PhD Thesis

# SYNCHRONISATION OF WIRELESS IOT NETWORKS UNDER INTEGRATION & CONSUMPTION CONSTRAINTS

## Application and research context

One of main trends in Internet of Things (IoT) goes to low power consumption systems, entirely autonomous in their mission, with capabilities of operation in network ensuring the information transfer to ground or air based station.

For one of our future IoT applications in the context of local monitoring (Local Seismology, Microclimat, Local Airflow, Soil and crop state) using a network of spatially distributed sensors (hundreds in < 100m range between communication nodes) and a drone based station, the question of the information transfer from each node to the base station necessarily arises. The main problem happens during a short time fly-by over the nodes by the drone. Since the nodes are not necessarily all connected to the base station, the network information cannot be fully transferred to the base. In general, the communication phase being extremely power consuming, an asynchronous transfer approach cannot be used due to among others a high number of nodes in the network. Targeting the low power consumption for the overall network, low bandwidth for the communication channels (about 200Hz) and guarantee of the minimum communication time might be possible through the decentralized synchronization between the nodes where the base station is used as the reference. In this context, one has to ensure the synchronization of spatially distributed clocks (time domain criterion) together with spectral constraints for the carrier signal (frequency domain criteria).

The main objective is to find the most efficient clock synchronization solution based on the extensive use of signal processing and automatic control techniques that may deal with numerous aspects of the initial application specification such as synchronization constraints expressed in time and frequency domains as well as the decentralized character of the problem.

## Scientific challenges and possible contributions

This thesis will tackle new scientific challenges coming actually to the IoT from the ultra-low consumption needs, distributed architectures, and Ultra Narrow Band communication specifications. The first challenge consists in introducing a clock synchronization algorithm that involves uncertain/dynamic delays between nodes and the base station signals that are unavoidable and often neglected by the State-of-the-Art. The second challenge is to face the variable character of the interconnection topology between nodes and the base station due to the fly-by phase. In that case the base station will not constantly have connection to a chosen node but fly through a sequence of one or multiple nodes with varying IDs during the fly-by. The relative Doppler frequency shift will have impact on the network operation frequency.

Thus, the potential main contribution of the thesis is to propose a solution for a Control Theory Problem being not formulated before in the context of the communication network design. On the other hand, this solution allow to pave the way to the “quartzless” communication System on Chip (SoC) for IoT being extremely challenging since the constraints of overall consumption, frequency and phase stability are the main questions actually arise.

## Proposed research program

This work is part of recent researches in the IoT domain [LDBFO+:2018] and Control Theory where the first theoretical basis were introduced in decentralized control [Kor:11, Zar:13] based on robust control techniques [SkP:05] (control using time and frequency constraints) and based on input-output approach (decentralized network aspects ) [ScD:01, Kor:11, Zar:13].

On the other hand, the input-output approach allows to develop the Control Theory methods that provide the analysis of the delay impact on the decentralized system [Sco:97] and also some methods providing the performance analysis of interconnected systems [LKDSM:17]. The set of these results with some extensions might allow to resolve the synchronization problem being explained in the application context.

## Thesis supervision

This thesis is being part of long-term collaboration between CEA-Tech and Laboratoire Ampère, site Ecole Centrale de Lyon. The PhD student will be employed by the CEA and will pass 75% of time in CEA Grenoble under the supervision of Mykhailo Zarudniev, Research Engineer whose researches focus on control theory for microelectronics in the Laboratory for Embedded Software and Tools for Systems on Chip, and 25% of time in Ecole Centrale de Lyon under the supervision of Anton Korniienko, Assistant Professor and Gérard Scorletti, Professor whose researches focus on network design and robust control.

## Professional project

This thesis allows to work in two outstanding scientific environments: a Research and Technology Organization that is one of the World reference in the IoT domain, creating the excellence for the future industry, and a Research Laboratory of an Engineering school being well known actor of high quality of its education and fundamental research. It allows the candidate to make an equal opportunity fundamental of applied science career.

## Bibliographie


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