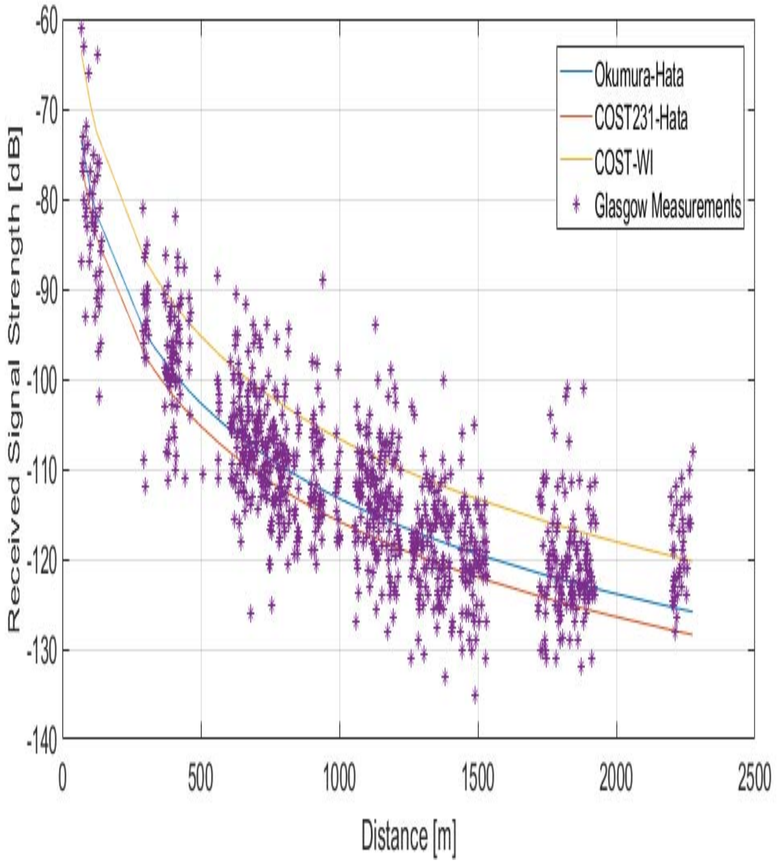
Main Work (2) - How and what did we use?



At the walking speed, measurements taken to collect LoRaWAN real-world transmission data.We used a LoRaWAN transceiver with a Multitech mDot^{TM} long-range RF module, regulated by a Raspberry Pi single board computer and Kerlink gateway equipment.

- **1 transceiver (mobile).**
- **3 gateways (see map)**
- **The channel: city enviroment(Glasgow)**
- **RSSI recorded (backpack,networkserver)**

Main Work (2) - How and what did we use?



Simulated LoRaWAN propagation with models in opposite figure and codes written in C++.The predicted received signal strength values as depicted in opposite figure for every individual model were recorded.

- **1 transceiver**
- **1 LoRa Gateway**
- **In the channel: City environment**
- **RSSI manually recorded**
- **Clustered data**

Main Work (3) - Performance Analysis Results

Table 3.2: Statistical Error Performance Metrics

Error parameters	Okumura-Hata	COST-231	COST-W.I
μ_e	-0.366	-2.915	6.484
$\lvert\Delta y\rvert$	5.564	6.131	7.413
σ_e	9.158	11.425	7.454

To benchmark the accuracy of each model and evaluate models performance against the real-world data, we used the mean prediction error, μ_e, mean absolute error, $|\Delta y|$ and standard deviation, σ_e of the prediction error.

The mean prediction error, μ_e showed that while Okumura-Hata and COST-231 Hata models under-estimated the RSSI, COST-WI model over-estimated it for LoRaWAN.

Main Work (3) - Performance Analysis Results

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*Mean absolute error:used to measure accuracy of models' prediction.It is a measure of the expected average magnitude of the prediction error.

- **Models Vs real-word data.**
- **Acurracy:Predicted Vs expected prediction error.**

*Standard deviation

Conclusion

- Of the three RF propagation models evaluated, the performance analysis results showed that COST-WI predicted RSSI values that have the closest match to LoRaWAN real world-data measured in the city of Glasgow.

- Value: Some models are a vital tool for practical LoRaWAN IoT deployment.

Thank You