

Detailed description of the courses followed in first year of Master's degree (ENS Rennes)

Roméo La Spina

First semester (average mark: 15.68/20)

- Projet 1 **Projet de recherche 1**, *David Pichardie*, 5 ECTS, mark : 16/20
1st semester of a research project supervised throughout the year. Weekly meeting with the supervisors.
Subject : Verification of a Just-In-Time compiler
Supervisors : David Pichardie, Aurèle Barrière (IRISA, CELTIQUE team)
- PDS **Programmation dirigée par la syntaxe**, *Olivier Ridoux*, 4h/week, 5 ECTS, mark : 18.56/20
Contents : Abstract syntax (grammars and trees), attributed grammars, syntax-directed programming, implementation in object-oriented languages and in ML, concrete syntax, pretty-printing, syntactic analysis, programming languages, type checking, intermediate code generation, control flow graph and optimizations, natural languages and query languages.
Practical sessions :
 - Syntactic analysis with OCaml parsers
 - First project : compilation of graphical representations
 - Second project : compilation of a little imperative language to an existing compiler back-end
- THX **Théorie de la complexité**, *François Schwartzentruber*, 2h/week, 3 ECTS, mark : 18/20
Contents : Turing machines, time complexity classes, P and NP, polynomial reduction, NP-completeness, Cook's theorem, Ladner's theorem.
Space complexity classes, PSPACE, Savitch's theorem, PSPACE-completeness, quantified boolean formulas.
L and NL classes, logarithmic-space reduction, accessibility in a graph, Immerman-Szelepcényi theorem, NL = co-NL.
Undecidability, diagonalization, hierarchy theorems, relativization, oracles.
Alternating machines, Chandra-Kozen-Stockmeyer theorem, polynomial hierarchy.
Circuits, uniformity, AC and NC classes, parity, Karp-Lipton theorem.
- MVFA **Modélisation et vérification formelle par automates**, *Sophie Pinchinat*, 4h/week, 5 ECTS, mark : 11.8/20
Contents : Modelling systems, linear-time properties, regular safety properties, liveness and fairness, Büchi automata, linear-time temporal logic, verifying regular safety properties.
LTL model checking, decision problems on LTL, branching-time logics, CTL / CTL* model checking, bisimulation, LTL vs CTL, fairness in LTL / CTL, CTL+.
Refers to *Principles of model checking*, C. Baier, J.P. Katoen, et al. MIT press, 2008.
Practical sessions : Model checking with NuSMV. Modelling several problems such as mutual exclusion or the problem of the dining philosophers.

SEL **Systèmes d'exploitation - fondements et programmation sous Linux**, *Isabelle Puaut*, 4h/week, 5 ECTS, mark : 17.5/20

Contents : Multi-tasking, processes, scheduling policies, synchronization between processes, semaphores, locks, critical section, mutual exclusion, deadlock, client/server, producer/consumer, reader/writer.

Input/output, control interface, busy waiting, interruptions.

Memory management, virtual memory, memory hierarchy, cache, replacement policies, hardware/software caches, memory paging, virtual/physical address, MMU, page fault, write-back/write-through, swap, page replacement, clock algorithm.

Link edition, static/dynamic linking, implementation on Linux.

Practical sessions : Design of a tool to optimize code dynamically in a traced process (using the syscall ptrace).

DSL **Domain-Specific Languages**, *Jean-Marc Jézéquel, Mathieu Acher*, 2h/week, 4 ECTS, mark : 12/20

Contents : Model-Driven Engineering, Software Language Engineering.

Staging, attributed grammars, typing, operational semantics.

Language workbenches, program and model transformation (static analysis, code/test/documentation generation,...), program and model execution, simulation and debugging, program and model composition (merge, coordination, synchronization).

Integration of formal methods within DSLs (e.g., model checking).

Variability modeling (software product lines, feature models, etc.), automated reasoning (e.g., with solvers), cost-effective strategies.

Practical sessions : Project : Design of a DSL with Eclipse Xtext to write queries on CSV files, as well as :

- a pretty-printer and an interpreter for our DSL
- a compiler of our DSL to Python
- another compiler of our DSL to Bash

Anglais 1 **Translation and Perception**, *Chris McLoughlin*, 1h30/week, 3 ECTS, mark : 16.4/20

Description : A mixture of straight translation and communication exercises based on psychological and philosophical themes held together by a common problem: What does it all mean, and how do we know?

XTRA **Initiation à la recherche**, *Martin Quinson*, 2h/week, 3 ECTS (only for the magistère of the ENS Rennes), mark : 14/20

Methodology and training for oral presentation and design of slides. Evaluation on a 15 minute long presentation about previous research work, followed by questions.

Second semester (average mark: 15.89/20)

Projet 2 **Projet de recherche 2**, *David Pichardie*, 5 ECTS, mark : 18/20

2nd semester of a research project supervised throughout the year. Weekly meeting with the supervisors.

Subject : Verification of a Just-In-Time compiler

Supervisors : David Pichardie, Aurèle Barrière (IRISA, CELTIQUE team)

Stage **Stage de recherche**, *Simon Rockicki*, 3 ECTS

A 10-week long research internship.

Subject : Secure compilation of speculative-constant-time programs

Supervisor : Vincent Laporte (LORIA, PESTO team)

TI **Théorie de l'information**, *Eric Fabre*, 2h/week, 4 ECTS, mark : 15/20

Contents : Information source, entropy, AEP (almost equipartition property).

Joint entropy, conditional entropy, graphical representation (Venn diagram), relative entropy, mutual information between two sources, conditional mutual information, data processing inequality.

Source encoding and compression limit (1st Shannon's theorem), Huffman coding, Shannon coding, Lempel-Ziv coding.

Communication channels, channel capacity (2nd Shannon's theorem).

SEM **Sémantique des langages de programmation**, *Sandrine Blazy*, 4h/week, 5 ECTS, mark : 14.27/20

Contents : Functional programming in Coq, inductive types, proofs by induction, lists, maps, polymorphism, proof tactics and logic in Coq.

Syntax and semantics of an imperative language, compilation to a stack machine, computational and relational definitions.

Small-step and big-step operational semantics, correctness proofs, determinism, typing, statically-typed lambda calculus, substitution, reduction, normal forms, contexts, progress, type preservation, soundness.

NOY **Programmation noyau**, *Isabelle Puaut*, 4h/week, 5 ECTS, mark : 17.25/20

Contents : Implementation of kernels of operating systems, hardware mechanisms to control execution, context switches.

Main data structures in a kernel, implementation of synchronization tools (mutual exclusion, semaphores) and scheduling.

Implementation of input/output.

Implementation of memory management : dynamic memory allocation, memory paging, copy-on-write, resource sharing, dynamic linking, segmentation and coexistence with paging.

Security in operating systems.

Kernels of multi-processor machines, virtualization.

Practical sessions : Design of a small kernel of operating system

CBD **Cloud et Big Data**, *Anne-Cécile Orgerie, Shadi Ibrahim*, 4h/week, 5 ECTS, mark : 14.38/20

Cloud part :

Contents : Introduction to Cloud, definitions, general principles, problems and challenges. Introduction to virtualization, virtualization system, paravirtualization and software virtualization. Resource sharing (memory, devices, network, disks), live migration, Linux containers. IaaS Cloud, Green computing, impact of the Cloud on energy consumption of TIC infrastructures.

Practical sessions : Introduction to Grid'5000, assessment of performances of virtual machines (CPU, memory, disk), assessment of performances of containers, deployment of Kubernetes.

Big Data part :

Contents : Introduction to Big data, MapReduce System, Google File System (GFS) MapReduce programming model, Hadoop Ecosystem, Yarn, Spark and Flink.

Data skew, fault-Tolerance and scheduling in MapReduce applications.

Practical sessions : Introduction to Hadoop and HDFS, analysis of Hadoop logs, deployment of Hadoop on Grid'5000, utilization and configuration of HDFS.

Configuration and optimization of Hadoop, execution of multiple MapReduce applications, job scheduling. Development of MapReduce applications.

Anglais 2 **Crisis? What crisis!**, *Alex O'Reilly*, 1h30/week, 3 ECTS, mark : 16.5/20

Description : The history of "Things have never been so good" pre COVID19. Is it a disaster or an opportunity? What needs to change in our society and how to go about it?

Philo **Epistémologie**, *Filipe Vieira Contim, Olivier Ridoux*, 2h/week, 4 ECTS (only for the magistère of the ENS Rennes)

Epistemology course revolving around the book of Thomas Kuhn, *Structure of scientific revolutions* (1962), compared to other schools of thought and methods such as confirmation theories, falsifiability, crucial experiments, Lakatos' epistemology, etc.

There is many examples from science history, but not from computer science. Therefore, another problem to address is the position of this science with respect to Kuhn's analysis ?

Contents : Introduction to epistemology, Kuhn's model, science and pre-science, birth and structure of paradigms, "normal" science, crisis, revolution, incommensurability.

XTRA **Initiation à la recherche**, *Sophie Pinchinat*, 2h/week, 0 ECTS (only for the magistère of the ENS Rennes)

Methodology and training for reading and writing articles.