

## **Programme**

### **Data Science and Network Intelligence**

#### **Programme syllabus (M2, S9)**

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## Data Science and Network Intelligence (DANI)

### Coursework Description

This MSc (and VAP) in Data Science and Network Intelligence (DANI) is home for creative problem-solvers who want to use data strategically to advance the ITC society. We are cultivating a new type of quantitative thought leader who uses computational strategies to generate innovation and insights.

Artificial Intelligence (AI) and Machine Learning (ML) approaches, well known from IT disciplines, are beginning to emerge in the networking domain. These approaches can be clustered into AI/ML techniques for network management; network design for AI/ML applications and system aspects. Recently, networking has become the focus of a transformation enabled by new technological and economical models resulting from virtualization and cloud computing. These techniques provide novel architectures supported by emerging technologies such as Software-Defined Networking (SDN), Network Function Virtualization (NFV) and more recently, edge cloud and fog.

DANI combines rigorous technical training with field knowledge, industry insights and practice in critical thinking, teamwork, communication techniques, and collaborative leadership to generate data scientists with a deep understanding of how telco/webcos evolve and who can add value to any technical field.

The program covers areas such as network intelligence, automation, communication services, large-scale data analytics, advanced machine learning and data-mining, information retrieval, natural language processing and web mining. It also includes foundational modules on topics such as programming for data analytics, Internet of things, services and optimization. Students enrolled in the program deepen their knowledge in an elective topic by working on a project in conjunction with either a research group or an industry partner. In addition to six key technical courses, a course on telecom management and economics, jointly taught with Institut Mines-Telecom Business School, gives students essential information about markets and business models. Moreover, each student becomes involved in concrete projects and produces a Master's thesis. The Master's thesis can be conducted in collaboration with industrial partners or research laboratories.

Students attend the ICIN international conference ([www.icin-conference.org](http://www.icin-conference.org)). In addition, World-renowned experts from Orange Labs, CISCO, ITRON, Telecom Italia and ETSI are invited to give lectures during the year. English is the language of instruction and courses are taught jointly with MSc students from University Carlos III, Madrid (Spain), Asian Institute of Technology (international) and National Chiao Tung University (Taiwan).

### Career prospects

The demand for professionals who can interpret large quantities of data with a deep understanding of telcos and webcos has never been greater, and these skills are vital for scientific advancement and business success. Given the program's solid foundations, students acquire both an in-depth theoretical background and practical knowledge. It only takes a few

weeks for graduates to find their first job in the field of ICT and most graduates are hired before graduation.

**Prerequisite for TSP students:** no S8 prerequisite.

**Courses / modules**

<b>Module</b>	<b>ECTS</b>	<b>Code</b>	<b>Coordinator</b>	<b>Hours</b>
<b>Network Intelligence and Communication Services</b>	4	NET7012	N. Crespi	48
<b>Internet of Things</b>	4	CSC7016	R. Minerva	18 (+3 days if ICIN)
<b>Data Science – theory to practice</b>	4	CSC7018	N. Crespi	33
<b>Service-oriented Computing</b>	4	CSC7017	W. Gaaloul	21
<b>Wireless Access Networks : State of the Art, Challenges and Evolutions</b>	4	NET7003	B. Jouaber	18
<b>Optimisation: Theory and applications</b>	4	NET7006	W. Benameur	27
<b>Business Modelling and ICT</b>	4	MGT7001	P.Vialle	15
<b>Project (for ingénieurs only)</b>	4	NET7515	N.Crespi	1 month
<b>Thesis or internship in the industry (for MSc only)</b>	32	NET7515	N.Crespi	6 month
<b>Internship in the industry (for ingénieurs)</b>				6 months

## Module NET7012

## Network Intelligence and communication services

**Department :** RS2M

**Coordinator :** Noël Crespi and Imen Grida Ben Yahia **Phone :** 01 60 76 46 23

**Email :** noel.crespi@telecom-sudparis.eu **Room :** D107

### Introduction:

The course concentrates on service architectures and also covers today's networks, to allow the students understand the changes that the world of telecommunications and internet is facing. Message flows and procedures are thoroughly examined in class and in small student groups to strengthen understanding. The course also introduces the alternatives to operator-centric architectures to provide communication services to the users. Other approaches such as Peer-to-Peer systems, OTT, web-NGN convergence, user generated services are introduced.

Network Intelligence course encompasses four main parts. The first part of the course aims to present the background on Autonomic computing and Networking as a core stone of Network intelligence. The Second part objectives are to zoom on the algorithmic part, the possible operations (classification, clustering, etc.). The third and fourth part target to practice the of machine learning for network data (data extraction, pre-processing, model set-up, configuration and validation, etc.)

### Organisation:

48h hour coursework .

### Evaluation:

Group work and oral presentation.

### Programme

#### Introduction to Network cognitive management

- Motivation
- Architecture
- Network Data
- Analytics and SDN & NFV

#### Zoom on machine learning algorithms for Network

- Basics
- Neural Network and deep learning algorithms
- Approach and process for ML in Networks

#### Tools, libraries and Hands-on (python based)

- **Basics** for a machine learning project set up, tools, manipulation of opensource dataset
- Network focused Hands-on (python based)

- Preprocessing of Network data:
- Model selection; Model execution;

#### Model validation

#### Intelligent Network

- IN principles, CAMEL
- Services: what are the challenges?
- Lessons learnt from IN.

#### From Telcos to WebCos

- UMTS
- SIP
- IMS, NGN architecture
- Service architecture
- Web-NGN convergence,
- SDN (Software Defined Networking)
- NFV (Network Function Virtualisation)

### Bibliography

R. Minerva, N. Crespi, "[Networks and New Services: A Complete Story](#)," Springer International Publishing, 2017.

E. Bertin, N. Crespi, [Architecture et Gouvernance des Services de Communication](#) Paris, France, Hermes Lavoisier (21013).

E. Bertin, N. Crespi, T. Magedanz (Eds), "[Evolution of Telecommunication Services – The Convergence of Telecom and Internet: Technologies and Ecosystems](#)

Copy of the slides. Standards: selected technical specifications from 3GPP, IETF and ITU-T.

## Module CSC7016

## Internet of Things

**Department :** RS2M

**Coordinator :** Roberto Miverva

**Email :** Roberto.minerva@telecom-sudparis.eu

**Room :** D108-20

### Introduction:

Internet of Things, IoT, is a set of technologies able to have a high impact on how people live, produce, and modify/interact with the environment. Such a transformation is driven by increasing technologies capabilities of sensors/actuators, communications, general purpose hardware, availability of software and programmability of devices. The integration of so different technologies is a problem in itself and it increases if very large scale systems are considered. IoT is also trying to solve cogent issues of specific problem domains, such as Assisted Living, e-health, transportation, manufacturing, smart cities and so on. The course will analyze the technologies, the current trends and the future challenges in this important real, considered under the possibilities of extreme softwarization of systems. At the end of the courses, Student will be able to design, evaluate and select the proper solutions within a large IoT system.

In addition to technological and problem domain specific challenges, there exist further challenges that fall in Business, Social and Regulation realms. They can greatly impact the deployment and the success of IoT. The course aims is to provide a view on some major technologies challenges of IoT and to cover a few critical Business and Social issues that could hamper the large deployment of IoT systems. The course requires basic notions about IP protocol communication and software architecture and programmability. It is devoted to PhD and graduate students willing to achieve a large perspective of the aims, goals and potentialities of the Internet of Things, and the possible impact on users.

**Organisation:** 18 hour coursework + optional ICIN conference.

**Evaluation:** Short project with design and possibly a draft implementation of a simple IoT service

### Programme

#### The Context of IoT

- A Definition of IoT
- A few Challenges of IoT

#### IoT Technologies

- \_ What Things are
- Networks of Things
- Communications Technologies
- Access Technologies
- Protocols
- Software
- SW Platforms
- Middleware
- Standards
- major contributions to standardization
- IoT Challenges
- Softwarization
- Identity, Data, and Ownership
- IoT and Artificial Intelligence
- Complex System
- Business and SOcial Perspectives on
- IoT Social Issues
- IoT Use Cases

### Bibliography

R. Minerva, N. Crespi, "[Networks and New Services: A Complete Story](#)," Springer International Publishing, 2017.

E. Bertin, N. Crespi, [Architecture et Gouvernance des Services de Communication](#) Paris, France, Hermes Lavoisier (21013).

E. Bertin, N. Crespi, T. Magedanz (Eds), "[Evolution of Telecommunication Services – The Convergence of Telecom and Internet: Technologies and Ecosystems](#)

Copy of the slides. Standards: selected technical specifications from 3GPP, IETF and ITU-T.

<h2>Module CSC70718</h2>	<h2>Data Science – from theory to practice</h2>
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**Department :** RS2M

**Coordinator :** Noel Crespi

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**Phone :** 01 60 76 47 23

**Room :** D107

### Objectives

The goal of the course is to have a broad introduction on data science and artificial intelligence techniques. The course is split into three parts:

- Introduction to Data Science, in which we learn the why data is the value and what are the existing challenges that needs mining of the data.
  - Unsupervised learning, in which we study the concept and some of the related algorithms: hierarchical clustering, kmeans, dbscan, hdbscan, etc.
  - Supervised learning, in which we study the concept and some of the related algorithm: regression (linear and logistic), decision trees, Naïve Bayes, SVM, random forest
  - Text analysis (supervised and unsupervised) in which we will review the specificities of text analysis
- Each course is followed by practical work using R and/or python

### Organisation

14 hour coursework, 20 hours practice

### Evaluation

Practical session grading

### Programme

- Data Science in scale
- Big Data problems
- Introduction to Data mining
- Data handling with R / Python
- Supervised Machine Learning algorithms
- Unsupervised Machine Learning algorithms
- Text mining

## Module CSC7017

## Service-oriented Computing

**Department :** INF

**Coordinator :** W. Gaaloul

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**Phone :** 01 60 76 47 74

**Room :** D3030

### Objectives

This course introduces fundamental concepts for Service-Oriented Computing (SOC) and business process management (BPM). SOC is a computing paradigm that is used by major enterprises and government agencies. SOC represents computing in a collection of loosely coupled services. BPM includes methods, techniques, and tools to support the design, enactment, management, and analysis of operational business processes. This course aims at presenting concepts, principles, and tools for SOC and BPM. It provides students with a comprehensive introduction to service-oriented computing by covering most known technical solutions and the research opportunities that exist. Students will also learn about the programming model of Web services and business processes and apply this knowledge to a group project in which they practice team work.

### Evaluation

- Evaluated Lab (30%)
- Mini project (70%)

### Programme

- Introduction to SOA and BPM
- Web services
  - SOAP-based Web services
  - RESTful Web services
- Introduction to BPM modeling languages (Petri-nets, EPC, BPMN)
- Service composition
  - Business Process Execution Language (BPEL)
  - Business process model and notation
  - Workflow Management systems
- Service integration and mediation (ESB)
- News trends
  - Cloud Computing
  - Process intelligence

### Bibliography

<http://www-inf.it-sudparis.eu/cours/CSC4503/>

<http://www-inf.it-sudparis.eu/cours/WebServices/>

Site de W3C (normes) : [www.w3.org](http://www.w3.org)

Site de Zvon (tutoriel XML) : <http://www.zvon.org/>

## Module NET7003

# Wireless Access Networks : State of the Art, Challenges and Evolutions

**Department :** RS2M

**Coordinator :** Badii Jouaber

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**Phone :** 01 60 76 42 08

**Room :** A106.01

### Objectives

This course addresses Wireless networks' technologies and architectures.

The first and major emphasis is on radio access network architectures, procedures and methods. We will address resource sharing and radio resource allocation, control and management from GSM to LTE networks (i.e. TDMA/FDMA, CDMA and OFDMA systems).

The course addresses Uplink and downlink interference management, scheduling issues and capacity evaluation for the air interface or the radio access network.

Physical to logical channel mapping for cellular networks are also described along with the RAN architecture and the associated procedures and protocols.

QoS management and service classes will be presented and debated.

The course also addresses transport technologies. The use of dedicated lines, ATM and IP and therefore the evolution from circuit to packet switched technologies are discussed and analysed.

The impact of current choices on QoS and mobility management as well as the trends and evolutions toward beyond 5G and C-RAN networks will be discussed.

**Organisation :** 18 hour coursework

**Evaluation:** Written test.

### Programme

#### RAN architecture

Radio Access Network Architecture for GSM, GPRS, UMTS and LTE, network devices, interfaces and protocols

#### QoS definition and management in cellular networks

**Access methods** and radio resource management in mobile networks, mainly for

- TDMA/FDMA systems,
- CDMA systems and
- OFDMA systems.

#### Scheduling issues for

- downlink
- uplink

#### Procedure and protocol used for resource allocation

#### Transport technologies in the RAN

- Circuit versus Packet modes
- QoS Classes and QoS mapping between radio and transport layers

#### C-RAN

#### Green IT

### Bibliography

3GPP documents and scientific papers

## Module NET7006

## Optimisation: Theory and Network applications

**Department :** RS2M

**Coordinator :** Walid Benameur

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**Phone :** 01 60 76 47 13

**Room :**

### Introduction

Designing a minimum cost network with high performance is an important challenge for network operators. Some mathematical and computer science tools are required to model and solve complex network optimization problems. This course will provide students with analysis, modelling and optimization capabilities by presenting principles from combinatorial optimisation and game theory. These notions will be applied to wireless systems, networks design and optimization problems.

### Objectives

This course focuses on the fundamentals of optimization theory: graph algorithms, linear programming, integer programming, and complexity theory. Some network optimization problems will be solved using some of the mathematical methods presented in the course. An introduction to game theory applied to wireless communication networks will also be provided. A main focus will be given to traffic engineering, network topology design, frequency assignment, network routing, dimensioning, and pricing problems.

### Organisation

27 hour coursework

### Evaluation

Written test.

### Programme

- Some graph algorithms
- Linear programming basics
- Introduction to Integer programming
- Traffic engineering
- Network topology calculus
- Network optimal routing and dimensioning
- Frequency assignment
- Pricing
- Game theory

### Bibliography

Telecommunication Network Design Algorithms, A. Kershenbaum, Mcgraw-Hill;

Network Optimization, Balakrishnan, Moire, Chapman Hall/CRC;

Network Optimization: Continuous and discrete models; Bertsekas, Athena Scientific

Routing, Flow, and Capacity Design in Communication and Computer Networks, M. Pioro, D. Medhi, Morgan Kaufmann

Game Theory for Wireless Engineers, A. MacKenzie and L. DaSilva

## Module MGT7001

## Business Modelling and ICT

**Department:** MMS

**Coordinator:** Pierre Vialle

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**Phone:** 01 60 76 47 93

**Room:** E415

Technological and service innovation induce the rise of innovative business models based on varying manners of managing revenues, costs and exchanges. This course develops the theory and practical applications of business modelling in the case of ICT-based businesses.

### Objectives

- Define the various dimensions of business models and their interaction
- Examine the main parameters of successful business models
- Design business cases and models
- Learn from successful business models in various contexts
- Appraise successful strategies

Expectations: Participation in courses, teamwork, document research. Pedagogical methods : Course, case studies, student's presentations

### Class schedule :

- Introduction
- Theoretical foundations for business modelling
- The dimensions of business models and their interaction: value-chains and activity model, supporting infrastructure, role model, value proposition, financial model
- The evolution of business models with technological innovation
- Tactics for capturing value
- The role of user's participation
- Analyses of various cases (i.e. mobile business models, web business models, digital games business models, TV and movie business models)

**Organisation:** 15 hours lecture, workload 30 hours.

**Evaluation:** Personal work, teamwork, test

### Bibliography

Leading the revolution., G. Hamel, Boston, Harvard Business School Press, 2000.

Place to space: Migrating to eBusiness Models., P. Weill and M. R. Vitale, Boston, Harvard Business School Press, 2001.

Internet Business Models and Strategies, A. Afuah and C. Tucci, Boston, McGraw Hill, 2003.

NET7515	MSc Thesis / Project
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**Department :** RS2M

**Coordinator :** Noël Crespi

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**Room :** D107

<p><b>Objectives</b> In parallel to this specialization coursework, students are involved in concrete projects requires personnel and team work. The student can choose his/her advisor in any department in Telecom SudParis: there have been advisors from RS2M, LOR, RST and INF departments as well as Telecom Business School.</p> <p><b>Organisation</b> 6 months (1 month for ingénieurs).</p> <p><b>Evaluation</b> Written document and feedback from the advisor.</p>	<p><b>Topics</b> Topics are jointly proposed by advisors or students.</p>
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