

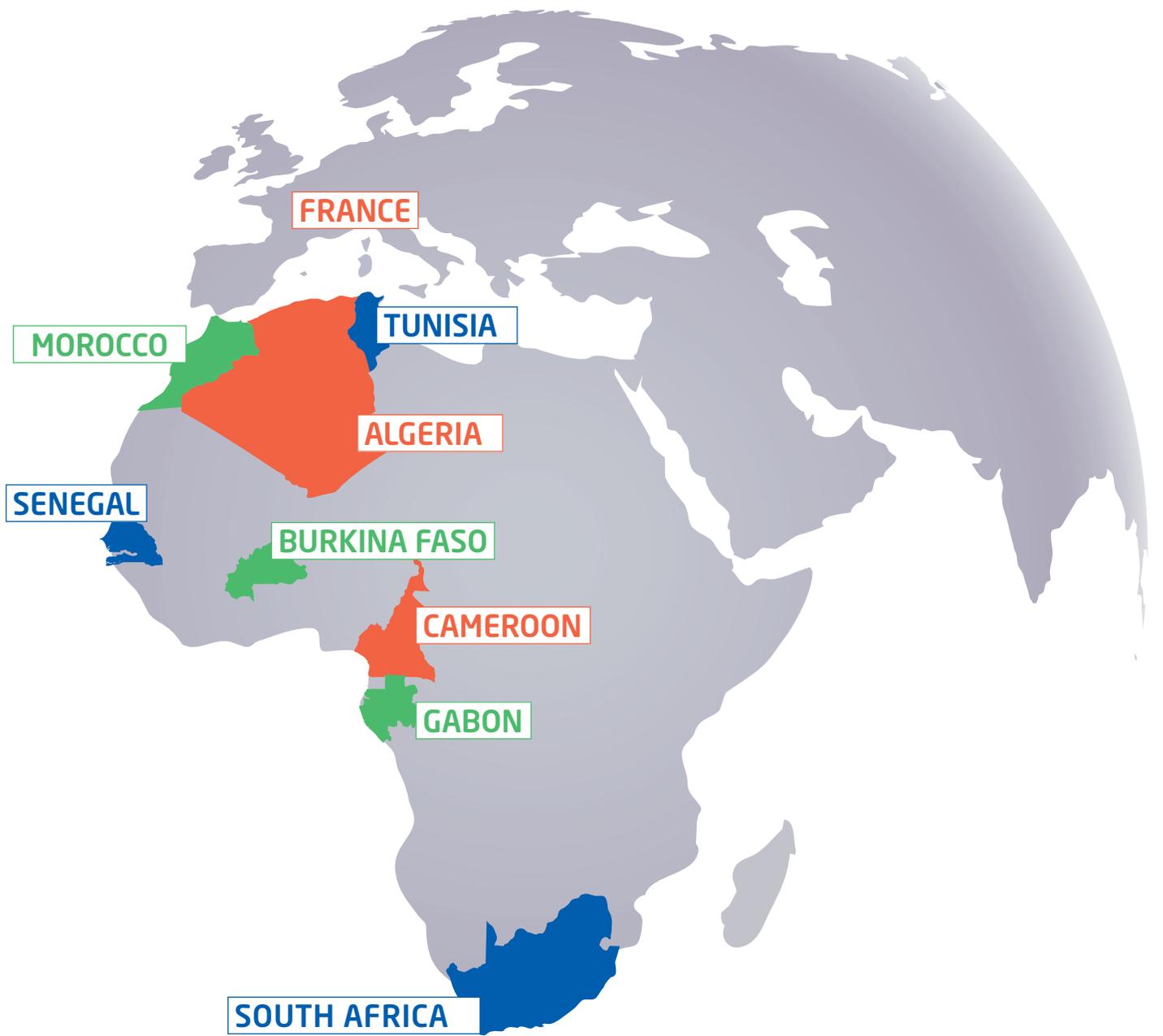
Inria
INVENTORS FOR THE DIGITAL WORLD



LIRIMA 2015

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 (five) 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.

This document aims to present the main research topics and the working axes of the LIRIMA project-teams during the year 2015.

PARTNERS INSTITUTIONS

Inria

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

University of Yaounde I, Cameroon

Ouagadougou University, Burkina Faso

Stellenbosch University, South Africa

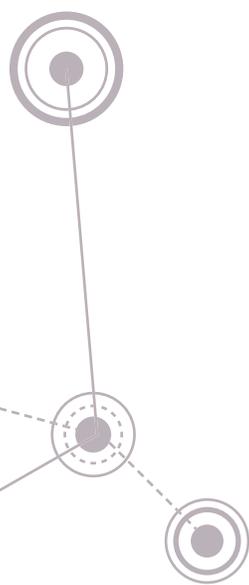
University of Science and Technology of Masuku, Franceville, Gabon

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

The **IRD** is an Associated Member.



A word of the directors ...

The evolution of **LIRIMA** into an **Inria International Laboratory** aims to increase the impact of the collaboration between Inria and its African partners. This mainly brings a greater flexibility in the creation of new teams. Under supervision of the LIRIMA Direction, who can advise and support it, a project-team proposal will be submitted to Inria « Associated Teams » program. In this way, new teams should be able to join LIRIMA each year.

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.

The new agreement, which creates the Inria International Laboratory in Africa, also brings some changes in the governance of LIRIMA. First, the management of the laboratory is entrusted to both, an African director and an Inria director. Second, to ensure a more effective management, each partner should be represented in the Steering Committee by a representative authorized to make commitments on its behalf. Furthermore, this function can not be combined with the responsibility of a team.



Prof. Moussa Lo

UGB Saint-Louis



Dr. Éric Badouel

Inria

The research teams in brief ...

ALOCO

Component-based Software Architectures

ALOCO activities are concerned with "Distributed Data and Collaborative Systems". A large part of the research activity is dedicated to a model of distributed and data-centric collaborative systems with the following objectives in mind: **(1)** Develop business process solutions for administrations and private companies from developing countries by promoting component programming and model driven engineering for the development and reuse of open source softwares; **(2)** Take advantage of some technological innovations to compensate for the degraded connection to Internet; **(3)** Define domain specific tools for the configuration of workspaces allowing end-users with low computer literacy to take part in the business processes of their companies or administration; **(4)** Develop some applications, such as a disease surveillance process, or a distributed e-learning platform.

■ ENSP/University of Yaoundé I, Cameroon

Team leader: Claude Tangha

Co-team leader Inria: Éric Badouel

Inria partner team: SUMO (Rennes - Bretagne Atlantique)



Claude Tangha, team-leader

ANO

Numerical Analysis of Partial Differential Equations and Optimization

The team focuses on the numerical analysis of PDEs and optimization among with several application areas including biomathematics and finance.

Our objective was to carry out a number of joint projects not only with our team but also with several young doctoral researchers. The themes covered essentially the development of mathematical models, numerical methods and algorithms suitable for solving engineering problems, especially in biomathematics, mechanics and finance.

The activities focused on the themes and areas of application, such as : plant growth, restoration and image segmentation, and modeling of cardiovascular and cerebrovascular diseases, in the theme of biomathematics, and also portfolio optimization, numerical methods for the valuation of derivatives, calibration and parameter estimation, in finance.

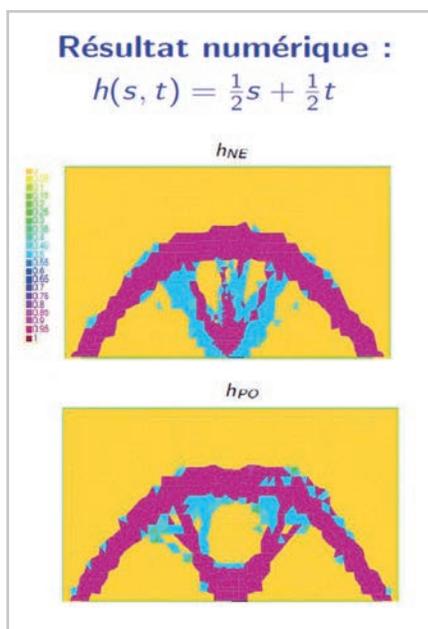
Members of the team were working on the development of algorithms and robust structural optimization, as well as the development of a posteriori error estimates.

■ EMI-Rabat / CNRST Morocco

Team leader: Rajae Aboulaïch

Co-team leader Inria: Abderrahmane Habbal

Inria partner team: OPALE (Sophia Antipolis - Méditerranée)



Study of different strategies for splitting variables in multidisciplinary topology optimization

EPIC

Inverse Problems and Control Team; applications to the flows in medicine and hydrogeology

The team developed several methods for solving a wide class of inverse problems (shape identification, parameter recovering). The main contribution lies on the use of both reciprocity gap and constitutive law error concepts. These ideas gave rise to very competitive identification procedures. The main application area of these methods concerns mechanical engineering.

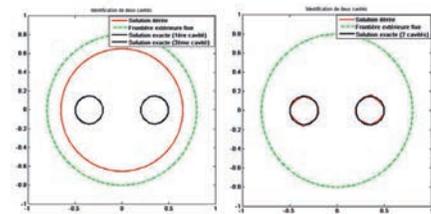
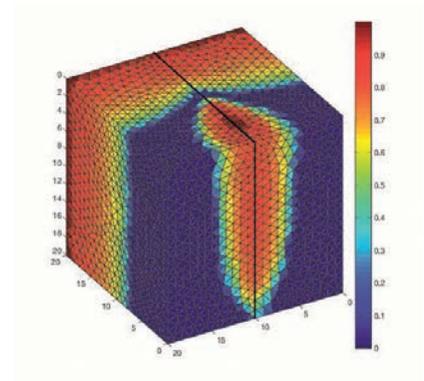
These last years, strong synergy between medicine, biology, mathematics and computer science has been noticed. The aim of EPIC was there the use of concepts developed within the Inverse Problem team and the development of other mathematical tools for treating problems arising from medicine or hydrogeology; more specifically, to share tools for modeling, analysis and numerical analysis of inverse problems in favor of applications in hydrogeology, biological fluids flow and cardiac electrophysiology.

■ University Tunis El Manar, ENIT/LAMSIN, Tunisia

Team leader: Maher Moakher

Co-team leader Inria: Housseem Haddar

Inria partner team: DEFI (Saclay - Île-de-France)



Identification de deux cavités



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.

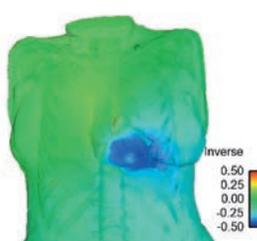
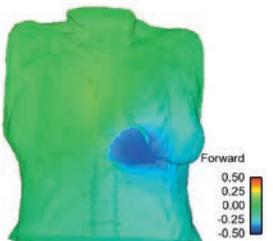
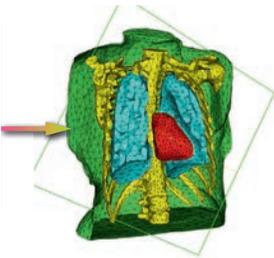
Entered in the LIRIMA in January 2015, this project-team aims at developing an experimental platform allowing to test various methods and compare their performance on real life experimental data.

■ University Tunis El Manar, ENIT/LAMSIN, Tunisia

Team leader: Nabil Gmati

Co-team leader Inria: Nejb Zenzemi

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





Some GRIMCAPE members - Meeting 2013 in Yaoundé

GRIMCAPE

Modeling, Analysis and Simulation in Epidemiology and Immunology

The work of GRIMCAPE is subdivided in **four main areas**: **(1)** Modeling and Analysis of structured epidemiological models (age-structured / or spatial and / or epidemiological status); **(2)** Modeling and Analysis of population dynamics; **(3)** Identification / parameter estimation and variables; **(4)** Modeling in ecology (Size Structured Tree-Grass Competition Model for Savanna Ecosystems).

This work leads to many fields of application, the most important are: forest dynamics and forest-savanna interactions, spread of vector-borne diseases, the meta-population models considering migration and spatial heterogeneity in cases of malaria and tuberculosis, and the transmission dynamics of infectious diseases that can account for the effects of differentiation susceptibility or infectivity of drug resistance and exogenous reinfection (TB, AIDS, meningitis, HBV ...).

■ University of Yaoundé I, Cameroon

Team leader: Samuel Bowong

Co-team leader Inria: Abderrahman Iggidr

Inria partner team: Nancy - Grand Est

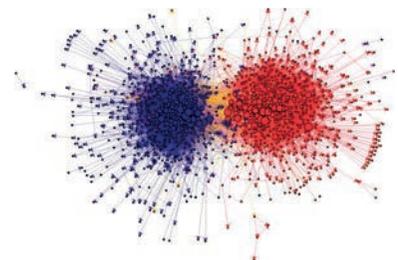
IDASCO

Distributed computing for the analysis of complex systems

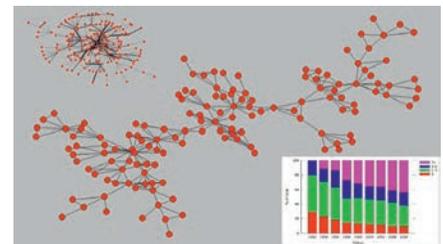
The work of IDASCO is organized around **three axes**: **(1)** Learning techniques for social network mining, especially with application to the detection and monitoring of communities, and recommendation systems; **(2)** Search of traces of multimedia applications on embedded systems, generated by complex architectures centered around integrated components called Multi-Processor Systems-on-Chips. The aim is to detect anomalies useful for debugging these applications; **(3)** Parallelization of complex system analysis algorithms. In fact, the treatment in reasonable time of wide networks requires computing power that goes beyond the capacity of a single-

processor machine. Thus, the use of parallelism cannot be avoided. The team is particularly interested in multi-core architectures that started to be commonly used in recent years.

The objective is to propose a dedicated language providing ease of programming, with a compiler that produces optimized code for social network algorithms running on multi-core platforms.



Detection of communities



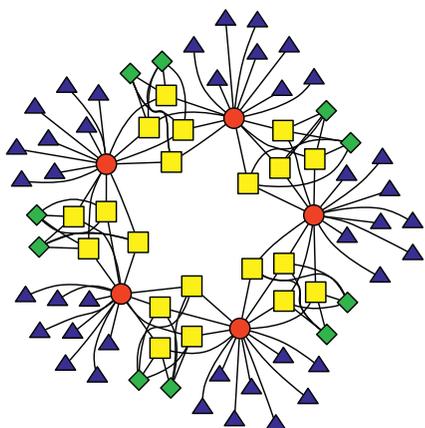
Characterisation of the structure of the social networks

■ University of Yaoundé I, Cameroon

Team leader: Maurice Tchuenté

Co-team leader Inria: Jean-François Mehaut

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



Members of the MACISA team - On the left the two leaders, Damien Robert and Guy Martial Nkiet

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. The MACISA team 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.

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

Team leader: Guy Martial Nkiet

Co-team leader Inria: Damien Robert

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



MASECNESS

Management and Security of Network Services and Systems

This project aims to define, validate and implement new solutions (tools, models and services) in the fields of the administration, the monitoring and security of network and system in general. The expected results of this research are : repercussions on the mastering, the deployment and the acceptance of the secured wireless sensor networks in the multiple environments; study and coupling proven models such as GSM, GPRS and adapted them to the fixed and mobile ad hoc networks; direct improvements of the life quality for people in developing countries.

The research activities includes **four main axes**: **(1)** configuration management in Wireless Sensor Networks (WSN) ; **(2)** intrusion detection in WSNs ; **(3)** wireless networks services for developing countries ; **(4)** mobile-based services and applications. The first two axes are developed within the framework of international cooperation with the Inria team MADYNES. The third axis is part of a broader collaboration with Fraunhofer Fokus Germany. The last axe of research results from the cross-collaboration with the LIRIMA team ALOCO.

■ ENSP/University of Yaoundé I, Cameroon

Team leader: Thomas Djotio Ndie

Co-team leader Inria: Emmanuel Nataf

Inria partner team: MADYNES (Nancy – Grand Est)

M2IPE2S

Mathematical and Computer Modeling of Water and Sahelian Ecosystems Problems

This team focuses on **five main areas of research:**

- (1) Modeling and mathematical analysis in epidemiology. The objective here is to study and model certain infectious diseases which are important for public health problems in sub-Saharan Africa;
- (2) Mediation data for the semantic web. The goal is to provide bodies eager to put their structures in partnership, with models, methods and tools for pooling their resources in a distributed environment, especially in the semantic web environment;
- (3) Mathematical modeling and numerical simulation related to the management of natural resources and the environment. This theme relates to the monitoring and control in the preservation of ecosystems;
- (4) Concepts and mathematical tools emerging. This is to export in various application areas fundamental advances in applied mathematics, statistical physics and basic computer, and use methods and concepts that are derived;
- (5) Algorithms and scheduling, distributed computing servers.

■ University Gaston Berger, Saint-Louis, Senegal

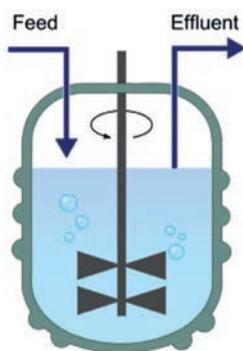
Team leader: Moussa Lo

Co-team leader Inria: Fabien Gandon

Inria partner team: WIMMICS (Sophia Antipolis - Méditerranée)



A part of the team M2IPE2S - UGB St Louis



Chemostat

NuWat

Numerics for water treatment research

The NuWat Team 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.

■ 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)** chacal 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.

■ Stellenbosch University, South Africa

Team leader: Riaan Wolhuter

Co-team leader Inria: Nathalie Mitton

Inria partner team: FUN (Lille - Nord Europe)



Meeting at the University Stellenbosch - On the right the two team leaders, Riaan Wolhuter and Nathalie Mitton



Abdou Kâ Diongue, team-leader

SIMERGE

Statistical Inference for the Management of Extreme Risks and Global Epidemiology

Entered in the LIRIMA in January 2015, this team federates researchers from LERS-TAD (Laboratoire d'Etudes et de Recherches en Statistiques et Développement, Université Gaston Berger), on the one part, and Mistis (Inria Grenoble Rhône-Alpes) on the other part. This project consolidates the existing collaborations between these two Laboratories. The team also involves statisticians from EQUIPPE laboratory (Economie QUantitative Intégration Politiques Publiques Econométrie, Université de Lille) and associated members of Modal (Inria Lille - Nord Europe) as well as an epidemiologist from IRD (Institut de Recherche pour le Développement) at Dakar.

The following **two research themes** are developed: **(1)** Spatial extremes with application to management of extreme risks ; **(2)** Classification with application to global epidemiology.

■ 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
www.lirima.inria.fr



Contact
lirima@inria.fr



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