

*Inria*  
INVENTORS FOR THE DIGITAL WORLD

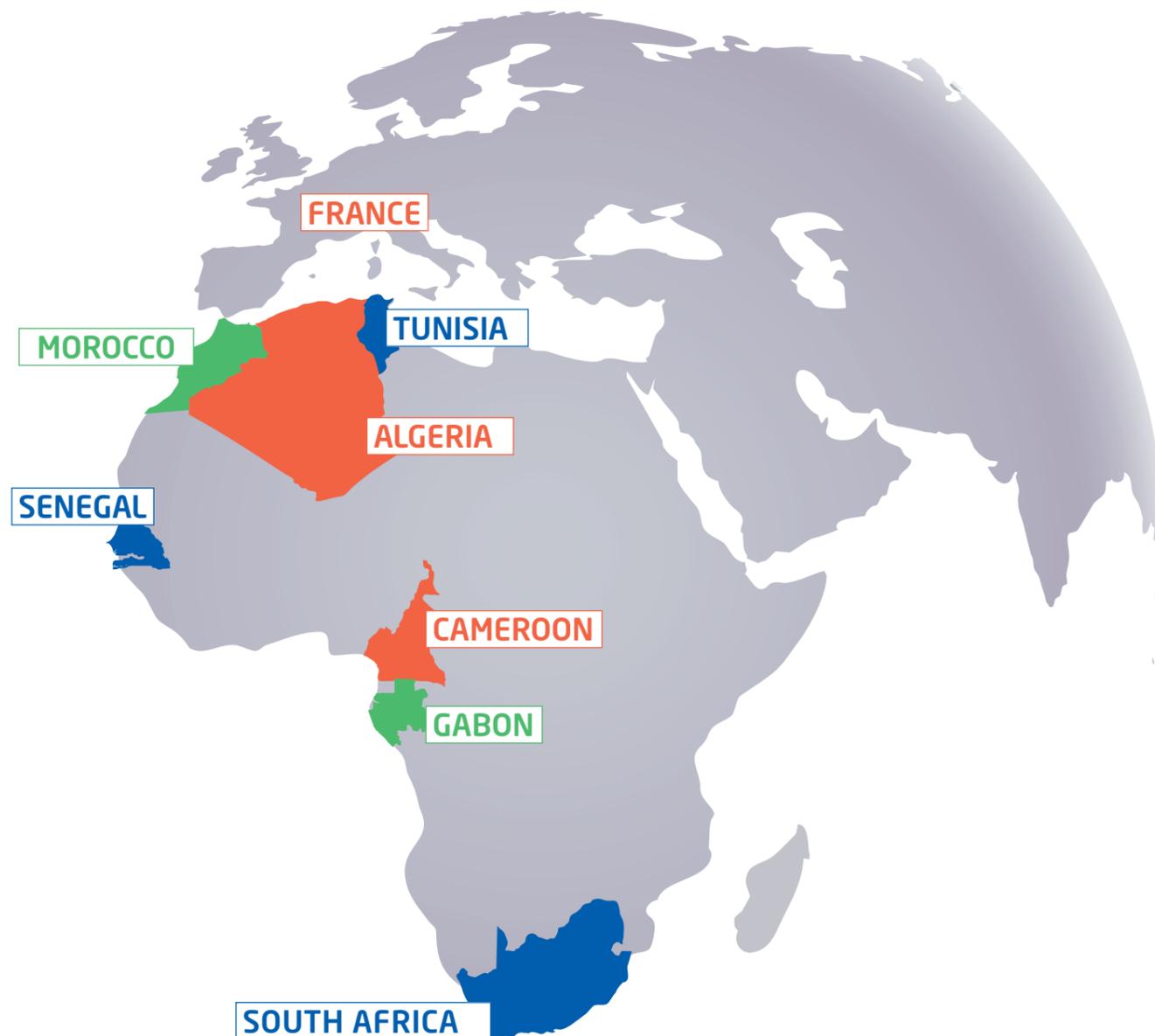


# LIRIMA 2016

International Laboratory  
for Research in Computer Science  
and Applied Mathematics



# LIRIMA: an Inria International Lab to strengthen Inria's collaborations with the African continent



**LIRIMA**, "Laboratoire International de recherche en Informatique et Mathématiques Appliquées", was founded in November 2009 for a period of 5 years by Inria and seven other institutions in sub-Saharan Africa and Maghreb. A new Agreement, signed in 2015, creates the **Inria International Lab "LIRIMA"** for a period of 4 years. The headquarters, based at the University Yaounde I during the period 2010-2014, are now hosted by the University Gaston Berger, Saint Louis, Senegal.

LIRIMA keeps and strengthens its objectives: to produce research at the highest international quality in computer science and mathematics ; to develop an active and structured partnership between the partners of this agreement, in particular through training and the supervision of students ; to contribute to economic and social development in Africa.

LIRIMA remains open to new French and African partners, and also to the creation of new project-teams, selected through the Inria Associate Teams Programme.

## PARTNERS INSTITUTIONS

Inria

Gaston Berger University, Saint-Louis, Senegal - *Headquarters of LIRIMA*

University of Yaounde I, Cameroon

Stellenbosch University, South Africa

University of Science and Technology of Masuku, Franceville, Gabon

Ministry of Higher Education and Scientific Research (MESRS-DGRSDT), Algeria

National Centre for Scientific and Technical Research (CNRST), Morocco

Ministry of Higher Education and Scientific Research (MESRS), Tunisia

# A word from the directors ...

**LIRIMA** is the **Inria International Laboratory** in Africa. It aims to increase the impact of the collaboration between Inria and its African partners. New teams should be able to join LIRIMA each year. Under supervision of the LIRIMA Direction, who can advise and support them, project-team proposals will be submitted to Inria Associated Teams program, after obtaining the support of partner institutions. In 2016, 3 new teams have joined LIRIMA: IoT4D, Moha and MoReWais.

According to this program, a proposal should follow the following guidelines:

- This is a collaboration driven by an Inria team and a partner team in Africa with a program developed jointly by an African leader and his/her Inria counterpart ;
- This program should be focused on a specific topic with short- and medium-term goals (three years, renewable once) and builds on a small team of 2 to 4 permanent researchers from each side together with some PhD students and post-docs ;
- The proposal should focus on the training of young researchers: it is desirable to involve PhD students on both sides or at least to include co-supervised theses.

These teams differs from their home African laboratories in their duration, focused target, and size. It is hoped that these teams be an opportunity for young researchers to access responsibilities.

We let you go through this document to discover the main research topics, as well as the working axes of LIRIMA project-teams during the year 2016.



**Prof. Moussa Lo**  
UGB Saint-Louis



**Dr. Éric Badouel**  
Inria

# The research teams in brief ...

## EPICARD

### Inverse Problems In CARDiac electrophysiology

Improving the information that can be extracted from electrical signals measured on patients with heart diseases is a major priority for the IHU LIRYC in Bordeaux, headed by Professor Michel Haissaguerre. From measurements of the electrical potential on the chest of the patient, the electrical potential on the heart surface can be non-invasively constructed. This helps the medical doctor to visualise an image of the electrical potential of the heart of the patient. It is known that the methods, that have been used in the literature for solving this electrocardiography imaging (ECGI) problem, including those used in commercial medical devices, have several limitations. This problem could be mathematically seen as a boundary data completion problem for elliptic equations. Many works in the literature have been carried out in order to solve this Cauchy problem, but have never been used for solving the ECGI problem.

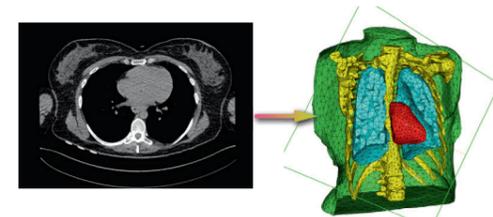
This project-team aims at developing an experimental platform allowing to test various methods and compare their performance on real life experimental data.

■ University Tunis El Manar, ENIT/LAMSIN, Tunisia

Team leader: Nabil Gmati

Co-team leader Inria: Nejib Zemzemi

Inria partner team: CARMEN (Bordeaux - Sud-Ouest)



Medical images segmentation (left) and generation of computational meshes (right). The CT-scans are for a 43 years old women and are provided by the CHU-Bordeaux.

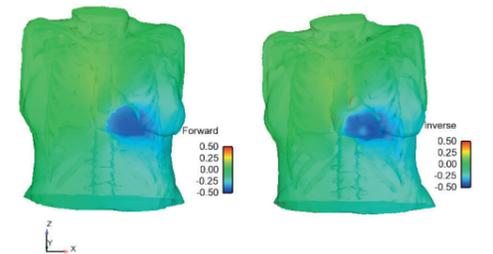


Illustration of the performance of an ECGI inverse problem method on *in silico* data: The color indicates the distribution of the electrical potential on the torso and on the heart for both exact (left) and inverse (right) solutions.

## IoT4D

The Internet of Things for developing countries (DC) research team (IoT4D) works on the integration of emerging technologies with footprint process in African countries.

In fact, the DC environment is by itself a research challenge for connected objects : high temperature or humidity in the tropical and equatorial zones, lack of high speed communication network access, for example, does not alleviate the deployment of a wireless sensor networks in the city or country-wide.

IoT4D will first experiment the interconnection of Internet of Things with the wired Internet. The goal is to allow IoT networks to be easily deployed with an acceptable quality of service.

■ ENSP/University of Yaoundé I, Cameroon

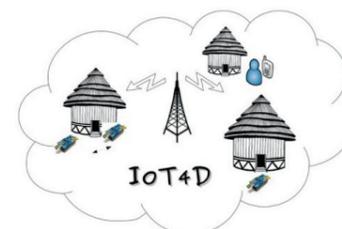
Team leader: Thomas Djotio Ndie

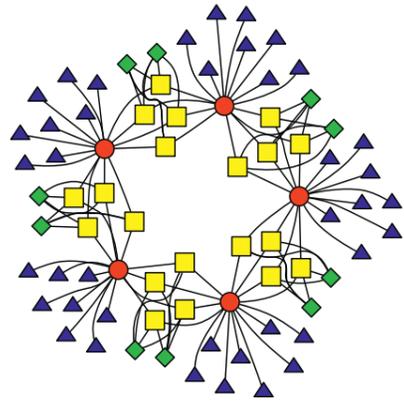
Co-team leader Inria: Emmanuel Nataf

Inria partner team: MADYNES (Nancy - Grand Est)



IoT4D Team Leaders  
At left Thomas Djotio and at right Emmanuel Nataf





## MACISA

### Mathematics applied to cryptology and information security in Africa

Public key cryptography plays a vital role in today's communication infrastructures. It guarantees the confidentiality, the integrity and the authenticity of a message. Understanding the whole chain of cryptography, from the theoretical algorithms to the implementation of fast and secure protocols, is a matter of national sovereignty. MACISA aims to provide a better understanding of public key cryptography from the point of view of algebra and geometry.

It focuses on the study of algebraic maps, along two main themes:

**(1)** the arithmetic aspects: rings, primality test, factorization and discrete logarithms. On the effective side of things, it aims for fast generation of normal basis, and using residue number systems to speed up the arithmetic ;

**(2)** the geometry, mainly elliptic and hyperelliptic curve cryptography. This theme focus on studying curves models and efficient addition laws, along with fast pairings and point counting computations.

The goal of the team is then to use these tools to develop more efficient and secure methods for designing public key cryptosystems.



MACISA team members

■ University of Science and Technology of Masuku, Franceville, Gabon

Team leader: Tony Ezome

Co-team leader Inria: Damien Robert

Inria partner team: LFANT (Bordeaux - Sud-Ouest)

## MOHA

With the smart grid revolution, house energy consumption will play a significant role in the energy system. The challenge of the mixed multi-objective household energy management problem is to control electrical appliances based on a user's operational information in order to minimize the electrical energy cost for the consumer and to maximize its satisfaction.

MOHA proposes a home automation system that can monitor appliance scheduling in order to simultaneously optimize the total energy cost and the customer satisfaction. The key challenge of this project is to propose new optimization models and new hybrid algorithms to the demand side management of smart grids in a context of uncertainty and in the presence of several conflicting objectives. Those complex optimization problems are also characterized by the presence of both continuous and discrete variables.

Moreover, the model will integrate some uncertainties in the data, so robust solutions, that are not sensitive to those uncertainties, must be found.



Production and consumption optimization in smart grids

■ EMI, Rabat, Morocco

Team leader: Rachid Ellaia

Co-team leader Inria : El-Ghazali Talbi

Inria partner team: DOLPHIN (Lille - Nord Europe)

## MoReWAIS

Knowledge sharing solutions must take into account local realities, especially regarding access to ICTs. So, it seems interesting to study how to develop and use mobile services to enhance access to social semantic web applications in general and to knowledge sharing platform in particular.

MoReWAIS proposes to explore the specificities of mobile knowledge sharing. The mobile application targeted in MoReWAIS must allow communities and their users to enrich and access more easily the knowledge base using the user's context with its richness and addressing its limitations.

The project will design and develop algorithms, methods and tools for mobile devices allowing users to: **(1)** Co-construct locally and on the road the Semantic Web of Data RDF triple stores representing the sociocultural shared knowledge ; **(2)** Access and visualize in context relevant data from the knowledge platform. This requires a complete rethinking of RDF storage and SPARQL querying in a mobile and unreliable network environment.

This will also require dedicated interaction design to ease and encourage access and contribution.

■ University Gaston Berger, Saint-Louis, Senegal

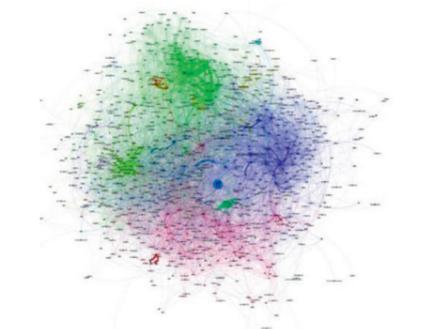
Team leader: Moussa Lo

Co-team leader Inria: Fabien Gandon

Inria partner team: WIMMICS (Sophia Antipolis - Méditerranée)



MoReWAIS Team Leaders  
At left Moussa Lo and at right Fabien Gandon



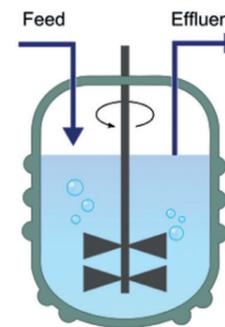
Visualization of links between different themes in a related data network

## NuWat

### Numerics for water treatment research

NuWat focuses on the numerical modeling and simulation of microbial ecosystems and their application in biotechnology with a focus on solutions considered as promising for countries of the Maghreb. In this context, the research topics handle: on the one hand, the elaboration of numerical hybrid models for simulation of bacterial ecosystems combining discrete models (for small size populations) and continuous models (for large size populations, substrate and environment); this theme appears to be strategic as conventional continuous models are not able to account for all phenomena. On the other hand, NuWat develops numerical tools for the control and simulation of biotechnology processes. A reflection about the software framework to adopt (choice of languages, development tools, etc.) is in progress. The question of interface between the process, data acquisition and processing, and the software development have to be considered.

Two major research axes are developed: **(1)** New tools for simulation and modeling ; **(2)** Numerical tools for optimization, identification and control.



Chemostat

■ Tlemcen University, Algeria

Team leader: Brahim Cherki

Co-team leader Inria: Fabien Campillo

Inria partner team: MODEMIC (Sophia Antipolis - Méditerranée)

## PreDnet

### Predator predictive Networks

PreDnet proposes to investigate the most suitable topologies and subsequent deployment of a wireless sensor network for sparsely populated outlying rural and wilderness areas, for effective monitoring and protection of resources and ecosystems. In particular, the PREDNET project focuses on two specific use cases : **(1)** chagal behavior understanding and cattle surveillance and **(2)** fight against rhinoceros poaching. To do so, PreDnet investigates deployment and self-deployment of nodes and some scheduling algorithms that takes into account the available energy.

The goal is to develop experimental platforms, further implemented in real networks to test and validate hardware and software development.

The main goals of the PredNet project are: Design of compact, electronically reconfigurable antennas for frequency-hierarchical cluster networks specifically adapted to the rural target environment ; Design of energy-efficient and harvesting routing protocols for data retrieval from low energy consumption sensors, while considering environmental and antenna characteristics ; Development of experimental platforms, further implemented in real networks to test and validate hardware and software development ; Investigation of smart mechanisms to enforce data resilience and network reliability.



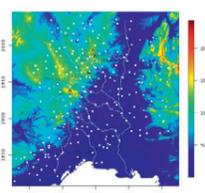
PREDNET team members

#### ■ Stellenbosch University, South Africa

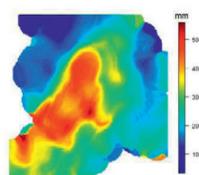
Team leader: Riaan Wolhuter

Co-team leader Inria: Nathalie Mitton

Inria partner team: FUN (Lille - Nord Europe)



Map of the Cévennes-Vivarais region (France), horizontally: longitude (km), vertically: latitude (km), the color scale represents the altitude (m), the white dots represent some rain gauge stations



Estimation of the expected-shortfall for a 100-year return period

## SIMERGE

### Statistical Inference for the Management of Extreme Risks and Global Epidemiology

SIMERGE is based on two research themes : **(1)** Spatial extremes, application to management of extreme risks : the team investigates the estimation of risk measures making heavy use of the extreme-value theory by focussing both on the cases of spectral and distortion risk measures. SIMERGE also aims at proposing estimators of such extreme risk measures able to deal with covariates ; **(2)** Classification, application to global epidemiology : this work is based on the use of mixture models for classification. The team uses parsimonious multinomial probability distributions to model each class of the mixture. In the verbal autopsy context, the simplest way to achieve parsimony is to assume conditional independence of the symptoms given the cause-of-death. SIMERGE also adapts the classical Gaussian mixture model to binary data thanks to the introduction of a kernel function.

#### ■ University Gaston Berger / LERSTAD, Saint-Louis, Senegal

Team leader: Abdou Kâ Diongue

Co-team leader Inria: Stéphane Girard

Inria partner team: MISTIS (Grenoble - Rhône-Alpes)

For more information  
<http://lirima.inria.fr/en/>



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