
**Contract type:** Public service fixed-term contract  
**Level of qualifications required:** PhD or equivalent  
**Function:** Post-Doctoral Research Visit

**Context**

The Delys group (previously Regal) is a joint team of Inria and Sorbonne University whose research topics cover the whole spectrum of distributed systems and multicore systems. Our research topics span the whole spectrum between theoretical aspects of distributed systems, such as possibility and impossibility results, consensus or fault detectors, to the design and implementation of highly efficient algorithms and systems, such as an extreme-scale geo-replicated database minimising synchronisation. We publish in the best venues across the spectrum, such as PODC, DISC, SSS, OPODIS, JPDC, OPODIS, Middleware, SRDS, DSN, IPDPS, EDCC, OSR, Systor, ASAPLOS, POPL, etc.

Delys is located at LIP6, the Informatics research laboratory of Sorbonne University, in the Latin Quarter of Paris.

**Assignment**

Distributed computing, once a niche research topic, is now ubiquitous, and has become a crucial technique across many areas of computing. Geo-distributed applications are massively deployed, and programming highly-available distributed applications is no longer reserved to expert programmers. Consider for instance, mobile computing, Internet of Things (IoT), high-performance computing, Network Function Virtualisation (NFV), neural networks, or internet gaming.

However, distributed programming remains difficult and error-prone, exposing users, the economy, and critical infrastructure to bugs and security violations. Indeed, concurrency and failures, essential features of a distributed system, are difficult to abstract away. Interacting concurrent processes do not compose well. Furthermore, any large-scale distributed system suffers undetectable failures and cannot be strongly consistent, i.e., processes cannot reach consensus on a single up-to-date view of shared state; this is a fundamental result of distributed system theory (the FLP and CAP theorems).

Furthermore, applications have opposing requirements. On the one hand, correctness (controlling what the system does), requires events to happen in a reliable, deterministic way. On the other, application performance (including availability, responsiveness and throughput), requires concurrent, asynchronous execution. There is no single right solution to this trade-off; it depends on the application requirements, the expected environment and workload, the available resources, etc. A promising direction is a hybrid approach, where updates avoid coordination by default, but specific operations that are essential to application correctness are synchronised. Getting this right is difficult: current practice in building distributed systems rests on programmer expertise, i.e., trial and error, which is costly and dangerous.

Thus, currently, large numbers of non-expert programmers are required to navigate uncomfortable and weighty trade-offs in the presence of non-composable, non-deterministic, and weak consistency.

**Main activities**

We believe that the situation is ripe for a new, high-level approach. The proposed post-doc aims to develop methods, tools and languages to aid the programmer of general distributed programs.

Highly successful and explicative abstractions already exist, such as (at opposite ends of the spectrum) consensus or data flow. Frameworks and languages are making distributed programming easily accessible in some restricted domains, for instance MapReduce, Spark or TensorFlow. Our team has been active in research to provide both high availability and correctness, e.g., developing high-level distributed data types (CRDTs), and efficient and correct protocols (NMSI, TCC). Our AntidoteDB database supports concurrent data types, including simple ones such as counters, flags, sets and maps, and more complex ones enforcing common invariants, such as uniqueness, bounded counter, referential integrity, and access control; multiple operations compose into atomic transactions. Our CISE tool verifies that the execution model of an application is sufficiently synchronised to guarantee the application’s safety invariants.

However, currently, the heavy lifting remains manual. We propose to develop programming methods and tools that allow the developer to make use of the full power of concurrency and distribution; this...
may include:

1. Shared and persistent data objects, with replication and versioning.
2. Asynchronous (concurrent) and synchronous (consensus-based) operation invocation, with transactional and causal consistency guarantees.
3. Publish-subscribe/data flow, with forward and backward paths, and dataflow combiners. Data flow carries any mixture of state, delta, or operation.
4. Metadata, such as timestamps, provenance, security labels, or accounting information.
5. Specifying preconditions, effects and invariants, in order to enable verification.
6. Elastic configuration of the number and placement of computation and data entities, transparently to the program text.

At the same time, our approach helps avoid many of the opportunities for error, by focusing on the essential properties of application correctness. It is often the invariants required over application data that dictates the protocol for accessing the data; this is an intuition that programmers commonly apply. Hence, we aim to apply leverage language and verification tools, to aid the programmer in choosing the best consistency level and in synthesising a program that respects its specification.

**Benefits package**
- Subsidised catering service
- Partially-reimbursed public transport

**Remuneration**
- Location: Sorbonne Université, 4 Place Jussieu - 75006 Paris
- Gross Salary per month: 2 653 €

**Security and defense procedure:**

This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).

Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.