



# RESEARCH MASTER INTERNSHIP

Department of Complex Systems Engineering

Location : Toulouse, campus ISAE  
: SUPAERO

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## INTERNSHIP DESCRIPTION

Domain : **RESEAU COM (NETWORKS AND COMMUNICATIONS)**

Title : **SIMULATION OF REGULATORS IN TIME SENSITIVE NETWORKS WITH REALISTIC CLOCKS.**

**Time-sensitive networks** are used for safety-critical systems in planes, satellites or even power plants. Their significance has been increasing over the years and they are now used in many more applications, ranging from autonomous cars, automated manufacturing (industry 4.0) to 5G backbone networks. While traditional public networks aim at improving the mean service performances (mean ping, mean throughput), time-sensitive networks provide guarantees for the worst case (e.g. guarantee of a maximal latency, guarantee of a minimal throughput, guarantee of no loss, ...).

To achieve such guarantees, working groups of the IEEE (*Institute of Electrical and Electronics Engineers*) and the IETF (*Internet Engineering Task Force*) have been developing technologies. One of them is known as **traffic shaping**: specific hardware elements, called **regulators**, are placed at the output ports of routers. They enforce the traffic of flows to respect a given contract (in terms of burst and rate), delaying packets if required. Analyses of regulators using Network Calculus [[en.wikipedia.org/wiki/Network\\_calculus](http://en.wikipedia.org/wiki/Network_calculus)] have proved that they do not increase the End-To-End latency bounds. On the contrary, deploying regulators at every router within a network tends to reduce the maximum latencies and bursts. This effect is significant when the network is highly loaded.

Regulators do not need to share the same notion of time (they don't need to be synchronized). However, previous analyses of regulators always assume that they share the same notion of a duration: 1 second on a device also means 1 second on another device. In the real world, this assumption does not hold. Indeed, the oscillator within a clock may have a frequency slightly different from its nominal one. When this happens, **a regulator may enforce a slightly different contract from the one it has been configured with.** In a recent work, we have proved that clock non-idealities can generate network instability in time-sensitive networks, when regulators are used. When this happens, buffers of routers are overflowed, packets are lost in the network, and no more guarantee can be provided to the flows. The instability has been tested and confirmed in simulations.

### In this project:

The clock model that we use to generate the instability complies with the IEEE requirements. It means that it is possible to observe an instability in an Ethernet network, but it doesn't say how probable this is. In this project, we propose to study how probable such instability can be generated.

To do so, we need **more realistic clock models**. We will select in the Time Metrology domain what clock models are of interest. Using ns-3, we will then test the behavior of regulators under such clock models. ns-3 is an open-source network simulator, widely used for research and development in networking [[www.nsnam.org](http://www.nsnam.org)]. We will assess what are the realistic conditions that trigger the instability.

Depending on the results, we will then consider the interaction of regulators and clock non-idealities with other mechanisms used in time-sensitive networks, such as redundancy management systems and synchronization protocols.

**Deadline for applications: 31<sup>st</sup> January 2021. Internship start date : March 2020 (negotiable).**

Send your resume and a cover letter to [ahlem.mifdaoui@isae-sup aero.fr](mailto:ahlem.mifdaoui@isae-sup aero.fr). Questions about the internship can be sent to [ahlem.mifdaoui@isae-sup aero.fr](mailto:ahlem.mifdaoui@isae-sup aero.fr) or [ludovic.thomas@isae-sup aero.fr](mailto:ludovic.thomas@isae-sup aero.fr)

50 % Theoretical Research

50 % Applied Research

0 % Experimental Research

Possibility to go on a Ph.D.:

Yes

No

## APPLICANT PROFILE

Capabilities in Object-Oriented Conception and Programming.

Interest in networks, communications or real-time systems would be a plus.