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Extending LPWAN Architectures with Heterogeneous Mesh Networks. The Challenge.

Mina Rady (Orange Labs). Supervised by Dominique Barthel, Quentin Lampin (Orange Labs), and Thomas Watteyne (INRIA Paris).

The Context

- One of the challenges faced by LPWANs today is hard to reach areas, for example:
 - Smart Meters (with the CE M/441 mandate)
 - Parking lot sensors
- Current network architecture is closer to Aloha style protocols via Gateways used to create hotspots with high-throughput back-haul such Ethernet, WiFi, or 3GPP. Such scheme faces three challenges:

I. Towards Extreme Coverage

- Orange has an infrastructure for LoRaWAN coverage across France.
- In **urban** scenarios, deep indoor nodes such as smart meters or parking sensors are difficult to reach, despite existing coverage from outdoor gateways.
- In **suburban** or agricultural scenarios, some land spaces outside of the cities are out of coverage.
- First sub-conclusion:** more pervasive coverage is needed.



Orange LoRa coverage in France.

<https://www.orange-business.com/fr/reseau-iot>



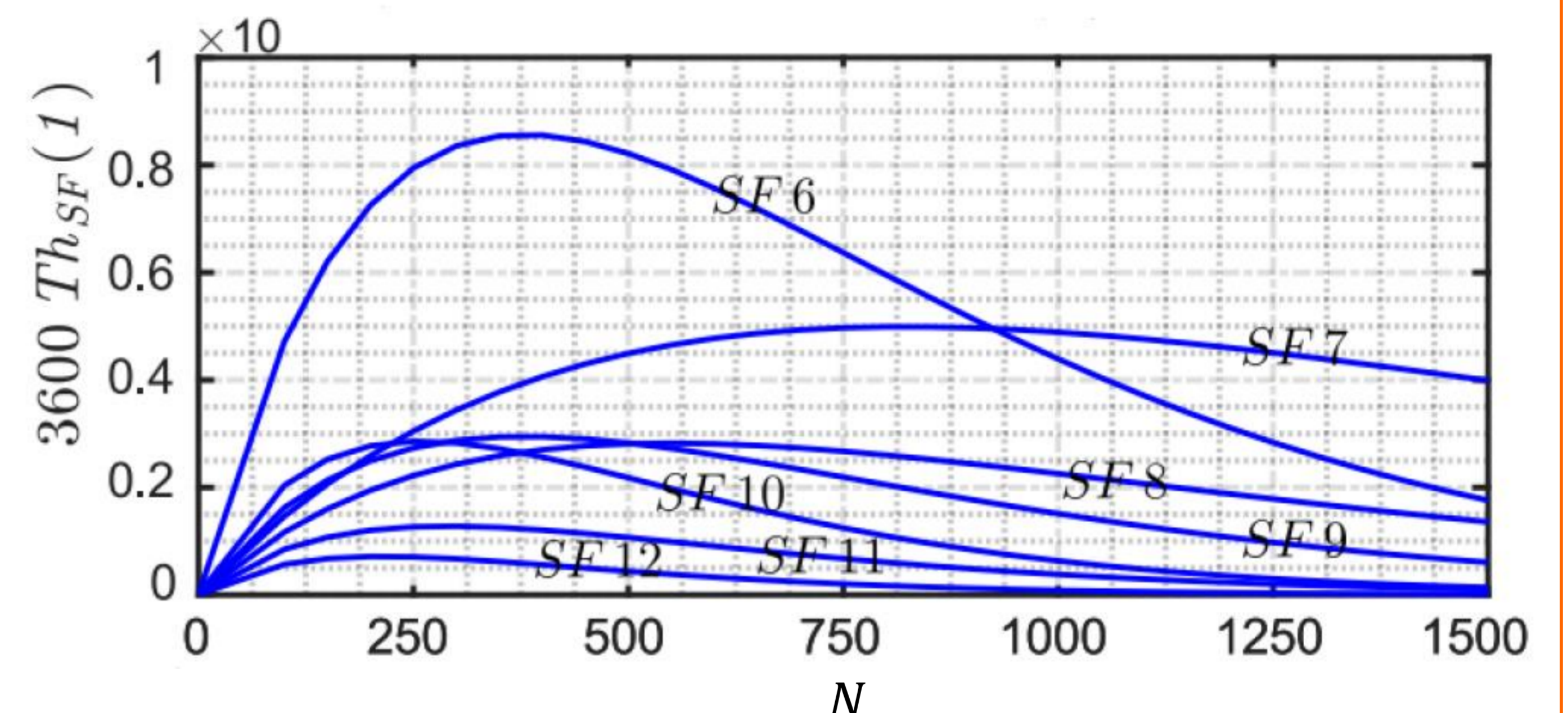
Example of concrete structure environments of underground parking sensors parking in Orange Labs Meylan

II. Economic Efficiency

- In the current network architecture, coverage can be extended by adding more GWs.
- Some out of coverage devices are so isolated that the financial outcome from their subscription is too small to justify the CapEx and OpEx costs of a new GW:
 - CapEx:** A typical LoRaWAN station costs around 1000 euros CapEx. A fixed power source (at least) needs to be secured.
 - OpEx:** Recurring fees per GW by third parties and for roof rental contracts.
- Second sub-conclusion:** cheaper coverage devices are needed with minimized installation and recurring costs.

III. Coverage and ISM Band Capacity Limitations

- Another way to extend coverage is using more robust modulations at higher Tx powers.
 - Such modulations consume significant time on air, thus draining the ISM band, leading to overall lower capacity.
- ISM band is a limited resource that is shared among non-cooperating players (i.e. with diverse owners). This makes the above challenges even worse due to collateral influence to/from all players.



Average effective throughput in one hour of LoRaWAN with different spread factors with one repetition.

(Quentin Lampin, Zhuocheng Li, Nadège Favre, Orange Labs)

- A better solution could be to split the link in two or more links where robust modulations are used only where necessary- to optimize ISM band tenancy, data rate, and network capacity.
- An allocation-based approach is beneficial to minimize contention at network bottlenecks.
- Third sub-conclusion:** A multi-hop, multi-radio, allocation based paradigm is required.

The Proposal: An Agile Mesh Architecture

We propose a mesh architecture that allows heterogeneous Radio Access Technologies and physical layer modulations within the same system for an agile and adaptive network.

- Some modulations are robust and long range but long air time with low data rate.
- Others are less robust but with less air time such as 15.4g (2.4 GHz or 868 MHz) or LoRa at SF6.

Related Implementations

- A Smart Extender for LoRaWAN has been implemented by Orange Labs. It offers a cheaper and portable alternative for extending coverage.
- OpenWSN TSCH based mesh network technology based on 802.15.4e and 802.15.4g has been intensively researched and tested. It offers a reliable framework for agile mesh development.



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