Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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PhD information	
Title	Efficiency improved Internet of Things (IoT) networks
Main topics regards to CSC list (3 topics at maximum)	Embedded electronics Computer Science

	Internet of Things
Required skills in science and engineering	Software design (Linux, C, Python) Modeling Embedded software and hardware knowledges

Subject description (two pages maximum)

The Internet of Thing (IoT) is dramatically growing and is expected to bring together more than 30 billions of things or objects in 2020 [1]. These things are very heterogeneous in terms of size and hability to compute. However, they share some main characteristics. The objects can sense their environment, compute some data, and communicate either to other objects, or to gateways. They are mainly made of one or more sensors, a microcontroller, and a radio unit. In this thesis, we focus on small objects with low-power microcontrollers, and small radiofrequency transceivers. As they are supposed to be autonomous, they are often powered by a compact energy source such as a battery. In this case, the energy become a critical issue. The size of the battery is generally limited – restricting its available energy – due to the limited space.

To ensure the functioning of the thing over an extended period of time, it is crucial to (1) save the energy while functioning, and (2) to predict the consumption at the design stage.

The consumption can be roughly divided into two parts. The first occurs during stand-by or sleep period: the thing is in a low-power mode (current less than 1 mA), generally during long period. The second implies moderate- to high-power (current in the range of a few mA to hundreds mA), during short periods of time. The electrical consumption comes from electronics devices (microcontroller or peripherals such as sensors, radio, storage memory, …), but are mainly driven by an embedded software.

This PhD work is focused on the energy issue at the border between electronics and software, and is based on a previous PhD thesis recently defend at Université Lille [2]. The overall objective is to provide to the embedded software developers, an ecosystem based on the energy consumption. To reach such ambitious goals, the PhD work covers different tasks.

- A framework made of a software part to mark the embedded code and to provide figures to the developer [3,4] and a hardware part to assess the current consumption [5] has been designed. The first task consists in upgrading the framework, notably the hardware part to better take into

account the low-power mode. The accuracy will be increased, while maintaining a small and cheap platform, since we plan to deploy at large scale ;

- The second task consists in adding a new functionality to the software platform. At the moment, the platform can deliver some consumption figures linked to the execution of the embedded code (power data and a function call tree), and can derive a model of the energy consumption. The next step is to use the upgraded platform to characterize specific cases in IOT usage and be able to automatically write design guides for low power programming ;
- The generation of the model will be improved to take into account the asynchronous consumption. For instance, to send data, an embedded software use a radio, which can be configured through a serial link (SPI, I2C, …). The software function can be executed very quickly in a few µs (a few lines of C code), while the time to effectively send the data through the radio can be quite long, up to a few seconds in the case of low-power low data rate radio. To clearly assign the real electrical consumption to the portion of code (responsible of the consumption), some deep modifications should be done on the model generation. One way could be the use of Markov's model or other theoretical works ;
- The next steps is to use the software/hardware platform in real cases of IOT, including many instrumented things. The main challenge is to collect the consumption data from many things and to be able to give sense to the data, by aggregating and presenting them in a readable way.

The work will be supervised by Prof. Nathalie Rolland, assisted by T. Vantroys (computer science) and A. Boé (electronics).

[1] Ericsson, Internet of Things forecast, 2016.

[2] N. Cherifi, Assistance au développement de logiciels embarqués contraints en énergie, PhD thesis, defended on the 19th of September 2019.

[3] N. Cherifi, T. Vantroys, A. Boe, H. Colombe, and Gilles Grimaud, "Automatic Inference of Energy Models for Peripheral Components in Embedded Systems," FiCloud 2017 : The 5th International Conference on Future Internet of Things and Cloud, Aug 2017, Prague, Czech Republic. 2017

[4] N. Cherifi, G. Grimaud, A. Boe, T. Vantroys, "Toward Energy Profiling of Connected Embedded Systems," NTMS 2016 - 8th IFIP International Conference on New Technologies, Mobility and Security , Nov 2016, Larnaca, Cyprus. pp.1 - 4, 2016

[5] N. Cherifi, A. Boe, T. Vantroys, C. Herault, G. Grimaud, "A Low-cost Energy Consumption Measurement Platform," INTESA workshop, Turin, Italy, 2018, accepted paper.