RESEARCH CENTRE

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2020
ACTIVITY REPORT

Project-Team
DANTE

Dynamic Networks : Temporal and Structural Capture Approach

DOMAIN

Networks, Systems and Services, Distributed Computing

THEME

Networks and Telecommunications

Contents

Project-Team DANTE

Creation of the Team: 2012 November 01, updated into Project-Team: 2015 January 01

Keywords

Computer sciences and digital sciences

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2 Overall objectives

The goal of DANTE is to develop **novel models, algorithms and methods to analyse the dynamics of large-scale networks**, (*e.g. social networks, technological networks such as the Web and hyperlinks, Articles and co-citation, email exchanges, economic relations, bacteria/virus propagation in human networks...*). Large datasets describing such networks are nowadays more "accessible" due to the emergence of online activities and new techniques of data collection. These advantages provide us an unprecedented avalanche of large data sets, recording the digital footprints of millions of entities (*e.g.* individuals, computers, documents, stocks, etc.) and their temporal interactions [1]. Such large amount of information allows for easier and more precise traceability of social activities, better observation of the structural and temporal evolution of social/technological/economical networks, the emergence of their localized and cascading failures, and provides information about the general roles of self-organization in an interdisciplinary sense. All these questions represent a major scientific, economic, and social challenge, which has the potential to revolutionize our understanding of the arising socio-technical world of our age.

[1] YouTube claims to receive 48 hours of video every minute, Google and Facebook represent major world companies that generate millions of traces on our activities every second. Every day, hundreds of millions of posts are added to the blogosphere, from which information on citizen opinions and their evolutions can be collected.

Our main challenge is to propose **generic methodologies and concepts to develop relevant formal tools to model, analyse the dynamics and evolution of such networks, that is, to formalise the dynamic properties of both structural and temporal interactions of network entities/relations**:

- **Ask** application domains relevant questions, to learn something new about such domains instead of merely playing with powerful computers on huge data sets.
- **Access** and collect data with adapted and efficient tools. This includes a reflexive step on the biases of the data collected and their relations to real activities/application domain.
- **Model** the dynamics of networks by analyzing their structural and temporal properties jointly, inventing original approaches combining graph theory with signal processing. A key point is to capture temporal features in the data, which may reveal meaningful insights on the evolution of the networks.
- **Interpret** the results, make the knowledge robust and useful in order to be able to control, optimise and (re)-act on the network structure itself and on the protocols exchange/interactions in order to obtain a better performance of the global system.

The challenge is to solve a major scientific puzzle, common to several application domains (*e.g.*, sociology, information technology, epidemiology) and central in network science: how to understand the causality between the evolution of macro-structures and individuals, at local and global scales?

3 Research program

3.1 Graph-based signal processing

Participants Paulo Gonçalves, Rémi Gribonval, Marion Foare, Márton Karsai.

Glossary

Evolving networks can be regarded as "*out of equilibrium*" systems. Indeed, their dynamics are typically characterized by non standard and intricate statistical properties, such as non-stationarity, long range memory effects, intricate space and time correlations.

Analyzing, modeling, and even defining adapted concepts for dynamic graphs is at the heart of DANTE. This is a largely open question that has to be answered by keeping a balance between specificity (solutions triggered by specific data sets) and generality (universal approaches disconnected from social realities). We will tackle this challenge from a graph-based signal processing perspective involving signal analysts and computer scientists, together with experts of the data domain application. One can distinguish two different issues in this challenge, one related to the graph-based organization of the data and the other to the time dependency that naturally exits in the dynamic graph object. In both cases, a number of contributions can be found in the literature, albeit in different contexts. In our application domain, high-dimensional data "naturally reside" on the vertices of weighted graphs. The emerging field of signal processing on graphs merges algebraic and spectral graph theoretic concepts with computational harmonic analysis to process such signals on graphs [76].

As for the first point, adapting well-founded signal processing techniques to data represented as graphs is an emerging, yet quickly developing field which has already received key contributions. Some of them are very general and delineate ambitious programs aimed at defining universal, generally unsupervised methods for exploring high-dimensional data sets and processing them. This is the case for instance of the “diffusion wavelets” and “diffusion maps” pushed forward at Yale and Duke [59]. Others are more traditionally connected with standard signal processing concepts, in the spirit of elaborating new methodologies via some bridging between networks and time series, see for instance [71] and references therein. Other viewpoints can be found as well, including multi-resolution Markov models [79], Bayesian networks or distributed processing over sensor networks [70]. Such approaches can be particularly successful for handling static graphs and unveiling aspects of their organization in terms of dependencies between nodes, grouping, etc. Incorporating possible time dependencies within the whole picture calls however for the addition of an extra dimension to the problem "as it would be the case when switching from one image to a video sequence", a situation for which one can imagine to take advantage of the whole body of knowledge attached to non-stationary signal processing [60].

The arrival of Rémi Gribonval in August 2019 brought a new dimension to the research program of this theme. Specialist of parsimonious representations of large data sets, R. Gribonval developed this last year a specific activity related to the sparsification of resources (computing and storage but also regarding the data volumes) in the context of machine and deep learning. This new orientation of Dante will be elaborated and fully integrated to the objectives of the future Inria project that will be proposed after Dante.

3.2 Theory and Structure of dynamic Networks

Participants Christophe Crespelle, Anthony Busson, Éric Guichard.

Glossary

Characterization of the dynamics of complex networks. We need to focus on intrinsic properties of evolving/dynamic complex networks. New notions (as opposed to classical static graph properties) have to be introduced: rate of vertices or links appearances or disappearances, the duration of link presences or absences. Moreover, more specific properties related to the dynamics have to be defined and are somehow related to the way to model a dynamic graph.

Through the systematic analysis and characterization of static network representations of many different systems, researchers of several disciplines have unveiled complex topologies and heterogeneous structures, with connectivity patterns statistically characterized by heavy-tails and large fluctuations, scale-free properties and non trivial correlations such as high clustering and hierarchical ordering [73]. A large amount of work has been devoted to the development of new tools for statistical characterisation and modelling of networks, in order to identify their most relevant properties, and to understand which growth mechanisms could lead to these properties. Most of those contributions have focused on static graphs or on dynamic process (*e.g.* diffusion) occurring on static graphs. This has called forth a major effort in developing the methodology to characterize the topology and temporal behaviour of complex networks [73, 64, 80, 69], to describe the observed structural and temporal heterogeneities [57, 64, 58], to detect and measure emerging community structures [61, 77, 78], to see how the functionality of networks determines their evolving structure [68], and to determine what kinds of correlations play a role in their dynamics [65, 67, 72].

The challenge is now to extend this kind of statistical characterization to dynamical graphs. In other words, links in dynamic networks are temporal events, called contacts, which can be either punctual or last for some period of time. Because of the complexity of this analysis, the temporal dimension of the network is often ignored or only roughly considered. Therefore, fully taking into account the dynamics of the links into a network is a crucial and highly challenging issue.

Another powerful approach to model time-varying graphs is via activity driven network models. In this case, the only assumption relates to the distribution of activity rates of interacting entities. The activity rate is realistically broadly distributed and refers to the probability that an entity becomes active and creates a connection with another entity within a unit time step [75]. Even the generic model is already capable to recover some realistic features of the emerging graph, its main advantage is to provide a general framework to study various types of correlations present in real temporal networks. By synthesising such correlations (*e.g.* memory effects, preferential attachment, triangular closing mechanisms, ...) from the real data, we are able to extend the general mechanism and build a temporal network model, which shows certain realistic feature in a controlled way. This can be used to study the effect of selected correlations on the evolution of the emerging structure [66] and its co-evolution with ongoing processes like spreading phenomena, synchronisation, evolution of consensus, random walk etc. [66, 74]. This approach allows also to develop control and immunisation strategies by fully considering the temporal nature of the backgrounding network.

3.3 Distributed Algorithms for dynamic networks: regulation, adaptation and interaction

Participants Thomas Begin, Anthony Busson, Isabelle Guérin Lassous, Philippe Nain.

Glossary

Dedicated algorithms for dynamic networks. First, the dynamic network object itself trigger original algorithmic questions. It mainly concerns distributed algorithms that should be designed and deployed to efficiently measure the object itself and get an accurate view of its dynamic behavior. Such distributed measure should be "transparent", that is, it should introduce no bias or at least a bias that is controllable and corrigible. Such problem is encountered in all distributed metrology measures / distributed probes: P2P, sensor network, wireless network, QoS routing... This question raises naturally the intrinsic notion of adaptation and control of the dynamic network itself since it appears that autonomous networks and traffic aware routing are becoming crucial.

Communication networks are dynamic networks that potentially undergo high dynamicity. The dynamicity exhibited by these networks results from several factors including, for instance, changes in the topology and varying workload conditions. Although most implemented protocols and existing solutions in the literature can cope with a dynamic behavior, the evolution of their behavior operates identically whatever the actual properties of the dynamicity. For instance, parameters of the routing protocols (*e.g.* hello packets transmission frequency) or routing methods (*e.g.* reactive / proactive) are commonly hold constant regardless of the nodes mobility. Similarly, the algorithms ruling CSMA/CA (*e.g.* size of the contention window) are tuned identically and they do not change according to the actual workload and observed topology.

Dynamicity in computer networks tends to affect a large number of performance parameters (if not all) coming from various layers (viz. physical, link, routing and transport). To find out which ones matter the most for our intended purpose, we expect to rely on the tools developed by the two former axes. These quantities should capture and characterize the actual network dynamicity. Our goal is to take advantage of this latter information in order to refine existing protocols, or even to propose new solutions. More precisely, we will attempt to associate "fundamental" changes occurring in the underlying graph of a network (reported through graph-based signal tools) to quantitative performance that are matter of interests for networking applications and the end-users. We expect to rely on available testbeds such as SensLab and FIT to experiment our solutions and ultimately validate our approach.

4 Application domains

4.1 Life Science & Health

In parallel to the advances in modern medicine, health sciences and public health policy, epidemic models aided by computer simulations and information technologies offer an increasingly important tool for the understanding of transmission dynamics and of epidemic patterns. The increased computational power and use of Information and Communication Technologies make feasible sophisticated modelling approaches augmented by details in vivo data sets, and allow to study a variety of possible scenarios and control strategies, helping and supporting the decision process at the scientific, medical and public health level. The research conducted in the DANTE project finds direct applications in the domain of LSH since modelling approaches crucially depend on our ability to describe the interactions of individuals in the population.

Within PhD work of G. Frusque, we collaborate with Dr. Julien Jung from Hôpital de Neurologie de Bron (HCL) and with Nadine Ravel, DR CNRS (CRNL, INSERM).

4.2 Network Science / Complex networks

In the last ten years the science of complex networks has been assigned an increasingly relevant role in defining a conceptual framework for the analysis of complex systems. Network science is concerned with graphs that map entities and their interactions to nodes and links. For a long time, this mathematical abstraction has contributed to the understanding of real-world systems in physics, computer science, biology, chemistry, social sciences, and economics. Recently, however, enormous amounts of detailed data, electronically collected and meticulously catalogued, have finally become available for scientific analysis and study. This has led to the discovery that most networks describing real world systems show the presence of complex properties and heterogeneities, which cannot be neglected in their topological and dynamical description. This has called forth a major effort in developing the methodology to characterise the topology and temporal behaviour of complex networks, to describe the observed structural and temporal heterogeneities, to detect and measure emerging community structure, to see how the functionality of networks determines their evolving structure, and to determine what kinds of correlations play a role in their dynamics. All these efforts have brought us to a point where the science of complex networks has become advanced enough to help us to disclose the deeper roles of complexity and gain understanding about the behaviour of very complicated systems.

In this endeavour the DANTE project targets the study of dynamically evolving networks, concentrating on questions about the evolving structure and dynamical processes taking place on them. During the last year we developed developed several projects along these lines concerning three major datasets:

- Mobile telephony data: In projects with academic partners and Grandata we performed projects based on two large independent datasets collecting the telephone call and SMS event records for million of anonymised individuals. The datasets record the time and duration of mobile phone interactions and some coarse grained location and demographic data for some users. In addition one of the dataset is coupled with anonymised bank credit information allowing us to study directly the socioeconomic structure of a society and how it determines the communication dynamics and structure of individuals.
- Skype data: Together with Skype Labs/STACC and other academic groups we were leading projects in the subject of social spreading phenomena. These projects were based on observations taken from a temporally detailed description of the evolving social network of (anonymised) Skype users registered between 2003 and 2011. This data contains dates of registration and link creation together with gradual information about their location and service usage dynamics.
- Twitter data: In collaboration with ICAR-ENS Lyon we collected a large dataset about the microblogs and communications of millions of Twitter users in the French Twitter space. This data allows us to follow the spreading of fads/opinions/hashtags/ideas and more importantly linguistic features in online communities. The aim of this collaboration is to set the ground for a quantitative framework studying the evolution of linguistic features and dialects in an social-communication space mediated by online social interactions.

4.3 Social Sciences / Epistemology

Political impacts of the internet and of networks begin to be well known (Cambridge Analytica, Russian trolls, etc.). Hence the public at large begins to be aware of the abuses of the leaders of the internet (privacy by firms and advertising, surveillance by states, fake news by activists, etc.). In the same time, on-line exchanges now give scientific estimations of the political life [62] and policital sciences begin to consider the internet as a relevant subject of study. As the internet is a *technology*, philosophy is the best approach to understand what socially happens (or can be made) with the internet. We develop it by two ways:

- political philosophy. Some Dante members are working with Triangle laboratory (social sciences, philosophy and politics; Ens de Lyon and CNRS).
- epistemology, because computer sciences discoveries are related with the evolution of science(s): we discovered that, in the case of the internet, political philosophy can do few if not strongly related to epistemology [63]. Epistemological approach is developped in collaboration with Jean Dhombres (who holds a seminar at Enssib: `http://barthes.enssib.fr/cours/Dhombres2018-2019.html` and with Hcéres (new relations between social and exact sciences.

This approach should help computer scientists to understand how their research may depend on foreign initiatives and to create new links between social sciences and Inria.

5 Social and environmental responsibility

5.1 Contribution to the monitoring of the Covid-19 pandemic

Estimation of the Covid-19 infectiousness risk from Bluetooth (BLE-RSSI) measurements [51]: the corresponding algorithm is implemented in the officiel contact tracing application *TousAntiCovid* of the French government (more than 12 million downloads in January 2021).
Prediction of the spatio-temporal evolution of the reproduction number $R(t)$ of the Covid-19 pandemia from open data (Santé-Publique-France and the European Center for Disease Prevention) [12]. An algorithm exploiting sparsity and convex optimization was developed, and dynamic maps were proposed.

The tool is being evaluated by the DREES governmental agency “to ensure the quality and coherence of COVID data, useful for crisis management”.

6 Highlights of the year

- R. Gribonval obtained an Artificial Intelligence Chaire from ANR program. The proposed research project, called "Algorithms, Approximations, Sparsity and Sketching for AI" (AllegroAssai), runs from 2020 until 2024.

6.1 Awards

- T. Begin received the "rising star award" at the ACM MSWiM conference on performance evaluation and wireless networks. 2020.

7 New software and platforms

7.1 New software

7.1.1 Queueing Systems

Functional Description: This tool aims at providing a simple web interface to promote the use of our proposed solutions to numerically solve classical queueing systems.

URL: `http://queueing-systems.ens-lyon.fr/`

Contact: Thomas Begin

Participants: Alexandre Brandwajn, Thomas Begin

7.1.2 WSNet

Keyword: Network simulator

Functional Description: WSNet is a modular event-driven simulator targeted to Wireless Sensor Networks. Its main goals are to offer scalabiliy, extensibility and modularity for the integration of new protocols/hardware models and a precise radio medium simulation. We still hope to find the proper resource to make WSNet evolve into a wireless capillary network simulator suitable for conducting simulations at the urban scale.

URL: https://gforge.inria.fr/projects/wsnet-3/

Contact: Guillaume Chelius

Participants: Rodrigue Domga Komguem, Fabrice Valois

Partner: CEA-LETI

7.1.3 Wi-Fi experimentation platform

Keywords: Wi-Fi, Hardware and Software Platform

Functional Description: Networking experimental platform in order to test and evaluate the Wi-Fi communication technology in various configurations. The platform consists in a server and Wi-Fi nodes. The server, remotely manageable, can deploy the images on the Wi-Fi nodes. These latter and the server are connected via a wired network.

Contact: Isabelle Guérin-Lassous

7.1.4 FAuST

Keywords: Learning, Sparsity, Fast transform, Multilayer sparse factorisation

Scientific Description: FAuST allows to approximate a given dense matrix by a product of sparse matrices, with considerable potential gains in terms of storage and speedup for matrix-vector multiplications.

Functional Description: FAUST is a C++ toolbox designed to decompose a given dense matrix into a product of sparse matrices in order to reduce its computational complexity (both for storage and manipulation).

Faust includes Matlab and Python wrappers and scripts to reproduce the experimental results of the following papers: - Le Magoarou L. and Gribonval R,. "Flexible multi-layer sparse approximations of matrices and applications", Journal of Selected Topics in Signal Processing, 2016. - Le Magoarou L., Gribonval R., Tremblay N. "Approximate fast graph Fourier transforms via multi-layer sparse", IEEE Transactions on Signal and Information Processing over Networks, 2018

Release Contributions: Faust 1.x contains Matlab routines to reproduce experiments of the PANAMA team on learned fast transforms.

Faust 2.x contains a C++ implementation with preliminary Matlab / Python wrappers.

Faust 3.x includes Python and Matlab wrappers around a C++ core with GPU acceleration.

News of the Year: In 2020, major efforts were put into finalizing Python wrappers, producing tutorials using Jupyter notebooks and Matlab livescripts, as well as substantial refactoring of the code to optimize its efficiency and exploit GPUs.

In april 2018, a Software Development Initiative (ADT REVELATION) started in for the maturation of FAuST. A first step was to complete and robustify Matlab wrappers, to code Python wrappers with the same functionality, and to setup a continuous integration process. A second step was to simplify the parameterization of the main algorithms. The roadmap for next year includes showcasing examples and optimizing computational efficiency. – In 2017, new Matlab code for fast approximate Fourier Graph Transforms have been included. based on the approach described in the papers:

-Luc Le Magoarou, Rémi Gribonval, "Are There Approximate Fast Fourier Transforms On Graphs?", ICASSP 2016 .

-Luc Le Magoarou, Rémi Gribonval, Nicolas Tremblay, "Approximate fast graph Fourier transforms via multi-layer sparse approximations", IEEE Transactions on Signal and Information Processing over Networks,2017.

URL: http://faust.inria.fr/

Publications: hal-01416110, hal-01627434, hal-01167948, hal-01254108, tel-01412558, hal-01156478, hal-01104696, hal-01158057, hal-03132013

Contact: Rémi Gribonval

Participants: Luc Le Magoarou, Nicolas Tremblay, Rémi Gribonval, Nicolas Bellot, Adrien Leman, Hakim Hadj-Djilani

8 New results

8.1 Graph Signal Processing and Machine Learning

Participants Paulo Gonçalves, Rémi Gribonval, Marion Foare, Elisa Riccietti, Gaetan Frusque, Amélie Barbe, Márton Karsai, Titouan Vayer.

8.1.1 Diffused Wasserstein Distance for Optimal transport between attributed graphs

Participants Paulo Gonçalves, Rémi Gribonval, Amélie Barbe, Titouan Vayer.

We proposed the Diffusion Wasserstein (DW) distance, as a generalization of the standard Wasserstein distance to undirected and connected graphs where nodes are described by feature vectors. DW is based on the Laplacian exponential kernel and benefits from the heat diffusion to catch both structural and feature information from the graphs. We further derived lower/upper bounds on DW and showed that it can be directly plugged into the Fused Gromov Wasserstein (FGW) distance that has been recently proposed, leading - for free - to a DifFused Gromov Wasserstein distance (DFGW) that allows a significant performance boost when solving graph domain adaptation tasks [31, 30].

8.1.2 Sparse tensor dimensionality reduction with application to the clustering of functional connectivity in the brain

Participants Paulo Gonçalves, Gaetan Frusque.

Within the framework of G. Frusque PhD work [46], we addressed the problem of clustering FC into relevant ensembles of simultaneously activated components, yielding a multiplex network that reveals characteristic patterns of the epileptic seizures of a given patient. While k-means is certainly the most popular method for data clustering, it is known to perform poorly on large dimensional data sets, and to be highly sensitive to noise. To overcome the so- called curse of dimensionality, we proposed a new tensor decomposition to reduce the size of the data set formed by FC time-series recorded for several seizures, prior to apply k-means. We proposed an adapted procedure to infer a multiplex network from several FC time series, and we emphasised one particular variant that imposes sparsity constraint [19, 33, 34]. Then, we conducted a real case study, applying the proposed sparse tensor decomposition to iEEG data to infer a multiplex network corresponding to the different stages of an epileptic seizure [20].

In another collaboration, we conducted a theoretical analysis of a variant of the Wasserstein distance for optimal transport, where minibatches are used to reduce complexity [44].

8.1.3 Neural networks : approximation theory and compression algorithms

Participants Rémi Gribonval, Pierre Stock.

From an approximation theoretic perspective, we studied the expressivity of deep neural networks and highlighted the role of depth to enable efficient approximation of functions with very limited smoothness [23].

From a more computational perspective, within the framework of the Ph.D. of Pierre Stock, we proposed a technique to drastically compress neural networks using product quantization [45], and an approach to learn networks that can be more efficiently quantized [50]

8.1.4 Compressive learning : guarantees on privacy preservation and statistical significance

Participants Rémi Gribonval.

The compressive learning framework proposes to deal with the large scale of datasets by compressing them into a single vector of generalized random moments, called a *sketch*, from which the learning task is then performed. We provided a theoretical analysis establishing statistical guarantees on the generalization error of this procedure, first in a general abstract setting illustrated on PCA [22], then for the specific case of compressive k-means and compressive Gaussian Mixture Modeling [52].

In the context of the Ph.D. thesis of Antoine Chatalic (in the PANAMA team in Rennes) we showed [16] that a simple perturbation of this mechanism with additive noise is sufficient to satisfy differential privacy, a well established formalism for defining and quantifying the privacy of a random mechanism. We combined this with a feature subsampling mechanism, which reduces the computational cost without damaging privacy. The framework was applied to the tasks of Gaussian modeling, k-means clustering and principal component analysis (PCA), for which sharp privacy bounds were derived. Empirically, the quality (for subsequent learning) of the compressed representation produced by this mechanism is strongly related with the induced noise level, for which we gave analytical expressions.

A tutorial paper on the principle and the main guarantees of compressive learning was prepared [53].

8.1.5 Sparse matrix factorizations: algorithms and identifiability guarantees

Participants Rémi Gribonval, Elisa Ricietti, Marion Foare, Léon Zheng, Quoc-Tung Le.

Matrix factorization with sparsity constraints plays an important role in many machine learning and signal processing problems such as dictionary learning, data visualization, dimension reduction. From a theoretical perspective, we investigated the uniqueness properties of sparse matrix factorizations. From an algorithmic perspective, we analyzed and fixed a weakness of proximal algorithms in sparse matrix factorization. We also described a new tractable proximal operator called Generalized Hungarian Method, associated to so-called k-regular matrices, which are useful for the factorization of a class of matrices associated to fast linear transforms. We further illustrated the effectiveness of our proposals by numerical experiments on the Hadamard Transform and magnetoencephalography matrix factorization [37, 56]. The new proximal operator was implemented in the FAμST software library.

8.1.6 Sparsity-based audio declipping

Participants Rémi Gribonval.

We provided a selected overview of sparsity-based audio declipping methods, as well as some new algorithms and a large-scale evaluation. Recent advances in audio declipping have substantially improved the state of the art. Yet, practitioners need guidelines to choose a method, and while existing benchmarks have been instrumental in advancing the field, larger-scale experiments are needed to guide such choices. First, we showed that the clipping levels in existing small-scale benchmarks are moderate and call for benchmarks with more perceptually significant clipping levels. We then proposed a general algorithmic framework for declipping that covers existing and new combinations of variants of state-of-the-art techniques exploiting time-frequency sparsity: synthesis vs. analysis sparsity, with plain or structured sparsity. Finally, we systematically compared these combinations and a selection of state-of-the-art methods. Using a large-scale numerical benchmark and a smaller scale formal listening test, we provided guidelines for various clipping levels, both for speech and various musical genres. The code was made publicly available for the purpose of reproducible research and benchmarking [21].

8.2 Computational Human Dynamics and Temporal Networks

Participants Márton Karsai, Jacobo Levy Abitbol, Samuel Unicomb, Sicheng Dai.

8.2.1 Interpretable socioeconomic status inference from aerial imagery through urban patterns

Participants Márton Karsai, Jacobo Levy Abitbol.

Urbanization is a great challenge for modern societies, promising better access to economic opportunities, but widening socioeconomic inequalities. Accurately tracking this process as it unfolds has been challenging for traditional data collection methods, but remote sensing information offers an alternative way to gather a more complete view of these societal changes. By feeding neural networks with satellite images, the socioeconomic information associated with that area can be recovered. However, these models lack the ability to explain how visual features contained in a sample trigger a given prediction. In our work published in [11], we closed this gap by predicting socioeconomic status across France from aerial images and interpreting class activation mappings in terms of urban topology. We showed that trained models disregard the spatial correlations existing between urban class and socioeconomic status to derive their predictions. These results pave the way to build more interpretable models, which may help to better track and understand urbanization and its consequences.

8.2.2 Dynamics of cascades on burstiness-controlled temporal networks

Participants Márton Karsai, Samuel Unicomb.

In the work published in [28], we developed a master equation formalism to study cascades on temporal networks with burstiness modelled by renewal processes. Supported by numerical and data-driven simulations, we described the interplay between heterogeneous temporal interactions and models of threshold-driven and epidemic spreading. We found that increasing interevent time variance can both accelerate and decelerate spreading for threshold models, but can only decelerate epidemic spreading. When accounting for the skewness of different interevent time distributions, spreading times collapse onto a universal curve. Our framework uncovers a deep yet subtle connection between generic diffusion mechanisms and underlying temporal network structures that impacts a broad class of networked phenomena, from spin interactions to epidemic contagion and language dynamics

8.2.3 Temporal social network reconstruction using wireless proximity sensors: model selection and consequences

Participants Márton Karsai, Sicheng Dai.

In our study published in [17], we analysed a proximity dataset collected during a longitudinal social experiment aiming to understand the co-evolution of children's language development and social network. Physical proximity and verbal communication of hundreds of pre-school children and their teachers were recorded over three years using autonomous wearable low power wireless devices. The dataset is accompanied with three annotated ground truth datasets, which record the time, distance, relative orientation, and interaction state of interacting children for validation purposes. We used this dataset to explore several pipelines of dynamical event reconstruction including earlier applied naïve approaches, methods based on Hidden Markov Model, or on Long Short-Term Memory models, some of them combined with supervised pre-classification of interaction packets. We found that while naïve models propose the worst reconstruction, Long Short-Term Memory models provide the most precise way to reconstruct real interactions up to 90% accuracy. Finally, we simulated information spreading on the reconstructed networks obtained by the different methods. Results indicate that small improvement of network reconstruction accuracy may lead to significantly different spreading dynamics, while sometimes large differences in accuracy have no obvious effects on the dynamics. This not only demonstrates the importance of precise network reconstruction but also the careful choice of the reconstruction method in relation with the data collected. Missing this initial step in any study may seriously mislead conclusions made about the emerging properties of the observed network or any dynamical process simulated on it.

8.2.4 Socio-geography of mobile telephony

Participants Eric Guichard, Thomas Begin, Anthony Busson.

Within the "Better-Net" IPL leaded by Isabelle Chrisment (Loria), we conducted an original research on the socio-geography of mobile telephony. By combining the division of inhabited France into two million 200 m2 squares proposed by INSEE and public data relating to mobile telephony media, antennas and transmitters, an online atlas was created. It is available at the URL `http://betternet-rumbi.lhs.loria.fr/website/antennes.html`. It proposes an interactive map of France, that can be zoomed in up to the scale of the dwelling, with the precise location of the transmitters, completed (when it exists) with information relating to the place and the nature of their medium, their operator and their generation. This map also integrates the 900m2 squares with more than 10 inhabitants, enriched with the following socio-demographic details:

- the percentages of young people aged 15 to 25,
- the percentages of poor households
- and the total population of these small squares.

Readers can choose a department, a postcode, and one of the three variables mentioned above. They can also hide sparsely populated squares. And any visualization is memorizable via its URL.

Such mapping attempts are rare. Those that do exist in France (Arcep, etc.) are not correlated with sociological data. This work was conducted in collaboration with Antoine Chemardin, an Inria engineer and will give rise to an article in the review Mappemonde (expected publication: 2021).

8.3 Communication Networks

Participants Thomas Begin, Anthony Busson, Isabelle Guérin Lassous, Marion Foare, Philippe Nain, Lafdal Abdelwedoud, Marija Stojanova, Rémy Grünblatt, Juan Pablo Astudillo, Alexandre Bonnefond.

8.3.1 Quantum communications

The work on performance analysis of a multipartite quantum switch has been continued (cf. description in Section 7.3.1 in Dante 2019 activity report). In [26] the stability of a multipartite switch with infinite memory and identical links is derived via Lyapounov techniques for Markov chains. The capacity and the number of stored Qbits are found in explicit form. In [29] a bipartite switch is analyzed via a discrete-time Markov chain (DTMC). The aim is to compare the results with that obtained in [26] where a continuous-time Markov chain (CTMC) is used, the latter model being considerably easier to manipulate than the DTMC model. We conclude that the CTMC model is overall a suitable model. In [39] we study a quantum switch serving a set of users in a star topology. The function of the switch is to create bipartite or tripartite entangled state among users at the highest possible rates at a fixed ratio. We model a set of randomized policies for sharing the switch bipartite and tripartite state generation and find that the best policy outperforms a TDM (time-division multiplexing) policy. However, the performance improvement decreases as the number of users grows. The model can be augmented to capture Qbit decoherence and we show that the latter has little effect on the switch capacity.

8.3.2 Network caching

Caching systems have long been crucial for improving the performance of a wide variety of network and web based online applications. In such systems, end-to-end application performance heavily depends on the fraction of objects transfered from the cache, also known as the cache hit proba-bility. Many cache eviction policies have been proposed and implemented to improve the hit probability. In [38], we propose a new method to compute an upper bound on hit probability for all non-anticipative caching policies, i.e. for policies that have no knowledge of future requests. At object request arrival, we use hazard rate HR function based ordering to classify the request as a hit or not. Under some statistical assumptions, we prove that our proposed HR based ordering model computes the maximum achievable hit probability and serves as an upper bound forall non-anticipative caching policies. We also provide simulation results to validate its correctness and to compare it to Belady's upper bound. We find it to almost always be tighter than Belady's bound.

8.3.3 Resource Allocation

The work on 1-D ressource allocation has been continued (see description in Section 7.3.2 of 2019 Dante activity report). A first set of extensions in [27] consists of a preliminary cost model where the communication cost is a function of the request distance (this model is generalized in [55]), an extension in which each user requests two resources, and an approximation algorithm for the optimal allocation problem in a 2-D setting where users and servers are located on a 2-D Euclidean plane. In [55] we compute the expected communication cost associated with the move-to-right policy in a 1-D service network. Users are distributed according to a Poisson process. This 1-D network setting applies to various service networks, in particular in the context of vehicular wireless ad-hoc networks on a one-lane roadway, where users are in vehicles and resources are attached to fixed infrastructure such as lamp posts. We use results in [27] to map the request distance of an assigned user in a 1-D service network to the sojourn time of a customer in an exceptional service accessible batch queueing system. We compute the Laplace-Stieltjes transform of the sojourn time distribution for this queueing system and in the process also generate new results for batch service queues.

8.3.4 VoD broadcasting over vehicular networks

Participants Thomas Begin, Anthony Busson, Isabelle Guérin Lassous.

In this work [14], we introduce a relatively simple and versatile analytical model to the performance computation of an IEEE 802.1 1-basedVideo-on-Demand (VoD) service for connected vehicles traveling along a highway or an expressway. We use a probabilistic approach to account for the intrinsic dynamics (mobility) of vehicles, the density of subscriber vehicles, the distance between Road Side Units (RSUs), as well as the video codec bit rate. Our solution delivers estimates for the attained throughput of each subscriber vehicle as well as for their interruption times in the playback of their video. We studied several scenarios to assess the accuracy of our approximate solution comparing its results with those of a discrete-event simulator with realistic vehicular traffic trajectories, video traffic, and networking protocols. Overall, our solution is found to be accurate delivering estimates in good agreement with the simulation results. Through several applications, we illustrate how our analytical solution can help in the design of a VoD service for vehicles for capacity planning purposes, or at improving its performance with the use of a blocking policy.

8.3.5 Towards a Fast and Efficient Strategy to Assign Channels in WLANs with Channel Bonding

Participants Thomas Begin, Anthony Busson, Marija Stojanova.

With the aim of increasing wireless data rates, IEEE 802.11n introduced the possibility for WLAN nodes to bond two channels into a single channel. However, channel bonding also limits spacial reutilization and complexifies channel assignment. In this work [42], we present a fast and efficient solution for channel width selection and channel assignment in 802.11 WLANs using channel bonding. The proposed algorithm uses a novel, graph-centric metric to propose a single channel width for all the APs of the WLAN aiming at avoiding starvation in any of the network's APs. Decoupling the choice of channel width and channel assignment results in a scalable approach that bypasses the usual complexity issues of classic channel assignment schemes. We test the solution's precision in choosing a suited channel width and assignment by comparing its results with those delivered by the ns-3 network simulator. We obtain that, in the large majority of the cases, the choice made by our solution matches the simulation results.

8.3.6 Distributed Congestion Control mechanism for NANs

Participants Thomas Begin, Anthony Busson, Juan Pablo Astudillo.

The need for significant improvements in the management and efficient use of electrical energy has led to the evolution from the traditional electrical infrastructures towards modern Smart Grid networks. Taking into account the critical importance of this type of networks, multiple research groups focus their work on issues related to the generation, transport and consumption of electrical energy. One of the key research points is the data communication network associated with the electricity transport infrastructure, and specifically the network that interconnects the devices in consumers' homes, the so-called Neighborhood Area Networks (NANs). In this paper, a new distributed congestion control mechanism is proposed, implemented and evaluated for NANs. Besides, different priorities have been considered for the traffic flows transmitted by different applications. The main goal is to provide with the needed Quality of Service (QoS) to all traffic flows, especially in high traffic load situations. The proposal is evaluated in the context of a wireless ad hoc network made up by a set of smart meter devices, using the Ad hoc On-Demand Distance Vector (AODV) routing protocol and the IEEE 802.11ac physical layer standard. The application of the proposed congestion control mechanism, together with the necessary modifications made to the AODV protocol, lead to performance improvements in terms of packet delivery ratio, network throughput and transit time, fairness between different traffic sources and QoS provision [13].

8.3.7 Leveraging Antenna Orientation to Optimize Network Performance of Fleets of UAVs

Participants Rémy Grünblatt, Isabelle Guérin-Lassous.

In this work [35], we investigate the problem of optimizing the network performance of a fleet of unmanned aerial vehicles (UAVs) in static positions. More precisely, we allow each UAV to change its orientation in order to improve the quality of communication with its neighbours. This form of controlled mobility takes advantage of the effective radiation pattern of each UAV. We build a decentralized scheme based on the hill climbing optimization approach without *a priori* knowledge of the antennas radiation patterns. Then, we propose a simulation framework, based on ns–3, allowing to evaluate the gain in network performance. We provide results in several deployment scenarios involving different rate adaptation algorithms and network sizes.

8.3.8 A Passive Method to Infer the Weighted Conflict Graph of a IEEE 802.11 Network

Participants Lafdal Abdelwedoud, Anthony Busson, Isabelle Guérin-Lassous, Marion Foare.

We consider an IEEE 802.11 network composed of several Access Points (APs) managed by one controller. The controller relies on pieces of information describing the network state as channels, load, associated stations, conflicts, etc. to configure and optimize the network. In this work [10], we propose a method that infers the way the different channels are shared between APs according to the Clear Channel Assessment (CCA) mechanism. It is represented through a conflict graph where an edge exists if two APs are able to detect each other. As this detection is sometimes partial, the links are weighted. Our method relies on measures already available on most of Wi-Fi products and does not generate any traffic except the transmission of these measures to the controller. A Markov network and an optimization problem are then proposed to infer the weights of the conflict graph. Our solution is shown accurate on a large set of simulations performed with the network simulator ns-3.

9 Bilateral contracts and grants with industry

9.1 Bilateral contracts with industry

- Startup STACKEO (2020-2023)
  Context: In the IoT, it is often a complex matter to choose the appropriate network protocol with regards to the specif constraints, needs and usage of an application.
  Goals: Developing efficient simulation tools for the network protocols of the IoT.
  Overall budget: 120 k euro
  Funding: An ongoing Ph.D. degree (S. Si-Mohamed, 2020-).
  Scientific leaders: T. Begin and I. Guérin Lassous.

9.2 Bilateral grants with industry

- CIFRE contract with Facebook Artificial Intelligence Research, Paris on Deep neural networks for large scale learning

  Participants Rémi Gribonval, Pierre Stock.

  Duration: 3 years (2018-2021)

  Partners: Facebook Artificial Intelligence Research, Paris; Inria-Grenoble

Funding: Facebook Artificial Intelligence Research, Paris; ANRT

The overall objective of this thesis is to design, analyze and test large scale machine learning algorithms with applications to computer vision and natural language processing. A major challenge is to design compression techniques able to replace complex and deep neural networks with much more compact ones while preserving the capacity of the initial network to achieve the targeted task. An avenue primarily envisioned to achieve this goal is to rely on structured linear layers.

10 Partnerships and cooperations

10.1 International initiatives

Informal international partners

- Univ. of California, Santa Cruz (USA), Collaboration with Pr. Brandwajn

  Participants Thomas Begin.

  Goals: Designing efficient solutions to solve multi-server queueing systems.

- Polytechnic University of Catalonia (Spain), Collaboration with the network Research Team from UPC (Ass. Pr. M. Aguilar and Ass. Pr. Luis J. de la Cruz Llopis)

  Participants Thomas Begin, Anthony Busson, Isabelle Guérin Lassous.

  Goals: Designing tools to improve the sharing of resources in vehicular networks.

- Univ. of Ottawa (Canada), Collaboration with the Diva lab headed by Pr. Boukerche

  Participants Thomas Begin, Anthony Busson, Isabelle Guérin Lassous.

  Goals: Evaluating the feasbility of distributing video on demand (VoD) on vehicular networks.

- Univ. Louvain (Belgium), Collaboration with the team of Laurent Jacques

  Participants Rémi Gribonval.

  Topic: compressive learning and privacy guarantees

- Ohio State Univ. (USA), Collaboration with the group of Phil Schniter

  Participants Rémi Gribonval.

  Topic: algorihms for compressive learning

10.2 International research visitors

10.2.1 Visits of international scientists

- Visit from Pr. Brandwajn (Univ. of California, Santa Cruz) in September 2020, funded by the ENS Lyon.

10.3 National initiatives

10.3.1 ANR IA Chaire : AllegroAssai

Participants Rémi Gribonval *(correspondant)*, Paulo Gonçalves, Elisa Ricietti, Marion Foare, Léon Zheng, Quoc-Tung Le, Titouan Vayer, Ayoub Belhadji, Clement Lalanne.

Duration of the project: **2020 - 2024**.

AllegroAssai focuses on the design of machine learning techniques endowed both with statistical guarantees (to ensure their performance, fairness, privacy, etc.) and provable resource-efficiency (e.g. in terms of bytes and flops, which impact energy consumption and hardware costs), robustness in adversarial conditions for secure performance, and ability to leverage domain-specific models and expert knowledge. The vision of AllegroAssai is that the versatile notion of sparsity, together with sketching techniques using random features, are key in harnessing these fundamental tradeoffs. The first pillar of the project is to investigate sparsely connected deep networks, to understand the tradeoffs between the approximation capacity of a network architecture (ResNet, U-net, etc.) and its "trainability" with provably-good algorithms. A major endeavor is to design efficient regularizers promoting sparsely connected networks with provable robustness in adversarial settings. The second pillar revolves around the design and analysis of provably-good end-to-end sketching pipelines for versatile and resource-efficient large-scale learning, with controlled complexity driven by the structure of the data and that of the task rather than the dataset size.

10.3.2 ANR DataRedux

Participants Paulo Gonçalves *(correspondant)*, Rémi Gribonval, Marion Foare, Israel Campero Jurado.

Duration of the project: **February 2020 - January 2024**.

DataRedux puts forward an innovative framework to reduce networked data complexity while preserving its richness, by working at intermediate scales ("mesoscales"). Our objective is to reach a fundamental breakthrough in the theoretical understanding and representation of rich and complex networked datasets for use in predictive data-driven models. Our main novelty is to define network reduction techniques in relation with the dynamical processes occurring on the networks. To this aim, we will develop methods to go from data to information and knowledge at different scales in a human-accessible way by extracting structures from high-resolution, diverse and heterogeneous data. Our methodology will involve the identification of the most relevant subparts of time-resolved datasets while remapping the remaining parts of the system, the simultaneous structural-temporal representations of time-varying networks, the development of parsimonious data representations extracting meaningful structures at mesoscales ("mesostructures"), and the building of models of interactions that include mesostructures of various types. Our aim is to identify data aggregation methods at intermediate scales and new types of data representations in relation with dynamical processes, that carry the richness of information of the original data, while keeping their most relevant patterns for their manageable integration in data-driven numerical models for decision making and actionable insights.

10.3.3 ANR Darling

Participants Paulo Gonçalves *(correspondant)*, Rémi Gribonval, Marion Foare.

Duration of the project: **February 2020 - January 2024**.

This project meets the compelling demand of developing a unified framework for distributed knowledge extraction and learning from graph data streaming using in-network adaptive processing, and adjoining powerful recent mathematical tools to analyze and improve performances. The project draws on three major parallel directions of research: network diffusion, signal processing on graphs, and random matrix theory which DARLING aims at unifying into a holistic dynamic network processing framework. Signal processing on graphs has recently provided a comprehensive set of basic instruments allowing for signal on graph filtering or sampling, but it is limited to static signal models. Network diffusion on the opposite inherently assumes models of time varying graphs and signals, and has pursued the path of proposing and understanding the performance of distributed dynamic inference on graphs. Both areas are however limited by their assuming either deterministic graph or signal models, thereby entailing often inflexible and difficult-to-grasp theoretical results. Random matrix theory for random graph inference has taken a parallel road in explicitly studying the performance, thereby drawing limitations and providing directions of improvement, of graph-based algorithms (e.g., spectral clustering methods). The ambition of DARLING lies in the development of network diffusion-type algorithms anchored in the graph signal processing lore, rather than heuristics, which shall systematically be analyzed and improved through random matrix analysis on elementary graph models. We believe that this original communion of as yet remote areas has the potential to path the pave to the emergence of the critically needed future field of dynamical network signal processing.

10.3.4 ANR DylNet

Participants Márton Karsai *(correspondant)*.

Duration of the project: **September 2016 - September 2020**.

The DylNet project aims to observe and to characterise the relationships between childhood sociability and oral-language learning at kindergarten. With a view to this, it takes an multidisciplinary approach combining work on language acquisition, sociolinguistics, and network science. It will be implemented by following all the children (≈ 220) and teaching staff in one kindergarten over a 3-year period. The use of wireless proximity sensors will enable collection of social contacts throughout the study. The data on sociability will be linked to the results of language tests and recordings of verbal interactions used to follow the children's progress on both a psycholinguistic level (lexicon, syntax, pragmatics) and a sociolinguistic level (features showing belonging to a social group). The aim is to better understand the mechanisms of adaptation and integration at work when young children first come into contact with the school context.

10.3.5 CNRS GreenHMR

Participants Isabelle Guérin Lassous *(correspondant)*, Thomas Begin, Anthony Busson.

Duration of the project: **March 2020 - Decembre 2020**.

This project is an emergent collaborative project. The goal of the project is to propose end-to-end solutions to reduce energy consumption in heterogeneous wireless networks while offering a good level of performance to users. This project is based on different scientific steps: energy real measurements, modeling and solution designing.

10.3.6 Inria IPL BetterNet

Participants Éric Guichard, Thomas Begin, Anthony Busson.

An Observatory to Measure and Improve Internet Service Access from User Experience.

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks with a particular focus on geography and cartography.

10.4 Regional initiatives

10.4.1 Idex Lyon - ACADEMICS

Participants Paulo Gonçalves *(correspondant)*, Rémi Gribonval, Marion Foare, Amélie Barbe, Titouan Vayer, Gaetan Frusque.

Duration of the project: **September 2018 - December 2021**.

The project brings together a **consortium of 4 teams from Laboratories of Université de Lyon** (UdL) and will form a working group with complementary expertise in machine learning (deep learning, statistical learning, data mining), in data science (complex data analysis, adaptive and/or data-driven methods, network science) and in the studies of climate modeling and of computational social science. It comprises:

- Laboratoire Informatique du Parallélisme (LIP): P. Gonçalves (PI), M. Karsai (PI for Comp. Social Sc.)
- Laboratoire de Physique (LP): P. Borgnat (Coordinator), F. Bouchet (PI for Climate)
- Laboratoire Hubert Curien (LabHC), Université Jean Monnet: M. Sebban (PI)
- Laboratoire d'InfoRmatique en Images et Systèmes d'information (LIRIS): C. Robardet (PI)

The **impacts** of the project will stem from the efficiency of our proposed methods to learn from complex and dynamic data, and if so, **future applications** will naturally follow in many areas: social science and study of social interactions, climate and environmental science but also in technological networks, neuroscience with the study of brain networks and more generally in any domain where effective dynamical models of complex situations are to be learned from data. All these situations go beyond the current classical applicative frameworks of ML (time measurements, 2D images, or texts) and compel us to work out a major scientific breakthrough.

11 Dissemination

11.1 Promoting scientific activities

11.1.1 Scientific events: organisation

- Thomas Begin was co-organiser of the "Journées Cloud 2020" (with the financial help of the action "Virtualisation et Cloud" of the GdR RSD (Réseaux et Systèmes Distribués) of CNRS). More than 90 participants
  https://journeescloud20.sciencesconf.org/

11.1.2 Scientific events: selection

Member of the conference program committees

- Thomas Begin was a member of the PC of IEEE LCN 2020
- Isabelle Guérin Lassous was a membre of the PC of ACM MSWiM 2020, IEEE MASS 2020, IEEE ICC 2020, IEEE Globecom 2020, IEEE CCNC 2020
- Rémi Gribonval was a member of the PC of the Conference on "Mathematics for Audio and Music Signal Processing", CIRM 2021 (cancelled due to Covid-19), of the MiLYON Spring School on Machine Learning, Saint-Etienne Spring 2021 (postponed due to Covid-19)
- C. Crespelle was member of the PC of MARAMI 2020, Modeles et Analyse des Reseaux, Montpellier, Octobre 2020

Reviewer

- Paulo Gonçalves was a reviewer for ICASSP 2020
- Rémi Gribonval was a reviewer for NeurIPS 2020, EUSIPCO 2020, ICASSP 2021

11.1.3 Journal

Member of the editorial boards

- Isabelle Guérin Lassous is a member of the editorial board of Computer Communications (Elsevier), Ad Hoc Networks (Elsevier), Discrete Mathematics & Theoretical Computer Science, ITU Journal on Future and Evolving Technologies
- Rémi Gribonval is a member of the editorial board of Constructive Approximation (Springer) and a Senior Area Editor for the IEEE Transactions on Signal Processing

11.1.4 Invited talks

- Rémi Gribonval was an invited speaker at the IPAM Workshop "PDE and Inverse Problem Methods in Machine Learning", Los Angeles, April 2020 (participation canceled due to Covid-19), a plenary speaker at the SIGMA'2020 workshop (Signal, Image, Géométrie, Modélisation, Approximation), CIRM, Marseille, April 2020 (canceled due to Covid-19), at the workshop "Optimization for Machine Learning", CIRM, Luminy, March 2020 (participation canceled due to Covid-19)

11.1.5 Scientific expertise

- Isabelle Guérin Lassous is an expert for the MESRI / DAEI (Ministère de l'Enseignement Supérieur, de la Recherche et de l'Innovation / Délégation aux affaires européennes et internationales)
- Rémi Gribonval is a member of the Scientific Advisory Board (vice-president) of the Acoustics Research Institute of the Austrian Academy of Sciences, and a member of the Commission Prospective of Institut de Mathématiques de Marseille
- Rémi Gribonval is a member of the Cellule ERC of INS2I

11.1.6 Research administration

- P. Gonçalves is scientific correspondent for the international partnerships of Inria GRA
- P. Gonçalves is member of the executive board of the Labex MILyon

11.2 Teaching - Supervision - Juries

11.2.1 Teaching

- Licence :
  - Thomas Begin: Computer Networks, 18.5h, L3, Université Lyon 1
  - Isabelle Guérin Lassous: Computer Networks, 15h, L3, Université Lyon 1
  - Márton Karsai: Introduction to Complex Networks, 6h, L3, ENS Lyon
  - C. Crespelle: Introduction au reseau et au Web (L2, UCBL); Algorithmique et programmation avancee (L2, UCBL); Algorithmique, programmation et complexite (L3, UCBL) ; Algorithmique Avancé (L3, ENS de Lyon)
- Master :
  - Thomas Begin: Distributed Algorithms, 18h, M1, Université Lyon 1
  - Thomas Begin: Computer Networks, 44h, M1, Université Lyon 1
  - Thomas Begin: System Administration & Security, 10.5h, M2, Université Lyon 1
  - Thomas Begin: Advanced Networks, 58h, M2, Université Lyon 1
  - Thomas Begin: Cloud Computing, 9h, M2, Université Lyon 1
  - Isabelle Guérin-Lassous: Distributed Algorithms, 30h, M1, Université Lyon 1
  - Isabelle Guérin-Lassous: Networking, 14h, M1, Université Lyon 1
  - Isabelle Guérin-Lassous: Wireless networks, 9h, M2, Université Lyon 1
  - Isabelle Guérin-Lassous: Quality of Service, 5h, M2, Université Lyon 1
  - Isabelle Guérin-Lassous: ToIP and streaming, 12h, M1, Université Lyon 1
  - Éric Guichard: Économie du web et du document, 36h, M2, Enssib & Univ. Lyon 1
  - Éric Guichard: Programmation éditoriale, 18h, M2, Enssib & Univ. Lyon 1
  - Márton Karsai: Complex Networks, 36h, M2, ENS Lyon
  - Márton Karsai: Data Bases Data Mining, 20h, M1, ENS Lyon
  - Rémi Gribonval: Inverse problems and high dimension; Mathematical foundations of deep neural networks; Concentration of measure in probability and high-dimensional statistical learning; M2, ENS Lyon
  - C. Crespelle: Optimisation et Recherche Opérationnelle (M1, UCBL)
- Engineer cycle (Bac+3 to Bac+5):
  - Paulo Gonçalves: Traitement du Signal (déterministe, aléatoire, numérique), Estimation statistique. 80 heures Eq. TD. CPE Lyon, France
  - Marion Foare: Traitement du Signal (déterministe, aléatoire), Traitement d'images, Compression, Projets. 115 heures Eq. TD. CPE Lyon, France
  - Elisa Riccietti: M2 course Optimization and Approximation (28h) and 19h of tutor responsibility at ENS Lyon
- Responsabilities
  - Thomas Begin : Head of the Master 2 speciality SRIV (Systèmes, Réseaux et Infrastructures Virtuelles) at UCBL - http://master-info.univ-lyon1.fr/SRIV
  - Isabelle Guérin Lassous has been appointed as the president of the CAPES NSI (Numérique et Science Informatique) committee since November 2019. This committee is in charge of the recruitment of the computer science teachers in high schools
  - Anthony Busson is head of the computer science department at IUT Lyon 1 Doua

11.2.2 Supervision

- PhD defense: Jacobo Levy-Abitbol *Détection computationnelle des inégalités socioéconomiques*, jan. 9 2020. M. Karsai (Dir.)
- PhD defense: Samuel Unicomb *Threshold driven contagion on complex networks*, jan. 14 2020. M. Karsai (Dir.)
- PhD defense: Gaetan Frusque *Inférence et décomposition modale de réseaux dynamiques en neurosciences*, December 7, 2020. P. Gonçalves (Dir.)
- PhD defense : Rémy Grünblatt, *Controlled mobility for UAV networks*, jan. 8, 2021. I. Guérin Lassous (Dir.) and O. Simonin
- PhD in progress: Mohamed Adbelwedoud Lafdal, *Inference of conflict graph in IEEE 802.11 networks*. A. Busson (Dir.) and I. Guérin Lassous. Started sept. 2017
- PhD in progress: Sicheng Dai, *Dynamic Multilayer Network Modelling*, M. Karsai (Dir.). Started oct. 1st, 2017
- PhD in progress: Amélie Barbe, *From local to global learning*, P. Gonçalves (Dir., with M. Sebban and P. Borgnat). Started oct. 1st, 2018
- PhD in progress: Nour el Houda Bouzouita, *Wi-Fi network Optimization through crowd sensing applications*. A. Busson (Dir., with Hervé Rivano). Nov. 2018 - Nov. 2021
- PhD in progress: Quoc Tung Le, *Towards robust adversarial learning with sparse deep networks* . R. Gribonval (Dir., co-supervised with E. Ricietti). Started sept. 2020
- PhD in progress: Clément Lalanne, *The tradeoffs of learning with privacy*. R. Gribonval (Dir., with A. Garivier). Started sept. 2020
- PhD in progress: Pierre Stock, *Deep neural networks for large-scale machine learning* . R. Gribonval (Dir., with H. Jegou from Facebook AI Research). Expected defence march 2021
- PhD in progress: Anthony Bardou, *Machine Learning for the spatial reuse of Wi-Fi networks*. T. Begin (Dir.). Started oct. 2020
- PhD in progress: Samir Si-Mohammed, *Optimization of IoT Networks*. T. Begin (Dir.) and I. Guérin-Lassous. Started Sept. 2020
- PhD in progress: Israel Campero Jurado, *Temporal network reduction for modelling social contagion processes*, P. Gonçalves (Dir.) and M. Karsai and R. Gribonval. Started nov. 1st, 2020
- PhD in progress: Alexandre Bonnefond, *Dynamic flocking based on link quality in swarm of UAVs*, I. Guérin Lassous and O. Simonin (Dir.). Started Oct. 2019

11.2.3 Juries

- Paulo Gonçalves was reviewer of the Ph.D thesis examination board of Barbara Pilastre, Univ. de Toulouse, nov. 2020
- Paulo Gonçalves was reviewer of the Ph.D thesis examination board of Léo Gautheron, Univ. de Saint-Etienne, dec. 2020
- Isabelle Guérin Lassous was a reviewer of the PhD thesis examination board of Imane Oussakel, Univ. de Toulouse, July 2020
- Isabelle Guérin Lassous was a reviewer of the PhD thesis examination board of Lina Aliouat, Univ. Bourgogne Franche-Comté, Nov. 2020

- Isabelle Guérin Lassous was the president of the PhD thesis examination board of Baptiste Jonglez, Univ. Grenoble Alpes, Oct. 2020
- Isabelle Guérin Lassous was a member of the PhD thesis examination board of Robin Pelle, Univ. Paris-Saclay, Dec. 2020
- Rémi Gribonval was the president of the HDR jury of Vincent Gripon, ENS de Lyon, dec. 2020, and an external examiner for the HDR defense of Yannis Avrithis, Univ. Rennes 1, july 2020
- Rémi Gribonval was an reviewer for the Ph.D. thesis of Alia Abbara, ENS Paris, nov. 2020 and the Ph.D. thesis of Hermina Petric Maretic, EPFL, oct. 2020
- Rémi Gribonval was the president of the Ph.D. defense of Ayoub Belhadji, Ecole Centrale Lille, nov. 2020
- Rémi Gribonval was an external examiner for the Ph.D. thesis of Luc Giffon, Univ. Aix-Marseille, dec. 2020
- C. Crespelle was reviewer of the Ph.D thesis examination board of Nicolas Martin, Université Grenoble Alpes, Automatique, feb. 2020
- C. Crespelle was reviewer of the Ph.D thesis examination board of Léo Rannou, Sorbonne Université, Informatique, dec. 2020

11.3 Popularization

11.3.1 Articles and contents

- Isabelle Guérin Lassous is the author of the article "Enfin un CAPES en informatique !", published in the newsletter of the CNRS INS2I. https://ins2i.cnrs.fr/fr/cnrsinfo/enfin-un-capes-en-informatique
- The portrait of Isabelle Guérin Lassous belongs to the exposition of "La science taille XX elles". https://www.cnrs.fr/en/node/5282

12 Scientific production

12.1 Major publications

[1] E. Bautista, P. Abry and P. Gonçalves. 'L^γ -PageRank for Semi-Supervised Learning'. In: *Applied Network Science* 4.57 (2019), pp. 1–20. DOI: 10.1007/s41109-019-0172-x. URL: https://hal.inria.fr/hal-02063780.

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12.2 Publications of the year

International journals

[10] L. Abdelwedoud, A. Busson, I. Guérin-Lassous, M. Foare, M. L. Diakite and M. Farouk Nanne. 'Inference of a clear channel assessment based conflict graph'. In: *Internet Technology Letters* (7th Sept. 2020). DOI: 10.1002/itl2.227. URL: https://hal.inria.fr/hal-03124090.

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