Context:
The digitalization of embedded systems, where connected programmable objects are used to interact with physical environments, is becoming commonplace in our everyday life. It is expected to increase even more drastically with Autonomous Cars (ADAS), Smart Cities and Buildings, and many more domains welcoming connected objects in the Internet of Things (IoT). The need to model these so-called Cyber-Physical Systems (CPS) in a way both formal and abstract enough to support early heterogenous design is increasing commitedly, to cope with inherent complexity of due software reactions to changes in the physical context. Such reactive behaviors may be time-critical, to guarantee operational safety or security.

In previous works we introduced notions of Multiform Logical Time, and a corresponding design methodology based on "logical clocks" to introduce meaningful events with variable timing as support to system specification. Allowing time variables as first-order citizens in design, together
with dedicated constructs to express their mutual constraints, is a powerful way to describe systems that may be latter adjusted to concrete timings that are not known at design time, or may change according to distinct conditions (such as distinct execution platforms, and so on).

On the physical side, this time variability may correspond to natural notions of uncertainty, often raised by the abstraction of complex detailed models into tractable simpler ones. There are other sources of uncertainty that may be easily traced in the requirements of CPS modeling. This calls for an extension of our previous framework, mainly of the Clock Constraint Specification Language (CCSL) providing constructs to relate logical clocks. The extension must propagate to all CCSL constructs, maintaining the objective of expressing interactions between cyber/digital and physical/continuous components in a direct, easy specifiable way.

**Objective:**

According to the general philosophy behind CCSL, probabilistic extensions should be scarce (for instance, a subclock could tick 90% of the time its motherclock does, on average; or a clock could tick 90% of the time faster than another one). Still, the combinations permitted by relational constraints should allow quite powerful expressivity for the specification of natural phenomena, while the limited number of primitives should ease the definition and realization of analysis and verification tools for such constraint systems. The topic of the PhD thesis will be to consider the feasibility of such analysis tools, with concerns also on the theoretical algebraic properties of probabilistic time constructs, as well as practical modeling aspects in design of automotive and other cyber-physical systems (provided by existing ongoing collaborations with industrial partners from the team).

**References:**


**URL:** [https://team.inria.fr/kairos/](https://team.inria.fr/kairos/)
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References:

- Gérard Berry, Amar Bouali, Xavier Fornari, Emmanuel Ledinot, Eric Nassor, Robert de Simone:

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