MASTER'S THESIS INTERNSHIP OFFER

DESCRIPTION

- **Title :** SENSIFY: Sensor Network Expansion System with IoT Features using RIOT OS
- **Hosting organization:** University of Limoges
- **Lab:** XLIM
- **Research Team:** SRI/RUBIH
- **Scientific pole:** ELECTRONIC
- **Starting date (month/date):** 18 mars 2024

- **Short description of the internship offer (up to 5 sentences):**

Join our master's thesis internship to expand a Wireless Sensor Network (WSN) using LoRa protocol and 32-bit microcontrollers with RIOT OS. Explore advanced IoT technologies, conduct in-depth benchmarking, and contribute to the development of energy-efficient and reliable sensor nodes. Plus, seize the opportunity with a full thesis scholarship for the selected candidate.

- **Objectives (up to 5 sentences):**

The main objectives involve designing and implementing wireless sensor nodes using 32-bit microcontrollers and the LoRa protocol. Emphasis will be placed on conducting thorough benchmarking of 32-bit microcontroller architectures to select the optimal solution in terms of performance, energy efficiency, and features. Additionally, tasks include adapting and integrating the RIOT operating system to optimize sensor node performance, conducting comprehensive tests to ensure reliability and ease of maintenance, and documenting all aspects of the development and testing processes.

- **Description of the internship offer:**

In the framework of IoT, this project deals with Wireless Sensor Networks (WSN) as a set of sensors distributed in space to sense and which transmit physical conditions of an environment. In order to meet the highest demand in terms of reliability, energy efficiency, and ease of maintainability of IoT devices, it is essential to leverage cutting-

edge technologies such as edge computing and machine learning algorithms. This enables real-time data processing at the device level, reducing latency and enhancing reliability. Implementing low-power consumption protocols and optimizing communication protocols contribute to energy efficiency, while remote monitoring and over-the-air updates streamline maintenance processes, ensuring seamless operation and longevity of IoT objects.

These WSN nodes are connected through antennas communicating remotely with radio waves to cover a large area. The WSN remains operational as long as communicating nodes are powered, which means the WSN's "lifetime" depends on nodes battery life. Saving nodes batteries is a major economic and ecological challenge in WSN installation. It is well-know that the most energy-consuming components in a WSN node are on the one hand data sensing, involving sensors powering and signals processing and digitalizing; and on the other hand, wireless communication.

Compressive sensing (CS) theory is dedicated to data compression and reconstruction. CS is widely used in WSN field for its battery saving capability since it enables a drastic reduction of sensors measurements with a sampling rate well below the Nyquist-Shannon.

We are experiencing the CS method on signals acquired by a 34 sensors nodes WSN installed all over inside a 4-storey building. This WSN monitors environment parameters like temperature, humidity, luminosity, CO2. Nodes use Zigbee protocol to communicate. Measurements are send to a single gateway then synchronized and saved in a database. Sensors spatial arrangement is crucial to establish spatial correlations which could be exploited to reconstruct signals by a spatial CS method.

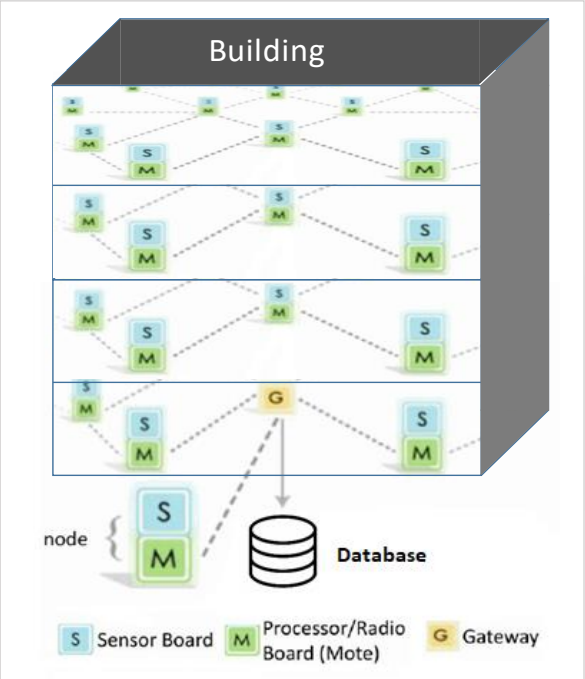
The proposed master's thesis internship deals with the expansion of this WSN using the LoRa protocol. We would like to increase to total number of node using 32-bit microcontroller architecture, typically SMT32 boards, running RIOT. RIOT is a free, open source operating developed by a broad community which aims to implement all relevant open standards supporting an Internet of Things that is connected, secure, durable and privacy-friendly.

Main tasks:

- **Development of New Sensor Nodes:** Design and implement wireless sensor nodes using 32-bit microcontrollers and the LoRa protocol. Primarily, conduct in-depth benchmarking of 32-bit microcontroller architectures to select the most suitable solution in terms of performance, energy efficiency, and features for the specific project requirements.
- **Integration of the RIOT OS:** Adapt and integrate the RIOT operating system to optimize the performance of the sensor nodes.
- **Testing and Optimization:** Conduct thorough tests to ensure the reliability, energy efficiency, and ease of maintenance of the new sensor nodes.
- **Documentation:** Prepare detailed documentation of the undertaken developments, conducted tests, and obtained results.

This internship provides a unique opportunity to contribute to cutting-edge IoT technologies, emphasizing the enhancement of sensor networks through advanced protocols, microcontroller architectures, and operating systems. The successful candidate will play a crucial role in addressing the challenges of energy efficiency and reliability in WSNs, contributing to both economic and ecological sustainability. Additionally, a full thesis scholarship is available for the selected candidate.

› Photo (optional)



WSN installation

› Description of the research team:

The RUBIH research team focuses on advanced compression techniques, specifically Compressive Sensing, applied to surveillance video networks. We explore the application of artificial intelligence, including Machine Learning and Deep Learning, in this context. The team's interest extends to challenging networks such as those in industrial settings (Industry 4.0), dealing with strong interference and stricter time constraints. Additionally, we apply these techniques to vehicular communication networks, considering mobility constraints and leveraging deep learning and deep reinforcement learning.

In the realm of virtualization, RUBIH investigates virtual functions (VNF) and mobility management in 5G cellular and vehicular networks. In the context of multimedia wireless sensor networks, the team seeks innovative deployment solutions to reliably and with low complexity transmit images or videos. Their link adaptation strategies incorporate compressive sensing schemes, coupled with low-complexity learning techniques, to reduce the data acquisition rate of multimedia sensors by taking advantage of the often correlated nature of captured data. In summary, RUBIH's research addresses cutting-edge technologies to enhance the efficiency of communication networks, employing advanced compression methods and artificial intelligence approaches.

SKILLS

› Expected skills of the applicant:

Embedded Systems: Proficiency in designing and implementing wireless sensor nodes using 32-bit microcontrollers, particularly STM32 boards.

IoT Protocols: Familiarity with communication protocols, especially LoRa, and experience in adapting and integrating protocols for optimal sensor node performance.

Operating Systems: Knowledge of operating systems, particularly experience with the RIOT OS, for effective integration into the sensor network.

Benchmarking: Ability to conduct in-depth benchmarking of 32-bit microcontroller architectures to select solutions based on performance, energy efficiency, and project-specific requirements.

Testing and Optimization: Strong skills in conducting thorough tests to ensure reliability, energy efficiency, and ease of maintenance of sensor nodes, coupled with the ability to optimize performance.

Documentation: Proficient in preparing detailed documentation of developments, tests, and results throughout the expansion process.

Team Collaboration: Effective collaboration within a research team and the ability to communicate technical concepts clearly.

Applicants with a background in computer science, electronics, or a related field are encouraged to apply.

PHD THESIS OPPORTUNITIES

› PhD thesis opportunity after the Master course:

☒ Yes ☐ No

› If yes, financing already obtained:

☒ Yes ☐ No

› If yes, what kind of funds: PEPR 5G - FITNESS

CONTACT & APPLICATION

› Surname and first name of the internship supervisor(s):
Fabien Courreges and Romain Négrier

› Email of the supervisor(s): fabien.courreges@unilim.fr and romain.negrier@unilim.fr

› Phone number of the supervisor(s): 0555867322

› The application shall be sent to the email: fabien.courreges@unilim.fr or romain.negrier@unilim.fr

› Closing date for applications: 27 janvier 2024