The LIP6 (Computer Science Laboratory of Paris 6) is part of Université Pierre & Marie Curie (UPMC) and depends on the National Center for Scientific Research (CNRS – UMR 7606). Its 500 members including 170 permanent researchers and 250 PhD students, make LIP6 one of France’s main research laboratories in Computer Science.

Research directions

Eighteen research groups, divided into five departments cover: Scientific Computation; Decision, Intelligent Systems & Operational Research ; Machine Learning and Data Representation ; Distributed Systems ; System on a Chip. Two teams are joint with INRIA Paris-Rocquencourt, on formal computation and distributed systems. Additionally, LIP6 leads FIT (Future Internet of Things), an Equipex Project.

International Relations

LIP6 is very open to scientific cooperation, and to hosting visiting scientists. International cooperation is strong. LIP6 is a member of many international Networks of Excellence, and maintains relations with universities in the United States, Japan, China and Brazil, as well as many European countries. By way of LIP6, UPMC is a member of KIC ICT Labs, a project of the European Institute of Innovation & Technology (EIT).

Partnerships

LIP6 is a founding partner of LINCS (Laboratory for Information, Networking and Communication Sciences), INRIA and Institut Telecom, CLEAR (Center for Learning and Retrieval) is a joint team of LIP6 and Thales Communications. LIP6 has strong links with Institut Telecom formalized as PariStic.

Research & Development

LIP6 has a long tradition of industrial partnerships national, European, or international projects. The laboratory is involved in two competitive research centers in Paris: Cap Digital, on digital content, and System@tic, centered on embedded systems.

Teaching

Members of LIP6 teach research-level classes in the Science & Technology Master Program at the Université Pierre & Marie Curie. EDITE de Paris (The Doctoral School of Informatics, Telecommunications and Electronics of Paris) is the academic structure that hosts the laboratory’s PhD students.
The Department of Scientific Computing covers both symbolic and numerical computations. This department gathers two teams. The scientific activity is organized around several specific actions.

SYNUS action (SYmbolic and NUmerical Solving)

Keywords: guaranteed results, symbolic/numerical algorithms

The SYNUS action aims at combining and developing symbolic and numerical algorithms for scientific computing. We want to improve the efficiency of symbolic algorithms by performing numerical computations when finite precision is appropriate.

GEOALG action (Algebraic Computational Geometry)

Keywords: Algebraic geometry, Polynomial Systems, topology

This action aims at developing algorithms based on polynomial system solving for dealing efficiently with 3D algebraic objects in algorithm geometry (curves, surfaces) and the study of their topology.

Images and dynamics action

Keywords: dynamical models, missing data, multiobject tracking, motion estimation

This action focuses on 2D and 3D sequence processing. For this purpose, models of the dynamics are used to describe the evolution of image structures, notably in the presence of missing data. Our methodologies rely on particle filters and variational data assimilation frameworks.

ADOR action (Artithmétique Des ORdinateurs)

Keywords: floating point, fixed point, representation of numbers, numerical validation

This action deals with the aspects of scientific computing related to elementary arithmetic operations on every materials (microprocessors, SoC, embedded systems). A special focus is dedicated on numerical validation (CADNA library, SOFIA toolbox) and on the representations of numbers on computers with the associated algorithms.

CRYPTALG action (Algebraic Cryptanalysis)

Keywords: security, Cryptanalysis, Gröbner Bases, finite fields

The goal of this action is to evaluate the security of a cryptosystem by reducing its study to the solving of a polynomial system with coefficients in a finite field. These attacks require the use of the most efficient Gröbner bases algorithms and a huge amount of computational resources (CPU and RAM as well).

PANAM action (PArallel Numerical AlgorithmMs).

Keywords: efficient numerical algorithms, new architectures, grid computing, numerical kernels

The goal of this action is the development of optimized numerical algorithms or kernels to reach a high level of performance (speed and/or numerical quality) on parallel computers, grids or heterogeneous systems.

EXACTA action

Keywords: polynomial functions, noisy systems, exact computations

The goal of this action is to develop algorithms yielding an exact resolution for global optimization problems of polynomial functions under polynomial constraints. Noisy systems (when equations contain errors) are also considered. These works are led with the Royal Holloway University of London, Chinese Academy of Sciences, Beihang University and Peking University.

SALSA team
(Solving ALgebraic Systems and Applications)

SALSA is a joint team between INRIA and University Pierre and Marie Curie in the area of solving polynomial systems using exact methods. Our goal is to develop efficient algorithms for computing the complex solutions and/or the real ones of polynomial systems in a finite field. Our group has developed several fundamental algorithms, in particular algorithms for computing Gröbner bases and algorithms based on the so-called critical point method. Complexity issues are also investigated. The practical efficiency of our algorithms relies on highly efficient linear algebra libraries where the group is strongly involved.

PEQUAN team
(PERformance et QUalité des Algorithmes Numériques)

The domain of the PEQUAN team deals with computer arithmetic and scientific calculus.

The team has developed the CADNA library and the SOFA toolbox based on a probabilistic approach of round-off error propagation.

The skill of the team covers:
- development of numerical algorithms using floating point or fixed point arithmetic and their numerical validation
- implementation of parallel numerical algorithms,
- systems of numeration and the associated algorithms in relationship with cryptology or signal processing,
- problems related to the modeling of 2D and 3D dynamics in video sequences.
The activities are focused on decision making, optimization problems and adaptive systems in the fields of Artificial Intelligence and Operations Research. They range from theoretical research (formal models and axiomatic analyses, algorithms and complexity) to the design of intelligent systems (adaptive agents, cognitive multiagent systems, optimization and decision systems, tutoring systems) in the perspective of industrial applications.

DESIR department is organized in four teams:

- **RO (Operations research)**
- **DECISION (Decision)**
- **SMA (Multi-agent systems)**
- **MOCAH (Models and tools in knowledge engineering for human learning)**

Within the department, the main axes for cooperation between teams concern combinatorial optimization (DECISION/RO), algorithmic game theory and collective decision making (RO/DECISION/SMA), adaptive agents (SMA/MOCAH), decision and planning under uncertainty (DECISION/SMA).

**Scientific Projects and Networks:**

- Network of excellence AGENTLINK
- Network of excellence EVONET
- Network of excellence KALEIDOSCOPE
- ActiveMath-EU (EAC-EA, E-learning)
- GDR Recherche Opérationnelle
- International GDR on “Algorithmic Decision Theory”
- ANR SKOOB (Probabilistic Relational Model)
- ANR LARDONS (learning and reasoning in MDPs, logic and probabilistic representation)
- GLIEPARD (French National Research Agency project on Multiobjective Optimization)
- COMSOC (projet ANR, Computational Social Choice)
- RIAM DEEP (Dialogue based on Emotion, Experience and Personality)
- RIAM C3 (Design of an editorial chain of educational content) - CNRS Research group Operations Research
- ICEA (Integrating Cognition, Emotion and Autonomy in an adaptive robot)
- ARCLUS (French Brazilian project on multiobjective modelling and simulation)
- Terra Dynamica project (FUI8)

**Research-driven education:**

- Master in Computer Sciences: Artificial intelligence and Decision making
- Master Sciences and Management: Specialization MC3

**Industry Partners:**

BOUYGUES TELECOM, Canal multimedia, DGA, DYNASIS, EDF, EDITIS, FRANCE TELECOM R&D, IFP, ILOG, ODILE JACOB MULTIMEDIA, QUANTIC DREAM, SPIROPS, THALES

**Keywords**

**RO**
Complexity, Combinatorial optimization, Scheduling, Satisfiability, Network routing, Algorithmic Game Theory.

**DECISION**
Algorithmic decision theory, Multiobjective optimization, Decision under risk and uncertainty, Graphical Models, Decision-support systems, Context, combinatorial optimization and LP.

**SMA**
Multi-agent systems, Coordination, Distributed decision making and planning, Negotiation, Dialog and interaction, Simulation.

**MOCAH**
Interactive learning environments (ILE), Methodology of resources design, semantic web (metadata, ontologies), cognitive modeling of the learner, serious games.
Research in the Department of Databases and Machine Learning is centered around statistical, symbolic and relational machine learning and distributed databases. Statistical methods, neural networks, fuzzy logic, information fusion, data replication, distributed query and transaction processing are amongst the methods currently used for fundamental and applied research, as well as formal concept analysis, ontologies and deep architectures in artificial vision.

The target applications are situated in a large variety of domains which range from adaptive or selective information retrieval in text, web, images, videos and social networks, to continuous query-based information aggregation and web archiving.

Content-based information retrieval, text, image and multimedia automatic indexing and database querying are three complementary approaches for accessing heterogeneous data. Methods are proposed for the efficient processing of structured or semi-structured information, for instance by means of statistical methods, to analyze structured corpora (XML, social networks) or to retrieve specific information. Several research activities in the department use advanced data management services like replication and streaming whose efficiency relies on new logical network organizations, distributed index structures and adaptive routing algorithms for efficiency. We also study new intelligent crawling strategies and temporal query languages for web archives and the issue of query-based continuous information aggregation in distributed web content syndication networks.

Risk analysis, crisis management, information evaluation, heterogeneous data fusion, evolutionary information follow-up in social networks, knowledge discovery, are particularly studied in large databases. Web usage mining, prefetching, recommendation systems, interface customization help the user interact with web pages and to extract relevant information. More generally, the Department's research concerns user modelling and profiling, adaptive hypermedia and interface personalization, for instance content adaptive navigation interfaces, pen-based interfaces, smartphones and tablets. Affective computing is also a domain addressed by the department through emotion and opinion mining in texts and images, as well as links between emotions and psycho-physiological signals.

**R&D projects**

**European Networks of Excellence**

Pascale2 (pattern analysis, statistical modeling and computational learning)

**European projects**

SCAPE (SCAlable Preservation Environments), USIXML

**Industrial research:**

Cap Digital (Business Cluster for Digital Content)

Numerous national research grants

**Industry Partners:**

THALES CFR, THALES TRT, ONERA, FRANCE TELECOM, EADS, IGN, INA, ALCATEL-LUCENT-BELL LABS, CEA, SONY, EDF, ANTIDOT, ARISEM, PERTIMM, KXEN, MONDECA, VECSYS, INTELLIGENT LEARNING OBJECTS, BBSP, CADEGE HOSSUR, PRYLLOS, BLOGSPIRIT, KARTOO, DIEP DESIGN, EXALEAD, EPAGINE, GOSTAI, PI AUTOMATION, MONDOMIX MEDIA, TRAVELSOFT, HEAVEN Consil, TELEFUN, ALTIC, GIE CARTES BANVAIRES, EUROPEAN ARCHIVES.

**Academic program:**

Master in Computer Science: Artificial intelligence and Decision making, Image Processing

Master Erasmus Mundus «Data Mining and Knowledge Management»

**Software patents:**

European patents on voluntary ocular signal utilization, information management for intelligence services, symbolic information fusion

**Teams:**

**MALIRE**

Machine Learning and Information Retrieval

**BD**

Databases

**ACASA**

Cognitive Agents and Automated Symbolic Learning

**Keywords**

Statistical and symbolic machine learning, large scale data processing, data flows, web archiving, text and multimedia information retrieval, interfaces et user modeling, semantic web.
The “Networks and Systems” department gathers LIP6 research activities related to networks, systems, and distributed systems. We analyze and design solutions for constructing and managing networks, systems, and distributed systems of the future. Those themes are represented by three complementary teams: NPA, Phare, and REGAL (the latter being a joint research team with INRIA Paris-Rocquencourt).

Keywords
Algorithms for dynamic environments, Distributed data management in multicore architectures, Content management, Wireless and Mobile networks, Metrology and Internet governance, Next generation access networks, Internet and Sky computing, eHealth, Internet and Cybercriminality.

NPA Team
NPA team aims at developing a vision for the future Internet as well as designing solutions to shape and manage it. The target of the team is the control of ubiquitous, mobile and versatile networks that expand everywhere in our private and professional environments. The core of our work concerns problems related to multimedia and mobile networks, resource management, scalability, ambient networks, and content networking. Moreover, significant work is developed in the area of Internet measurement, modeling and traffic engineering.

REGAL Team
REGAL is a joint project-team with INRIA Rocquencourt. The Regal team aims to manage resources in large scale networks. REGAL investigates solutions to deploy applications (with code and data) in highly distributed environments. The project targets large scale configurations (in terms of the number of nodes and distance between them), highly dynamic (with failure, deconnexion and partitionning). Regal is focused on replication techniques to tolerate failure, to increase the availability, and to provide efficient access to distributed services.

Phare Team
The PHARE team aims at developing the future generation of telecommunications networks. The IP (Internet Protocol), TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) protocols provide communications in the Internet world. These protocols are badly adapted to new generation of networks in particular wireless, ad hoc and sensors networks. The objective of PHARE is to propose a new generation of protocols able to adapt to its environment. This intelligent protocol will have to be able to change link by link to take into account local constraints. In this research, various solutions, resulting from the autonomic networks, active networks and intelligent systems, will be tested and compared.
A complex system is an object that cannot be globally described, understood, predicted or controlled through a detailed knowledge of its components and their interactions.

Typical examples include living organisms (and their ecosystems), complex industrial systems (like a factory or an airplane), or social systems (like social networks or cities, for instance). In computer science, typical examples include large software (complex mixtures of software elements), networks (like the internet or peer-to-peer networks), and what users do with them (on-line social networks, exchanges, etc).

In all these cases, the challenge consists in developing new methods and tools to observe, analyze, understand, handle, design and control these systems.

The Complex Systems department at LIP6 puts together three teams working in this area: APR (methodological aspects based on algorithmics and programming theory), ComplexNetworks (focused on structural aspects with key formalism graphs and networks) and MoVe (study, design, security and verification of complex softwares).

APR Team

The APR team works on thematics dealing with algorithmics and programming languages, from both theoretical and practical fundamental aspects, combining the language approach (design, implementation) and the algorithmic requirements (modeling, complexity analysis) in a wide range of applications, such as programming new machine architectures, developing languages for concurrence and mobility and software testing. More generally, in the APR team, we develop formal and mathematically founded methodological approaches, in the domains of semantics and combinatorics, in order to achieve concrete goals such as experimental software prototypes, as well as development of industrial applications.

The APR team revolves around two research projects: the project Random Generation (RG), and the project Web, Languages and Coherence (WLC). In the RG project, supported by the ANR project MAGNUM (Algorithmic Methods for Non Uniform Random Sampling, Models and Applications), we develop methods of analytic combinatorics for random sampling with Boltzmann method. This model allows for sampling combinatorial objects from their specification, using efficient and generic algorithms, with many applications, especially in software testing and complex networks. The WLC project is supported by an ANR project nicknamed PWD for «Programming Diffuse Web». In the WLC project, we develop new programming languages for the Web to enhance various aspects around HOP and OCsigen: formal semantics of Hop to ensure the security of the interactions between clients and servers. Around OCsigen, the PWD project studies how to handle the DOM in a strong typing context during all the lifecycle of the application.

ComplexNetworks Team

The ComplexNetworks team works on graphs modeling real-world objects like the internet, peer-to-peer networks, social networks or biological networks. It works on general questions regarding these objects, in particular: measurement (collection of data regarding these graphs), metrology (bias induced by the measurement procedure on observations), analysis (statistical or structural description of these graphs), modeling (building artificial graphs capturing observed properties), as well as algorithmic questions raised in this context.

Our approach consists in a permanent loop between fundamental questions and applied problems, guided by numerous and diverse case studies.

MoVe Team

MoVe centers its research on the modeling and analysis of complex and dynamic distributed systems. In particular, we put our focus on:

- Optimized techniques of formal verification through model-checking.
- Development methodologies based on Model-Driven Engineering.
- Integration of formal analysis in development processes.
- Design and implementation of new programming languages and models to increase the verifiability of distributed programs.

Keywords
The department is a major academic contributor in the field of Systems on Chip. It brings together a hundred people, including thirty academic staff from « Université Pierre et Marie Curie » (UPMC) and « Centre National de la Recherche Scientifique » CNRS. Our research activities are organised into four main areas:

- Many core architectures contain hundreds or thousands of heterogeneous cores. They are studied following software aspects (data-flow modelling and co design of software and hardware), execution environments (operating systems tailored to many core architectures) and hardware architectures.
- Structure of dynamic systems changes over time. The department is studying in particular the design of low power wireless sensor networks and receivers for Software Radio. Reconfigurable architectures are also addressed by integrating them into chips and for specific applications such as cryptography.
- Heterogeneous systems bring together, in a multi- physic context, software and digital functions, analog, MEMS and RF. The study of their modelling and simulation using SystemC-AMS and their prototyping is a transverse axis of the department.
- Safety and reliability of SoC are studied: hardware verification methods based on Model-checking, the study of power supply noise and clock synchronisation are addressed.

These four axis find applications in transport and health.

**Software platforms**

- **TSAR**
  - Many core general architecture with shared memory
- **SOCLIB**
  - A SystemC CABA library for SoCs simulation
- **CORIOLIS**
  - Design, placement and routing of mixed analog-digital circuits
- **CONSOMMATION**
  - Measurement of consumption of heterogeneous systems

**Partners**

- **French institutions**: AP-HP, ESIEE, ESPCI, IEMN, IJLL, IJLLR, INRA, INRIA, Institut Télécom, IRPHE, L2E, LIRMM, LSV, SUPELEC, TIMA, UTC, GIS eSys and Paristlic, GDR SOC/SIP
- **Companies**: ACE, Bull, CEA, CEA-LETI, FlexRas Tech, KALRAY, MAGILLEM, NXP, ONERA, Orange Labs, PHILIPS, STMicroelectronics, THALES, YACAST
- **Competitiveness cluster**: SYSTEMATIC, CAP DIGITAL, Optics Valley
- **International academics**: Ain Shams Université (Le Caire), Chess (Berkeley), CINVESTAV (Mexico), Universität Bremen, Delft TU, Fraunhofer, LIACS (Leiden), UQAC (Chicoutimi), Université de Monastir, Université Française d’Egypte (Le Caire), Wien TU

**Formations**

- Bachelor in Electronic and Computer Science from UPMC
- Master in Computer Science from UPMC, speciality « Systèmes Electroniques, Systèmes Informatiques » (including a bi-located formation with Université Française d’Egypte)
- Polytech’Paris-UPMC School of Engineering

**Production 2007 – 2010**

- 150 papers in journals and international conferences
- 28 PhD thesis and 4 Habilitation thesis
- 20 research projects about 4 ME
- 4 patents and 2 startups
- 2nd Price from Fondation SGAM Innovation Thérapeutique 2007
- 2 prices from Concours National Création Entreprises Innovantes OSEO 2009

**Projets**

- **Régional competitiveness cluster system@tic, financed by Ile-de-France and Europe via FEDER**: WAAVES-GP, WARM
- **National**: DGA DTC, NANO2012, ANR : ADAM, ENDOCOM, FME3, HERODOTOS, HODISS, SESAM, SEFPGA, SurfOnHertz, VALMEM, WASABI
- **International**: ANR ASTECAS, MEDEA+, BDREAMS, CATRENE, TSAR

**Teams**

**ALSOC**: integrated on chip multiprocessor systems, real time systems, formal verification systems and generating optimised code for a target architecture.

**CIAN**: architectures, methods and tools for the modelling, the simulation, the design and the verification of mixed and heterogeneous circuits.

**SYEL**: performance modelling of heterogeneous systems, wireless low-power sensor networks, applications to software radio and health.

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