Data Science and Network Intelligence

Programme syllabus (M2, S9/S10)

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). In addition, World-renowned experts fromfrom Orange Labs, CISCO, 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), Polytechnic University of Bucharest (Romania), University of Calabria (Italy), and National Chiao Tung University (Taiwan), Skoltech (Russia)

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 advancment 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: in S1 choose 7 technical modules + business modelling

Module	Sem	ECTS	Code	Coordinator	Hours
Network Intelligence and Communication Services	S1	4	NET7012	N. Crespi	48
Data visualisation	S1	4	IMA7201	M. Preda	18
Data Science and AI – theory to practice	S1	4	CSC7018	N. Crespi / R. Farahbakhsh	27
Internet of Things and Digital Twins	S1	4	CSC7016	R. Minerva	18 (+3 days if ICIN)
Wireless Access Networks : State of the Art, Challenges and Evolutions	S1	4	NET7003	B. Jouaber	18
Blockchain, Smart contracts, Bitcoin and off-chain payments	S1	4	CSC7208	J. Garcia Alfaro	15
Business Modelling and ICT (in cooperation with IMTBS)	S1	4	MGT7001	P.Vialle	15
Optimisation: Theory and applications	S1	4	NET7006	W. Benameur	27
Service-oriented Computing	S1	4	CSC7017	W. Gaaloul	21
MSc Thesis (for MSc only) or internship in the industry (for MSc or ingénieurs)	S2	28	NET7515	N.Crespi	6 months

Semester 1: choose 8 modules among 9.

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.

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.)

In cooperation with Orange Labs and CISCO.

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

From Telcos to WebCos
- SIP
- IMS, NGN architecture
- Service architecture
- Web-NGN convergence,
- SDN (Software Defined Networking)
- NFV (Network Function Virualisation)

Bibliography

R. Minerva, N. Crespi, "Networks and New Services: A Complete Story," Springer International Publishing, 2017.
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 IMA7201	Data Visualisation

Department : ARTEMIS
Coordinator : Marius Preda
Email: marius.preda@it-sudapris.eu

Phone: 0175314442
Room: 4A342

Objectives

The goal of the course is to have an overview on the data structures and transformations for visualization, get familiar with various types of graphical representations and practice 3D and immersive representations.

 The course is split into two parts:

- Traditional data visualisation techniques, mainly using 2D graphics components and numerical analysis.
- Advanced representation forms including 3D representations and immersive spaces.

Organisation
9 hours coursework, 9 hours practice

Evaluation

VR project to visualize and interact with a set of data of choice.

Programme

Introduction to Information Visualization & Data abstraction (course 3H)

Graphs and data transformation & Graphical components and mapping strategies (course 3H)

Introduction to Tableau (lab 3H)

VR for data visualisation (course 3H)

Unity hands on (lab 6H)

Module CSC70718	Data Science – from theory to practice

Department : RS2M
Coordinator : Noel Crespi   **Phone :** 01 60 76 47 23
Email : noel.crespi@mines-telecom.fr   **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

In cooperation with Total.

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 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.

In cooperation with ETSI.

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
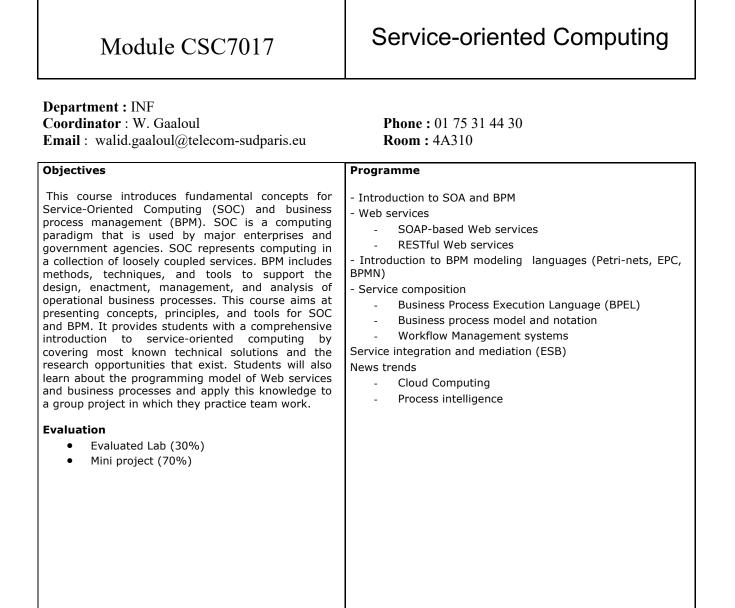- IoT Social Issues
- IoT Use Cases

Module CSC7208	Blockchain, Smart contracts, Bitcoin and off-chain payments

Department : RST
Coordinator : Joaquin Garcia Alfaro
Email : joaquin.garcia_alfaro@telecom-sudparis.eu

Phone : 01 75 31 44 10
Room : 4A 206

Objectives

Since its conception in 2008, Bitcoin and blockchain-based distributed ledgers have been presented to society as a technological revolution to transform industrial, economic and citizen worlds. This module will introduce the learners to different aspects of it, from basic use cases to real world applications. It will include as well an introduction to Ethereum and Smart Contract languages, as well as the use of off-chain payment channels and lightning networks.

[In collaboration with Orange Labs]

Hours
- 15 hours

Evaluation
- Written test or oral presentation.

Programme

1. The Bitcoin cryptocurrency
   - History of Bitcoin
   - Cyber-security & cryptocurrencies
   - Blockchain technologies
   - Blockchain definitions
   - Public vs. Private Blockchains
   - Blockchain explorers
   - Bitcoin P2P network
   - Bitcoin scripting language
   - DLTs & blockchain applications
   - Bitcoin transactions in depth

2. Ethereum and brief introduction to Smart Contracts (SC)
   - Ethereum & Distributed Networks
   - SC Basics
   - Ethereum Virtual Machine
   - Use Cases (Basic + Advanced)
   - SC advantages
   - How SC work?
   - Existing platforms and languages for SC
   - SC applications
   - Challenges of SC

3. Programming SC in Solidity
   - Introduction to Solidity
   - Enterprise Blockchain Real World Applications
   - Motivation and Perspective
   - Big Names
   - Auto and Mobility
   - Social Goods

4. Off-chain payment channels
   - UTXOs (Unspent Transaction Outputs)
   - Payment channels
   - Atomic swaps
   - Lightning networks

Module CSC7017	Service-oriented Computing

Department : INF
Coordinator : W. Gaaloul
Email : walid.gaaloul@telecom-sudparis.eu

Phone : 01 75 31 44 30
Room : 4A310

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
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
Email : Badii.jouaber@telecom-sudparis.eu

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 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   **Phone :** 01 75 31 44 24
Email : walid.benameur@telecom-sudparis.eu   **Room :** 4A244

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, IMTBS
Coordinator: Pierre Vialle   **Phone:** 01 60 76 47 93
Email: pierre.vialle@telecom-em.eu   **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 / Internship

Department : RS2M
Coordinator : Noël Crespi
Email : noel.crespi@telecom-sudparis.eu

Phone : 01 60 76 46 23
Room : D107

Objectives	Topics
In parallel to this specialization coursework students can either do their Master thesis in a lab or follow a 6 months internship in the industry (mandatory for ingenieurs). For Master thesis, 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. **Organisation** 6 months. **Evaluation** Written report and oral defense.	Topics are jointly proposed by advisors or students.