PhD Proposal 2017

School: CentraleSupélec	
Laboratory: IETR	**Web site: http://www.rennes.supelec.fr/ren/rd/ash/**
Team: ASH (Hybrid System Team)	**Head of the team: H. Guéguen**
Supervisor: H. Guéguen	**Email: herve.gueguen@centralesupelec.Fr**
Collaboration with other partner during this PhD: **In France:**	**In China:**

Title: Non-cooperative agent in distributed Model Predictive Control
Scientific field: Electrical, Electronic and Telecommunication Engineering, Control Science
Key words: Multi-agent system, distributed Model Predictive Control

Details for the subject:

Background, Context:

To achieve higher level of performance, a growing interest has been granted to model predictive control (MPC) due to its ability to handle constraints in an optimal control environment. In a few words, in MPC, the control input is computed by solving an optimal control problem over a given horizon, using a prediction model. Only the first element of the open-loop command sequence is applied to the system. At the next instant, a new optimization is performed based on current measurements. For complex systems, it is no longer possible to control each subsystem without taking in consideration its interactions with the other subsystems. The relations between the subsystems can be linked to their dynamical interactions: for example, improving the thermal comfort of a single room requires considering the thermal interactions with the adjacent rooms. Subsystems can also be linked by sharing resources (Power allocation for instance). Using MPC, a solution could be to solve the resulting optimization problem from a centralized point of view. But due to the huge number of variables and the inherent complexity, combinatorial explosion makes the problem difficult to solve, and sometimes unfeasible in a given time. There is an increasing community of researchers that propose to develop distributed model predictive control technics (dMPC) whose aim is to define methodologies to provide local controllers which solve some reduced optimization problems, but interact together such that the obtained solution is the same as the global one. To this purpose, communication between agents is required, and a coordination mechanism has to be developed. In the survey [1] and the recent book [2], many works have been proposed, and in all these works, all agents try to improve the global objectives instead of its own. But what could happen if one of them unofficially refuses to participate and tries to take advantage of this situation to improve its own objectives? Is the rest of the group able to detect it? And then how this group can reorganize itself?

Research subject, work plan:

Research will be conducted at CentraleSupélec, in the campus of Rennes, under the supervision of Prof. Hervé Guéguen, and will feed into the work of the Control of Hybrid Systems team on distributed predictive control [3,4]. More precisely, this work will address two objectives:

- Given a group of agents, driven by controllers from distributed model predictive control technics, it will be necessary to find ways to identify an uncooperative agent. The main difficulty of this part is linked to the ability to distinguish between behavioural errors related to uncertainties and those that would be associated with bad intentions of the agent. To do this, sensitivity studies are interesting possibilities, as is the use of techniques from the fault-detection community [5]. This system can also be seen as a hybrid system in which each agent has nominal operation mode which is collaborative and well defined, and other operating modes that are not collaborative and more uncertain. The introduction of hybrid observers can also be an interesting option [6]. The first part of this thesis will be dedicated to a consistent and comparative literature study of these different approaches, which should lead to a choice to resolve the problem, in which theoretical evidence is expected.

- The second part of this thesis will focus on the group's ability to reorganize itself following an uncooperative agent detection. If it is not possible to turn off the uncooperative agent, the rest of the group will have to compensate its actions. One possibility is to treat them the same way as disturbances. The use of robust control techniques can then be envisaged, although this can lead to group performance losses. Theoretical studies will be conducted in this direction, including stability analysis.

References:

[1] R. Scattolini, *Architectures for distributed and hierarchical Model Predictive Control – A review*, Journal of Process Control, vol 19(5), 2009, pp 723–731.

[2] J. Maestre, R. Negenborn. *Distributed Model Predictive Control Made Easy*. Science and Engineering, 2014.

[3] D. Morosan, R. Bourdais, D. Dumur and J. Buisson, *Building temperature control using a distributed model predictive control*, Energy and Buildings, 2010, vol 42(9), pp. 1445-1452.

[4] E. Herrera, R. Bourdais, H. Guéguen, *Predictive and interactive controllers for solar absorption cooling systems in buildings,* Journal of Process Control, 2014, vol 24(6), pp. 836-845.

[5] G. Meng, D.V. Dimarogonas, K.H. Johansson, *Distributed real-time fault detection and isolation for cooperative multi-agent systems*, Proceedings of American Control Conference, 2012, pp. 5270-5275.

[6] A. Tanwani, H. Shim, D. Liberzon, *Observability for Switched Linear Systems: Characterization and Observer Design*, Transactions on Automatic Control, 2013, vol 58(4), pp. 891-904.