IMT Atlantique
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PhD thesis subject: Interoperability and compression for massive and energy-efficient IoT

Lieu : IMT Atlantique, Campus de Rennes
Equipe de recherche ADOPNET (IRISA)

Context

Though the concept of Internet of Things was defined more than 20 years ago, the number of connected objects have experimented a moderate growth. IoT is still not mature and not deployed on a large scale.

On one hand, the deployment of applications for various verticals requires very simple objects for which implementing a full IP stack is not possible due to cost and energy constraints. In particular, the different headers related to the protocol stacks are too long compared to the payload. On the other hand, objects should be interoperable, which makes the IP compatibility a pre-requesite. Static-Context Header Compression (SCHC) is a solution to combine both constraints and to provide an end-to-end quality of service. It is now an international standard [RFC8724]. Some first uses of SCHC were made on LoRaWAN and showed very promising results [Interop]. However, there is still a potential of SCHC for other technologies.

Subject

Due to the objective of addressing various use cases, 5G protocols are complex. Though this complexity is required in most cases, it is useless for some applications and represents a waste of energy and capacity. Beyond the particular case of massive IoT, SCHC can offer a potential gain of quality of experience for a large variety of applications. Due to the flexibility of SCHC, profiles adapted to each specific application constraint can be defined and, for example, dynamically activated in a specific slice.

3GPP support of Machine-Type Communications (MTC) started with release 10 and was specified in 2016 in release 13 with NB-IoT and LTE-M. In the meantime, the LPWAN (Low Power Wide Area Network) was made popular by actors such as

LoRaWAN who developed their own ecosystem for constrained objects. Even if objectives and architecture are less ambitious, they present some similarities (cf. RFC 8376).

5G widens the scope of IoT; mMTC (massive Machine Type Communications) relies on release 13 NB-IoT features and URLLC (Ultra Reliable Low Latency Communications) requiring full 5G Core deployment to reach the latency reduction.

SCHC is a generic framework for header compression and fragmentation, designed with LPWAN in mind. IMT Atlantique contributed to its standardization at the IETF in 2020 in RFC8724 and to its performance evaluation [Sensor]. SCHC is generic, therefore profiles are needed to address specific network technology, e.g., RFC9011 for LoRaWAN; [SCHC-NBIoT] defines how SCHC can be added to the 4G architecture. In [Interop,] we show that the highly predictable nature of IoT application data flows, allows SCHC reducing the header overhead from tens of bytes down to only a few bytes, by going through all the stack layers, while still providing full interoperability with existing environment and end-to-end encryption.

In this thesis we aim to enhance the usage of SCHC in the 5G architecture, mainly thanks to slicing and virtualization. Slicing allows a group of devices to be managed through the same rules, and virtualization makes it possible to apply compression and fragmentation closer to the devices. The result is a scalability increase, latency reduction but also energy saving. If the SCHC process is virtualized in the core, fragmentation and compression rules must be a combination of network and application values. The thesis will focus on the following topics

- Architectural analysis of SCHC in virtualized architecture
- Rule management
- Performance measurement for massive terminals and low latency environment
- Optimization
- Possible participation to standardization groups (IETF)

This thesis includes both the specification of evolution of the 5G architecture and associated protocols but also the implementation of the solution on a testbed and of course the performance analysis.

Expected skills of the candidate

- Network architecture and protocols
- 4G and ideally 5G technologies
- OS, virtualization platform
- Standard soft skills for a doctoral thesis (imagination, precision, tenacity, listening, team spirit)

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References

[RFC8724] Minaburo, A., Toutain, L., Gomez, C., Barthel, D., & Zúniga, J. C., "RFC 8724 SCHC: Generic Framework for Static Context Header Compression and Fragmentation." (2020).

[RFC9011] Gimenez, Olivier, and Ivaylo Petrov, eds. "RFC 9011: Static Context Header Compression and Fragmentation (SCHC) over LoRaWAN." (2021).

[SCHC-NBIoT] SCHC over NB-IoT, draft-ietf-lpwan-schc-over-nbiot-06, Edgar Ramos (Ericsson), Ana Minaburo (Acklio), Nov 2021, work in progress.

[Interop] Effective interoperability and security support for constrained IoT networks, Marion Dumay, Dominique Barthel, Laurent Toutain, Julien Lecoeuvre, GLOBECOM 2021 - 2021 IEEE Global Communications Conference

[Sensor] Aguilar, Sergio, et al. "Performance analysis and optimal tuning of IETF LPWAN SCHC ACK-on-error mode." IEEE Sensors Journal 20.23 (2020): 14534-14547.

Location

Campus de Rennes of IMT Atlantique

The thesis is a part of “Programmes et équipements prioritaires de recherche” on 5G networks in the general framework of France 2030.

Supervision

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