The main activities of the post-doctoral fellows will be:

- Enrich the Modelica language capabilities including new components based in the nonsmooth dynamical systems paradigm (complementarity, relay, multi-valued law)
- Perform the structural analysis of the hybrid systems mixing DAE and nonsmooth dynamics
- Implement a prototype that allows to generate simulation code for siconos from a Modelica instance of nonsmooth dynamical systems are multibody systems with Signorini's unilateral contact, set-valued (Coulomb-like) friction and impacts. In Electronics, the main instances are switches electronic circuits with ideal components (diods, switches, transistors, ...)

Within the framework of a partnership
This position is available in the context of a FUI project, Modeliscale https://team.inria.fr/modeliscaleordinated by Dassault Systems and in collaboration with two other INRIA teams, HYCOMES, INRIA Rennes and PARKAS, INRIA Paris.

Assignment
Modeling languages such as Modelica https://www.modelica.org and SimScape https://fr.mathworks.com products/simscape.html are based on systems of algebraic differential equations (DAE). Although modeling is made scalable with the use of DAE, simulating large CPS is a challenge because of their exponential number of modes. Although the structural analysis of pure DAE systems is now well established and benefits from fast algorithms (based on graph theory or linear programming), the state-of-the-art structural analysis methods for multi-mode DAE systems either relies on overly restrictive assumptions on the structure of the model, or faces the combinatorial explosion of mode enumeration.

Modeling CPS with hybrid state machines is not always the best option at hand; there are alternative modeling paradigms, avoiding the inherent drawbacks of hybrid state machines. A fine example are NonSmooth Dynamical Systems (NSDS), a formalism best suited to capture the dynamics of multi-body mechanical systems (with contacts and friction), switched electronic circuits, or gene regulatory networks in cell biology. NSDS can be formulated in several ways, using Filippov differential inclusions (with piece-wise continuous functions appearing on the right-hand side of the differential inclusions), or using complementarity conditions.

The correct formulation of a NSDS has to follow a very strict structure, and modeling a CPS in this way often proves to be a challenging task. CPS models expressed in an equation-based language such as Modelica should not be expected to follow a predetermined structure. On the contrary, the model should rather be structured according to the physical structure of the system, in a component-based fashion. The mathematical structure of the model has to be discovered by the compiler, and this is the purpose of the structural analysis, implemented in most Modelica tools. Extending Modelica to NSDS requires new structural analysis algorithms, adapted to the new language constructs (piece-wise continuous operators or complementarity conditions).

Skills
Applied Mathematics, Dynamical Systems, Hybrid Systems, Programming languages
Benefits package
- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration
Gross income: 2653€