IN PARTNERSHIP WITH:
Ecole normale supérieure de Lyon

Université Claude Bernard (Lyon 1)

Activity Report 2019

Project-Team DANTE

Dynamic Networks : Temporal and Structural Capture Approach

IN COLLABORATION WITH: Laboratoire de l'Informatique du Parallélisme (LIP)

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Networks and Telecommunications

Table of contents

Project-Team DANTE

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

Keywords:

Computer Science and Digital Science:

A1.2. - Networks
A1.2.4. - QoS, performance evaluation
A1.2.5. - Internet of things
A1.2.6. - Sensor networks
A1.2.9. - Social Networks
A3.4.1. - Supervised learning
A3.5. - Social networks
A3.5.1. - Analysis of large graphs
A5.9. - Signal processing
A5.9.4. - Signal processing over graphs
A8.1. - Discrete mathematics, combinatorics
A8.7. - Graph theory
A8.8. - Network science
A8.9. - Performance evaluation

Other Research Topics and Application Domains:

B2.3. - Epidemiology
B6. - IT and telecom
B6.3.4. - Social Networks
B6.4. - Internet of things
B9.5.1. - Computer science
B9.5.6. - Data science
B9.6.5. - Sociology
B9.6.8. - Linguistics
B9.6.10. - Digital humanities

1. Team, Visitors, External Collaborators

Research Scientists

Paulo Gonçalves [Team leader, Inria, Senior Researcher, HDR]
Rémi Gribonval [Inria, Senior Researcher, from Aug 2019, HDR]
Philippe Nain [Inria, Senior Researcher, HDR]

Faculty Members

Thomas Begin [Univ de Claude Bernard, Associate Professor, HDR]
Anthony Busson [Univ de Claude Bernard, Professor]
Christophe Crespelle [Univ de Claude Bernard, Associate Professor, HDR]
Marion Foare [Ecole supérieure de chimie physique électronique de Lyon, Associate Professor]
Isabelle Guérin Lassous [Univ de Claude Bernard, Professor, HDR]
Márton Karsai [Ecole Normale Supérieure Lyon, Associate Professor, until Aug 2019, HDR]

Post-Doctoral Fellows
Sébastien Lerique [Inria, until Oct 2019]
Mikhail Tsitsvero [Univ de Lyon, until Jun 2019]

PhD Students
Lafdal Abdelwedoud [Ambassade de France en Mauritanie]
Amélie Barbe [Univ de Lyon]
Esteban Bautista Ruiz [CONACyT fellowship until Dec 2019]
Nour El Houda Bouzouita [Ecole Normale Supérieure Lyon]
Sicheng Dai [Univ de Lyon]
Gaetan Frusque [Ecole Normale Supérieure Lyon]
Rémy Grünblatt [Inria]
Jacob Levy Abitbol [Inria, until Nov 2019]
Marija Stojanova [Ecole Normale Supérieure Lyon]
Samuel Unicomb [Inria]

Technical staff
Hakim Hadj Djilani [Inria, Engineer, from Sep 2019]
Sébastien Lerique [Inria, Engineer, from Nov 2019]

Interns and Apprentices
Simon Fernandez [Ecole Normale Supérieure Lyon, until Jun 2019]
Mohamed Hadjoudj [Ecole Normale Supérieure Lyon, from Jun 2019 until Jul 2019]
Valentin Meriau [Inria, from Oct 2019]
Alexandre Noiret [Ecole Normale Supérieure Lyon, until Jun 2019]
Eliot Tron [Ecole Normale Supérieure Lyon, from Jun 2019 until Jul 2019]
Maxime de Freitas [Télécom Physique Strasbourg, from Jun 2019 until Aug 2019]
Julien Alamelle [Université Claude Bernard Lyon 1, from Oct 2019 until Dec 2019]

Administrative Assistant
Sophie Gérard [Inria]

Visiting Scientists
Alexandre Brandwajn [University of California, Santa Cruz, from Feb to Mar 2019]
Juan Pablo Astudillo [Universitat Politècnica de Catalunya, PhD, from Apr 2019 until Jul 2019]
Dorsaf Ghozlani [Visiting PhD from Ecole Nationale d'Ingénieurs de Tunis, from Jun 2019 until Aug 2019]
Jaqueline Oliveira [Visiting PhD from Brazil with a CAPES fellowship, from July 2019 to December 2019]
Laetitia Gauvin [Research Leader ISI foundation, Torino, Italy]

External Collaborators
Eric Philippe Guichard [Ecole Normale Supérieure Lyon, Maitre de Conférence ENSSIB, HDR]
Márton Karsai [Professor ECU, Budapest, Hungary, since Sep 2019, HDR]

2. Overall Objectives

2.1. 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.

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.

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 [74].

[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.

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 [57]. 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 [69] and references therein. Other viewpoints can be found as well, including multi-resolution Markov models [77], Bayesian networks or distributed processing over sensor networks [68]. 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 [58].

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 will develop at Dante 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, Márton Karsai, Éric Guichard.

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 [71]. 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 [71], [62], [78], [67], to describe the observed structural and temporal heterogeneities [55], [62], [56], to detect and measure emerging community structures [59], [75], [76], to see how the functionality of networks determines their evolving structure [66], and to determine what kinds of correlations play a role in their dynamics [63], [65], [70].

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 [73]. 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 [64] and its co-evolution with ongoing processes like spreading phenomena, synchronisation, evolution of consensus, random walk etc. [64], [72]. 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.

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 detailed 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 [60] 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 [61]. 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, cf. point 9.2.8).

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. Highlights of the Year

5.1. Highlights of the Year

Dante is member of the following new projects accepted in 2019, for funding by ANR:

- **DataRedux** Big data reduction for predictive computational modelling. Consortium: Dante (ENS de Lyon), Centre Physique Théorique Marseille (CNRS), Pierre Louis Institute of Epidemiology and Public Health (INSERM).
- **Darling** Distributed adaptation and learning over graphs. Consortium: Observatoire Côte d'Azur (U. Nice), Dante & LP (ENS de Lyon), L2S (Centrale Supelec).
- **CCS 2021** Márton Karsai and IXXI obtained the right to organise Conference on Complex Systems in Lyon in 2021.

5.1.1. Awards

- Article [10] has been highlighted as the cover page article of the journal MDPI.

BEST PAPER AWARD:

[25]
R. FONTUGNE, E. BAUTISTA, C. PETRIE, Y. NOMURA, P. ABRY, P. GONÇALVES, K. FUKUDA, E. ABEN. *BGP Zombies: an Analysis of Beacons Stuck Routes*, in "PAM 2019 - 20th Passive and Active Measurements Conference", Puerto Varas, Chile, Springer, March 2019, pp. 197-209, Best paper award. [*DOI :* 10.1007/978-3-030-15986-3_13], https://hal.inria.fr/hal-01970596

6. New Software and Platforms

6.1. GraSP

Graph Signal Processing

KEYWORDS: Matlab - LaTeX - Graph - Graph visualization - Signal processing - GNU Octave

FUNCTIONAL DESCRIPTION: Matlab / GNU Octave toolbox to manipulate and visualize signals on graphs. LaTeX package to draw signals.

- Contact: Benjamin Girault

6.2. IoT-LAB aggregation-tools

KEYWORD: Internet of things

FUNCTIONAL DESCRIPTION: IoT-LAB aggregation-tools allow aggregating data results from many nodes at a time. It connects to several tcp connections and handle the received data.

- Participant: Gaetan Harter
- Contact: Eric Fleury
- URL: https://github.com/iot-lab/aggregation-tools

6.3. IoT-LAB cli-tools

KEYWORD: Internet of things

FUNCTIONAL DESCRIPTION: IoT-LAB cli-tools provide a basic set of operations for managing IoT-LAB experiments from the command-line.

- Participants: Frederic Saint-Marcel and Gaetan Harter
- Contact: Eric Fleury
- URL: https://github.com/iot-lab/cli-tools

6.4. IoT-LAB gateway

KEYWORD: Internet of things

FUNCTIONAL DESCRIPTION: IoT-LAB software embedded on a IoT-LAB gateway node new generation provides the local management of the experiment on that node. It is a software bridge between the IoT-LAB server, the user open node and the control node.

- Contact: Frederic Saint-Marcel
- URL: https://github.com/iot-lab/iot-lab-gateway

6.5. IoT-LAB robots

KEYWORDS: Internet of things - Robotics

FUNCTIONAL DESCRIPTION: IoT-LAB robots is an embedded robot controler on a Turtlebot2 providing the IoT-LAB node mobility functionnality

- Partner: Université de Strasbourg
- Contact: Julien Vandaele
- URL: https://github.com/iot-lab/

6.6. 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.

- Participants: Alexandre Brandwajn and Thomas Begin
- Contact: Thomas Begin
- URL: http://queueing-systems.ens-lyon.fr/

6.7. 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.

- Participants: Rodrigue Domga Komguem and Fabrice Valois
- Partner: CEA-LETI
- Contact: Guillaume Chelius
- URL: https://gforge.inria.fr/projects/wsnet-3/

7. New Results

7.1. Graph Signal Processing and Machine Learning

Participants: Paulo Gonçalves, Rémi Gribonval, Marion Foare, Thomas Begin, Esteban Bautista Ruiz, Gaetan Frusque, Amélie Barbe, Mikhail Tsitsvero, Marija Stojanova, Márton Karsai, Sébastien Lerique, Jacobo Levy Abitbol.

7.1.1. L^γ -PageRank for Semi-Supervised Learning

Participants: Paulo Gonçalves, Esteban Bautista Ruiz.

PageRank for Semi-Supervised Learning has shown to leverage data structures and limited tagged examples to yield meaningful classification. Despite successes, classification performance can still be improved, particularly in cases of fuzzy graphs or unbalanced labeled data. To address such limitations, a novel approach based on powers of the Laplacian matrix L^γ ($\gamma > 0$), referred to as L^γ-PageRank, is proposed. Its theoretical study shows that it operates on signed graphs, where nodes belonging to one same class are more likely to share positive edges while nodes from different classes are more likely to be connected with negative edges. It is shown that by selecting an optimal γ, classification performance can be significantly enhanced. A procedure for the automated estimation of the optimal γ, from a unique observation of data, is devised and assessed. Experiments on several datasets demonstrate the effectiveness of both L^γ-PageRank classification and the optimal γ estimation. [11]

7.1.2. Designing Convex Combination of Graph Filters

Participant: Paulo Gonçalves.

In this work, we studied the problem of parametric modeling of network-structured signals with graph filters. Unlike the popular polynomial graph filters, which are based on a single graph shift operator, we considered convex combinations of graph shift operators particularly adapted to directed graphs. As the resulting modeling problem is not convex, we reformulated it as a convex optimization problem which can be solved efficiently. Experiments on real-world data structured by undirected and directed graphs were conducted. The results showed the effectiveness of this method compared to other methods reported in the literature. [18]

7.1.3. Optimal transport under regularity constraints for domain adaptation between graphs with attributes

Participants: Paulo Gonçalves, Amélie Barbe.

In this work, we addresses the problem of domain adaptation between two graphs by optimal transport. We aimed at benefiting from the knowledge of a labeled source graph to improve the classification of nodes in an unlabeled target graph. We focused on the setting where a set of features is associated to each node of the graphs. We proposed an original method that optimizes a transportation plan from the source to the target that *(i)* preserves the structures transported between the graphs and *(ii)* prevents the mapping from transporting two source nodes with different labels to the same destination. [30]

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

Participants: Paulo Gonçalves, Gaetan Frusque.

Functional connectivity (FC) is a graph-like data structure commonly used by neuroscientists to study the dynamic behaviour of the brain activity. However, these analyses rapidly become complex and time-consuming, as the number of connectivity components to be studied is quadratic with the number of electrodes. In our work, we addressed the problem of clustering FC into relevant ensembles of simultaneously activated components that reveal 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 badly on large dimensional data sets, and to be highly sensitive to noise. To overcome the co-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, before applying k-means. Our contribution is twofold: First, we derived a method that we compared to the state of the art, emphasizing one variant that imposes sparsity constraints. Second, we conducted a real case study, applying the proposed sparse tensor decomposition to epileptic data in order to infer the functional connectivity graph dynamics corresponding to the different stages of an epileptic seizure. [31], [47]

7.1.5. Graph signal processing to model WLANs performances

Participants: Paulo Gonçalves, Thomas Begin, Marija Stojanova.

As WLANs have become part of our everyday life, there is an increasing need for more transmission capacity and wireless coverage. In response to this growing need, network administrators tend to intensify the deployment of Access Points (APs). However, if not correctly done, this AP densification may lead to badly planned and uncoordinated networks with sub-optimal use of the available resources. In this work, we propose a data-driven approach using graph signal processing and a set of input/output signals to capture the behavior of a WLAN and derive a predictive performance model. Given the simplicity and the novelty of the proposed model, we believe that its relative error of around 10-20% in modeling and 25% in prediction may represent a promising start for new approaches in the modeling of WLANs. [33]

7.1.6. Joint embedding of structure and features via graph convolutional networks

Participants: Márton Karsai, Sébastien Lerique.

We propose *AN2VEC*, a node embedding method which ultimately aims at disentangling the information shared by the structure of a network and the features of its nodes. Building on the recent developments of Graph Convolutional Networks (GCN), we develop a multitask GCN Variational Autoencoder where different dimensions of the generated embeddings can be dedicated to encoding feature information, network structure, and shared feature-network information. We explore the interaction between these disentangled characters by comparing the embedding reconstruction performance to a baseline case where no shared information is extracted. We use synthetic datasets with different levels of interdependency between feature and network characters and show (i) that shallow embeddings relying on shared information perform better than the corresponding reference with unshared information, (ii) that this performance gap increases with the correlation between network and feature structure, and (iii) that our embedding is able to capture joint information of structure and features. Our method can be relevant for the analysis and prediction of any featured network structure ranging from online social systems to network medicine. [51]

7.2. Computational Human Dynamics and Temporal Networks

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

7.2.1. Optimal Proxy Selection for Socioeconomic Status Inference on Twitter

Participants: Márton Karsai, Jacobo Levy Abitbol.

The socioeconomic status of people depends on a combination of individual characteristics and environmental variables, thus its inference from online behavioral data is a difficult task. Attributes like user semantics in communication, habitat, occupation, or social network are all known to be determinant predictors of this feature. In this paper we propose three different data collection and combination methods to first estimate and, in turn, infer the socioeconomic status of French Twitter users from their online semantics. Our methods are based on open census data, crawled professional profiles, and remotely sensed, expert annotated information on living environment. Our inference models reach similar performance of earlier results with the advantage of relying on broadly available datasets and of providing a generalizable framework to estimate socioeconomic status of large numbers of Twitter users. These results may contribute to the scientific discussion on social stratification and inequalities, and may fuel several applications. [19]

7.2.2. Randomized reference models for temporal networks

Participant: Márton Karsai.

In this paper we propose a unified framework for classifying and understanding microcanonical RRMs (MRRMs). Focusing on temporal networks, we use this framework to build a taxonomy of MRRMs that proposes a canonical naming convention, classifies them, and deduces their effects on a range of important network features. We furthermore show that certain classes of compatible MRRMs may be applied in sequential composition to generate over a hundred new MRRMs from the existing ones surveyed in this article. We provide two tutorials showing applications of the MRRM framework to empirical temporal networks: 1) to analyze how different features of a network affect other features and 2) to analyze how such features affect a dynamic process in the network. We finally survey applications of MRRMs found in literature. [48]

7.2.3. Reentrant phase transitions in threshold driven contagion on multiplex networks

Participants: Márton Karsai, Samuel Unicomb.

Models of threshold driven contagion explain the cascading spread of information, behavior, systemic risk, and epidemics on social, financial and biological networks. At odds with empirical observation, these models predict that single-layer unweighted networks become resistant to global cascades after reaching sufficient connectivity. We investigate threshold driven contagion on weight heterogeneous multiplex networks and show that they can remain susceptible to global cascades at any level of connectivity, and with increasing edge density pass through alternating phases of stability and instability in the form of reentrant phase transitions of contagion. Our results provide a novel theoretical explanation for the observation of large scale contagion in highly connected but heterogeneous networks. [23]

7.2.4. Interactional and informational attention on Twitter

Twitter may be considered as a decentralized social information processing platform whose users constantly receive their followees' information feeds, which they may in turn dispatch to their followers. This decentralization is not devoid of hierarchy and heterogeneity, both in terms of activity and attention. In particular, we appraise the distribution of attention at the collective and individual level, which exhibits the existence of attentional constraints and focus effects. We observe that most users usually concentrate their attention on a limited core of peers and topics, and discuss the relationship between interactional and informational attention processes – all of which, we suggest, may be useful to refine influence models by enabling the consideration of differential attention likelihood depending on users, their activity levels and peers' positions. [10]

7.2.5. Efficient limited time reachability estimation in temporal networks

Participant: Márton Karsai.

In this paper we propose a probabilistic counting algorithm, which gives simultaneous and precise estimates of the in- and out-reachability (with any chosen waiting-time limit) for every starting event in a temporal network. Our method is scalable allowing measurements for temporal networks with hundreds of millions of events. This opens up the possibility to analyse reachability, spreading processes, and other dynamics in large temporal networks in completely new ways; to compute centralities based on global reachability for all events; or to find with high probability the exact node and time, which could lead to the largest epidemic outbreak. [52]

7.2.6. weg2vec: Event embedding for temporal networks

Participant: Márton Karsai.

Network embedding techniques are powerful to capture structural regularities in networks and to identify similarities between their local fabrics. However, conventional network embedding models are developed for static structures, commonly consider nodes only and they are seriously challenged when the network is varying in time. Temporal networks may provide an advantage in the description of real systems, but they code more complex information, which could be effectively represented only by a handful of methods so far. Here, we propose a new method of event embedding of temporal networks, called weg2vec, which builds on temporal and structural similarities of events to learn a low dimensional representation of a temporal network. This projection successfully captures latent structures and similarities between events involving different nodes at different times and provides ways to predict the final outcome of spreading processes unfolding on the temporal structure. [53]

7.3. Communication Networks

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

7.3.1. Quantum communications

In [29] we investigate the performance of a quantum switch serving a set of users. The function of the switch is to convert bipartite entanglement generated over individual links connecting each user to the switch, into bipartite or tripartite entangled states among (pairs or groups of) users at the highest possible rates at a fixed ratio. Such entanglement can then be converted to quantum-secure shared secret bits among pairs or triples of users using E91-like Quantum Key Distribution (QKD) protocols. The switch can store a certain number of qubits in a quantum memory for a certain length of time, and can make two-qubit Bell-basis measurements or three-qubit GHZ-basis projective measurements on qubits held in the memory. We model a set of randomized switching policies. Discovering that some are better than others, we present analytical results for the case where the switch stores one qubit per user at a given time step, and find that the best policies outperform a time division multiplexing (TDM) policy for sharing the switch between bipartite and tripartite entanglement generation. This performance improvement decreases as the number of users grows. The model is easily augmented to study the capacity region in the presence of qubit decoherence, obtaining similar results. Moreover, decoherence appears to have little effect on capacity. We also study a smaller class of policies when the switch can store two qubits per user.

7.3.2. Resource Allocation

In [28] we consider assignment policies that allocate resources to users, where both resources and users are located on a one-dimensional line $[0, \infty\infty)$. First, we consider unidirectional assignment policies that allocate resources only to users located to their left. We propose the Move to Right (MTR) policy, which scans from left to right assigning nearest rightmost available resource to a user, and contrast it to the Unidirectional Gale-Shapley (UGS) matching policy. While both policies among all unidirectional policies minimize the expected distance traveled by a request (request distance), MTR is fairer. Moreover, we show that when user and resource locations are modeled by statistical point processes, and resources are allowed to satisfy more than one user, the spatial system under unidirectional policies can be mapped into bulk service queueing systems, thus allowing the application of many queueing theory results that yield closed-form expressions. As we consider a case where different resources can satisfy different numbers of users, we also generate new results for bulk service queues. We also consider bidirectional policies where there are no directional restrictions on resource allocation and develop an algorithm for computing the optimal assignment which is more efficient than known algorithms in the literature when there are more resources than users. Finally, numerical evaluation of performance of unidirectional and bidirectional allocation schemes yields design guidelines beneficial for resource placement.

7.3.3. VoD broadcasting over vehicular networks

Participants: Thomas Begin, Anthony Busson, Isabelle Guérin Lassous.

We consider a VoD (Video on-Demand) platform designed for vehicles traveling on a highway or other major roadway. Typically, cars or buses would subscribe to this delivery service so that their passengers get access to a catalog of movies and series stored on a back-end server. The network infrastructure comprises IEEE 802.11p RSUs (Road Side Units) that are deployed along the highway and deliver video content to traveling vehicles. In this paper, we propose a simple analytical and yet accurate solution to estimate two key performance parameters for a VoD platform: (i) the average download data rate experienced by vehicles over their journey and (ii) the average "interruption time", which corresponds to the fraction of time the video playback of a given vehicle is interrupted because of an empty buffer. Through multiple examples, we investigate the influence of several parameters (e.g., the video bit rate, the number of vehicles, the distance between RSUs, the vehicle velocity) on these two performance parameters whose outcome may help the sizing of an IEEE 802.11p-based VoD platform [12].

7.3.4. Performance Evaluation of Channel Bonding in IEEE 802.11ac

Participants: Thomas Begin, Anthony Busson, Marija Stojanova.

WLANs grow in popularity in home, public, and work environments, resulting in constantly increasing demands for wireless coverage and capacity. There exist two dominant strategies that help solve the problem of WLAN capacity: the deployment of more APs and enhancement of the standards in use. These policies result in WLANs containing a larger number of more complex devices, making the prediction of the network's behavior an even more elaborate problem. Because of these issues, WLANs are prone to inefficient configurations. In this paper, we propose a Markovian continuous time model that aims at predicting the throughputs achieved by all the WLAN's APs as a function of the network's topology and the AP's throughput demands. By means of simulation, we show that our model achieves mean relative errors of less than 10% for networks of different sizes and with diverse node configurations. The model is adapted to the specificities of the IEEE 802.11ac standard amendment and can be used to solve problems such as channel assignment or channel bonding. We derive guidelines on the best practice in channel bonding given a performance metric and for different MCS indexes, frame aggregation rates, saturation levels, and network topologies. We then put our findings to the test by identifying the optimal channel bonding combination in a WLAN containing a diverse set of nodes.

7.3.5. 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 [35].

7.3.6. Simulation and Performance Evaluation of the Intel Rate Adaptation Algorithm

Participants: Rémy Grünblatt, Isabelle Guérin-Lassous.

With the rise of the complexity of the IEEE 802.11 standard, rate adaptation algorithms have to deal with a large set of values for all the different parameters having an impact on the network throughput. Simple trial-and-error algorithms can no longer explore solution space in reasonable time and smart solutions are required. Most of the WiFi controllers rely on proprietary code and the used rate adaptation algorithms in these controllers are unknown. Very few WiFi controllers expose their rate adaptation algorithms if they do not rely on the MINSTREL-HT algorithm which is implemented in the mac80211 component of the Linux kernel. Intel WiFi controllers come with their own rate adaptation algorithms that are implemented in the Intel IWLWIFI Linux Driver which is open-source.

In this work, we have reverse-engineered the Intel rate adaptation mechanism from the source code of the IWLWIFI Linux driver, and we give, in a comprehensive form, the underlying rate adaptation algorithm named IWL-MVM-RS. We describe the different mechanisms used to seek the best throughput adapted to the network conditions. We have also implemented the IWL-MVM-RS algorithm in the NS-3 simulator. Thanks to this implementation, we can evaluate the performance of IWL-MVM-RS in different scenarios (static and with mobility, with and without fast fading). We also compare the performances of IWL-MVM-RS with the ones of MINSTREL-HT and IDEALWIFI, also implemented in the NS-3 simulator [26], [32].

7.3.7. 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.

Wi-Fi networks often consist of several Access Points (APs) to form an Extended Service Set. These APs may interfere with each other as soon as they use the same channel or overlapping channels. A classical model to describe interference is the conflict graph. As the interference level varies in the network and in time, we consider a weighted conflict graph. In this work, we propose a method to infer the weights of the conflict graph of a Wi-Fi network.

Weights represent the proportion of activity from a neighbor detected by the Clear Channel Assessment mechanism. Our method relies on a theoretical model based on Markov networks applied to a decomposition of the original conflict graph. The input of our solution is the activity measured at each AP, measurements available in practice. The proposed method is validated through ns-3 simulations performed for different scenarios. Results show that our solution is able to accurately estimate the weights of the conflict graph. [24], [34].

8. Bilateral Contracts and Grants with Industry

8.1. GranData

Participants: Márton Karsai [correspondant], Éric Fleury.

Founded in 2012, Grandata is a Palo Alto-based company that leverages advanced research in Human Dynamics (the application of « big data » to social relationships and human behaviour) to identify market trends and predict customer actions. Leading telecom and financial services firms are using Grandata's Social Universe product to transform « big data » into impressive business results.

The DANTE team and Grandata started to collaborate in 2014 on the analysis of large datasets provided by the company. The aim of the collaboration is to gain better understanding about the dynamical patterns of human interactions, mobility, and the socio-economic structure of the society. Currently the collaboration is supported by the MOTIF Stic-AmSud project (2018-2020) (coordinated by Márton Karsai) which allows to meet frequently with the company. Recent projects within this collaboration are focusing on socioeconomic inference using remote sensing techniques.

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Idex Lyon ACADEMICS

Participants: Paulo Gonçalves, Rémi Gribonval, Marion Foare, Amélie Barbe, Gaetan Frusque.

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.

9.1.2. ISI Torino / Dante

Participant: Márton Karsai [correspondant].

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

This project involves M. Karsai and L. Gauvin (ISI Torino) and funded by the IXXI Complex System Institute. The purpose of this project is to investigate the presence and the importance of higher-order correlations in dynamical networks. As the first attempt to address this problem we applied autoencoder, a recent representation using deep neural networks, on modelled and small-scale real temporal networks. However, since the results were trivial on the modelled network and not convincing on the real one we decided to take a different approach during the second phase of the project. We involved an ISI PhD student Maddalena Toricelli, to work out a method for temporal network embedding. Our idea is to extend the node2vec representation of static networks for time-varying structures, by using a local random walk to explore the structural-temporal neighbourhood of a node. Based on such local information we can effectively propose an embedding, which captures the temporal and structural properties of nodes in a temporal network.

9.1.3. FIL PerfWiFi

Participants: Guérin-Lassous Isabelle [correspondant], Grünblatt Rémy.

Duration of the project: **January 2019 - December 2020**.

The goal of the project **PerfWiFi** is to set up a Wi-Fi experimental platform that will be, in the future, open to interested researchers. This platform consists in devices (cards, routers) implementing the last versions of Wi-Fi (Wi-Fi 5 and Wi-Fi 6) and with different chipsets from different manufacturers. This platform will also be interconnected to a fleet of UAVs equipped with Wi-Fi interfaces. The Wi-Fi devices are chosen to be as open as possible in order to have a large set of possibilities in terms of parameterization of the Wi-Fi parameters.

In 2019, a first version of the platform has been set up along with a set of software tools to automatically launch Wi-Fi experiments. The first experiments can monitor, during a long period, all the possible Wi-Fi channels and their medium use ratio. We intend to provide these data via an open website.

9.1.4. FIL ALIENOR

Participant: Begin Thomas [correspondant].

Duration of the project: **January 2019 - December 2020**.

The goal of ALIENOR (ArtificiaL IntElligence-assisted NetwORks) is to develop an approach to dynamically select adequate values for the IEEE 802.11 parameters related to the Rate Adaptation (RA) mechanism to the WLAN context. The search for an adequate setting for the RA parameters is made complex due to the vast number of parameters (e.g., the used amendment of 802.11, the channel transmission rate, the number of competing nodes, the Frame Error Rate (FER), the offered load, and the transport protocol to name a few) that may affect a WLAN behavior.

In ALIENOR, we propose to explore a new approach to determine an adequate setting of the RA parameters using a data-driven approach based on techniques of Machine Learning (ML) in Artificial Intelligence (AI). Our approach consists of three stages. First, we will build a large dataset of measurements that will serve as the training set. Second, we will use ML techniques to discover a function that fits the mapping between the dataset output and the inputs. Lastly, WLAN devices will embed and use this learned function to predict (approximately) what will be their attained throughput under various possible settings of their RA, and then select their best option.

9.1.5. ENS Lyon project Vehicular project

Participants: Begin Thomas [correspondant], Guérin Lassous Isabelle, Busson Anthony.

Duration of the project: **January 2017 - December 2020**.

The goal of this project is to design new performance tools to improve the sharing of communication resources in vehicular networks. In particular, we focus on the use case of delivering a Video on Demand service to vehicles traveling along a highway. Through the development of a simple and yet accurate performance modeling approach, we were able to demonstrate the feasibility of using IEEE 802.11p to deliver video content to vehicles. Our work also underlines the benefit of blocking the lowest transmission rates for the sake of a collective gain in terms of attained throughput and interruption time in the video playback. This somehow surprising property derives from the well-established performance anomaly of 802.11-based networks.

9.2. National Initiatives

9.2.1. ANR DataRedux

Participants: Paulo Gonçalves [correspondant], Rémi Gribonval, Marion Foare.

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.

9.2.2. 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.

9.2.3. Equipex FIT (Futur Internet of Things)

Participant: Éric Fleury [correspondant].

Duration of the project: **February 2011 - December 2019**.
FIT was one of 52 winning projects in the Equipex research grant program. It will set up a competitive and innovative experimental facility that brings France to the forefront of Future Internet research. FIT benefits from 5.8 million euro grant from the French government. The main ambition is to create a first-class facility to promote experimentally driven research and to facilitate the emergence of the Internet of the future.

9.2.4. ANR SoSweet

Participant: Márton Karsai [correspondant].

Duration of the project: **November 2015 - November 2019**.

The SoSweet project focuses on the synchronic variation and the diachronic evolution of the variety of French used on Twitter. The recent rise of novel digital services opens up new areas of expression which support new linguistic behaviours. In particular, social medias such as Twitter provide channels of communication through which speakers/writers use their language in ways that differ from standard written and oral forms. The result is the emergence of new varieties of languages. The main goal of SoSweet is to provide a detailed account of the links between linguistic variation and social structure in Twitter, both synchronically and diachronically. Through this specific example, and aware of its bias, we aim at providing a more detailed understanding of the dynamic links between individuals, social structure and language variation and change.

9.2.5. ANR DylNet

Participant: 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.

9.2.6. Inria PRE LIAISON

Participant: Márton Karsai [correspondant].

Duration of the project: **November 2017 - December 2019**.

This project implements unsupervised deep learning approaches to infer correlations/patterns that exist between dynamic linguistic variables, the mesoscopic and dynamic structure of the social network, and their socio-economic attributes. This interdisciplinary project is positioned at the crossroads of Natural Language Processing (NLP), Network Science, Data Science and Machine Learning.

More precisely, we develop a joint feature-network embedding, named AN2VEC (Attributed Network to Vector), which ultimately aims at disentangling the information shared by the structure of a network and the features of its nodes. Building on the recent developments of Graph Convolutional Networks (GCN), we use a multitask GCN Variational Autoencoder where different dimensions of the generated embeddings can be dedicated to encoding feature information, network structure, or shared feature-network information separately. This method thus defines a range of models whose performance in embedding a given data set varies depending with the allocation of dimensions. By exploring the behaviour of these models on synthetic data sets having different levels of feature-network correlation, we show (i) that embeddings relying on shared information perform better than the corresponding reference with unshared information, and (ii) that this performance gap increases with the correlation between network and feature structure, thus confirming that our embedding is able to capture joint information of structure and features.

9.2.7. HOTNET - IXXI

Participant: Márton Karsai [correspondant].

Duration of the project: **January 2019 - December 2021**.

The purpose of the HOTNet (Higher-order representation of temporal networks) project is to develop a pipeline for the embedding of temporal networks that captures higher order correlations relevant for dynamical processes. We propose to detach from the straightforward representations of networks — as successions of static networks — by focusing on representations that better reflects the higher-order neighbourhood and temporal paths. To project plans to develop a framework that learns from this representation an embedding sufficient to estimate the outcome of spreading processes that might take place on top of the original network.

This is a small-scale collaborative project funded by the IXXI Complex System Institute to foster collaborations between MK and Laetitia Gauvin (ISI Torino) for the period of 2019-2021.

9.2.8. Inria & HCERES

Participant: Éric Guichard [correspondant].

Bilateral project on the evolution of the Multi/inter-disciplinary of SHS.

An increasing number of researchers in SHS has the desire to develop new researches with computer scientists or mathematicians because they want to apply new methodologies (according to various or numerous data) or to develop older ones, which can now be easily implemented online. Some also develop a reflexion on their discipline, with the idea that epistemological questions are revitalized by the internet. This reality invite them to discuss with philosophers or with other SHS scientists who have the same intuition (eg: cartography, visualisation).

The project is hence to measure these new forms or inter-multi-disciplinarity. The main source will be the publications of all academics of French SHS laboratories, to find out who writes a paper with somebody of a different discipline and/or laboratories. All data are anonymized,

9.2.9. Inria IPL BetterNet

Participant: Éric Guichard.

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.

9.3. International Initiatives

9.3.1. Participation in Other International Programs

9.3.1.1. International Initiatives

MOTif

Title: Mobile phone sensing of human dynamics in techno-social environment

International Partners (Institution - Laboratory - Researcher):

Universidad de Buenos Aires (Argentina) - Instituto de Cálculo - Alejo Salles

Universidade Federal de Minas Gerais (Brazil) - Jussara M. Almeida

Duration: 2018 - 2019

Start year: 2018

Information and Communication Technology (ICT) is becoming increasingly social, as demonstrated by the multitude of emerging technologies and technology platforms that facilitate social interactions, taking place as communication via telephone, text message, email, online social networks etc. At the same time, our social activities are increasingly embedded in the ICT environments that enable and enhance our ability to transact, share experiences, and maintain social relationships. One of the best ways to explore these developments is through the mining and analysis of data, which are collected through mobile phones and allow us to investigate how individuals act when embedded in a technology-enabled environment. Unlimited access to a wide range of mobile applications and services may change our way to gain information, to communicate, or even to behave in different contextual places like home, work, or anywhere else. Thus understanding individual activity patterns and the source of decisions behind them is moreover important for the design of future services and to estimate the demand on the infrastructure. The MOTIf project builds on the analysis and modeling of geo-localized temporally detailed but fully anonymised mobile phone call networks. These datasets allow us to address the two scientific objectives about spatiotemporal patterns of service usage of anonymised individuals to learn when, where, and what people are doing; and about the fine-grained sociodemographic structure of society and its effect on the the individual social behaviour. In other words our goal in general is to understand how individuals behave in a dynamic techno-social environment.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Jaqueline Faria has been a long term visitor in the DANTE team as a visiting PhD student from the PUC Minas University of Belo Horizonte (Brazil). Her stay between May-December was supported by the CAPES.
- Alexandre Brandwajn from University of California, Santa Cruz (USA) has been a visiting Professor in the DANTE team between Feb and Mar 2019.
- Dorsaf Ghozlani, PhD student at Ecole Nationale d'Ingénieurs de Tunis, has been a visitor in the Dante team from April to July 2019.

9.4.1.1. Internships

- Maxime De Freitas, Télécom Physique Strasbourg, from Jun 2019 until Aug 2019.
- Julien Alamelle, Université Claude Bernard Lyon 1, from Oct 2019 until Dec 2019.

- Juan Pablo Astudillo, Universitat Politècnica de Catalunya, PhD, from Apr 2019 until Jul 2019.
- Simon Fernandez, Master 2 student, ENS Lyon, from February 2019 until June 2019.
- Paul Grangette, Master 2 student, Université Claude from November 2019 to July 2020 (work-study contract).

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Christophe Crespelle is on leave with a Marie Sklodowska-Curie Grant from EU. He is currently at the University of Bergen (Norway) until February 1st, 2020.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events: Organisation

10.1.1.1. General Chair, Scientific Chair

- Márton Karsai was in the organizing team (general chair) of the Computational Social Science Satellite of the CCS'19 Conference in September 2019 in Singapore
- Márton Karsai was in the organizing team (general chair) of the Machine Learning and Network Science Satellite of the NetSci'19 Conference in June 2019 in Burlington (VT)

10.1.2. Scientific Events: Selection

10.1.2.1. Chair of Conference Program Committees

- Thomas Begin was co-Chair for the National Conference Algotel 2019.

10.1.2.2. Member of the Conference Program Committees

- Thomas Begin has been member of the PC for the conference IEEE LCN 2019
- Isabelle Guérin Lassous has been a member of the PC for the following conferences in 2019: ACM MSWiM, Mascots, IEEE ICC, IEEE Globecom, IEEE WCNC.
- Márton Karsai has been the member of the PC of the conferences: NetSci, CompleNet, IC2S2, Algotel, NetSciX, CSSCCS, MLNS, Complex Networks, CCS, IC2S2
- Anthony Busson has been member of the PC for Algotel 2019, FNC 2019.
- Christophe Crespelle

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

- Isabelle Guérin Lassous is member of the editorial boards of Computer Communications (Elsevier), Ad Hoc Networks (Elsevier) and Discrete Mathematics & Computer Science.
- Anthony Busson is member of the editorial boards of Computer Communications (Elsevier).
- Márton Karsai is member of the editorial boards of Advances in Complex Systems (World Scientific)
- Márton Karsai is member of the editorial boards of PLoS ONE
- Philippe Nain is a member of the Advisor Board of Performance Evaluation (Elsevier).

10.1.3.2. Reviewer - Reviewing Activities

- Márton Karsai was acting as a reviewer for the journals of Nature Communications, PNAS, PRL, PRX, PRE, Scientific Reports, EPJ Data Science, SNAM, EPL, EPJ B, PLoS One, Journal of Statistical Mechanics, Physics Letter A, Advanced in Complex Systems, Journal of Physics: Condensed Matter, Complex Networks, New Journal of Physics, Physica Scripta, Network Science; and for project agencies as ANR, FET-H2020 RIA.

- Paulo Gonçalves was reviewer for the following journals: IEEE Transactions on Signal Processing, IEEE Signal Processing Letter, Signal Processing (Elsevier).
- Christophe Crespelle was a reviewer for Algorithmica (Springer) and Theoretical Computer Science (Elsevier).
- Thomas Begin was a reviewer for IEEE Transactions on Network and Service Management, IEEE Transactions on Parallel and Distributed Systems, and Performance Evaluation.
- Anthony Busson was a reviewer for Computer communication, Sensors, IEEE wireless communications letters.

10.1.4. Invited Talks

- Thomas Begin gave the following invited talk:

  Contributions to the Performance Modeling of Computer Networks - CITI lab (Avril 2019, Lyon, France)

- Isabelle Guérin-Lassous gave the following invited talks:

  UAVs and cellular networks: which usage, which constraints, which performance? - Entretiens Jacques Cartier (November 2019, Montreal, Canada)

  How to improve the performance of a Wi-Fi network without changing the Wi-Fi technologie? - Séminaire ENS Rennes (September 2019, Rennes, France)

- Márton Karsai gave the following invited talks:

  Lecture in the Business Analytics and Data Mining MSc program - Bocconi University (7 March 2019, Milano, Italy)

  Complex System Academy - Université de Côte d'Azure (25 March 2019, Nice, France)

  YEP XV - Information Diffusion on Random Networks - TU/e, EUROSTAT (27 April 2019, Eindhoven, The Netherlands)

  Lectures about Artificial Intelligence - EM Lyon Business School - AIM Institute (4 April 2019, Lyon, France)

  MOTIF Conference on Human Dynamics - Universidade Federal de Minas Gerais (10 April 2019, Belo Horizonte, Brazil)

  UNICEF Innovation seminar - UNICEF Innovation Office - United Nations (4 June 2019, New York, NY, USA)

  MédiaLab seminar - SciencePo Paris (25 June 2019, Paris, France)

  AGRANDA Simposio Argentino de Ciencia de Datos Grandes Datos - 48 JAIIO (17 Septemner 2019, Salta, Argentina)

  Kickoff meeting of the DYNASNET Synergy ERC project - Central European University (23 September 2019, Budapest, Hungary)

  Dondena Seminar Series- Bocconi University (14 October 2019, Milano, Italy)

  Agglomeration and Social Networks Seminar - MTA Center for Economic and Regional Studies (8 November 2019, Budapest, Hungary)

  BigData and Mobility Workshop - University of Havana (25-26 November, Havana, Cuba)

10.1.5. Scientific Expertise

- Isabelle Guérin Lassous

  has been a member of the strategic consulting of the Fondation Blaise Pascal since September 2019.

  has been a member of the scientific council of the Société Informatique de France since November 2019

- Éric Guichard

is a member of the scientific committee of LASCO Idea Lab of the IMT (LAboratoire Sens et COmpréhension du monde contemporain de l'Institut Mines-Télécom).

is a member of the international evaluation board of the doctoral program *Filosofia da Ciencia, Tecnologia, Arte e Sociedade* of the University of Lisbon.

is the manager of the RAIL (Réseau de l'Atelier Internet Lyonnais), founded in 2017 and supported by IXXI and Enssib.

10.1.6. Research Administration

- Paulo Gonçalves

  is scientific liaison officer for international relations in Inria Research Centre of Rhône-Alpes.

  is a member of the executive committee of the Milyon labex and referent for its valorisation committee.

  is correspondant for the theme "Big Data" of the *Fédération d'Informatique de Lyon*.

  is member of the Council of the LIP laboratory.

- Isabelle Guérin Lassous

  is member of the department council of the Computer Science department of Université Lyon 1.

- Anthony Busson

  is member of the Thesis Commission at LIP.

  is head of the computer science department at IUT (Institut Universitaire de Technologie) - Université Lyon Claude Bernard Lyon 1.

- Thomas Begin

  is an elected member of the Council of the LIP laboratory.

  is an elected member of the department council of the Computer Science department of Université Lyon 1.

- Márton Karsai

  is the co-responsible for the M2 master program in Modelling of Complex Systems at ENS Lyon

  is the elected council member of the Complex System Society (2015-)

  is the elected member of executive committee of the Complex System Society (2018-)

  is the elected member of the steering committee of the IXXI Complex System Institute (2017-)

  is the member of the computational infrastructure board of LIP

  is the member of the communication board of LIP

- Éric Guichard is a member of the steering committee of the IXXI Complex System Institute

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Licence :

Thomas Begin: Computer Networks, 18.5h, L3, Université Lyon 1.

Márton Karsai: Introduction to Complex Networks, 6h, L3, ENS 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

Cycle ingénieur (Bac+3 à 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.

Responsabilités

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 will be 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.

10.2.2. Supervision

PhD defense: Esteban BAUTISTA RUIZ, "Laplacian Powers for Graph-Based Semi-Supervised Learning", November 27, 2019. P. Gonçalves (Dir.).

PhD defense: Marija STOJANOVA, "Performance Modelling of IEEE 802.11 networks" ,December 16, 2019. T. Begin (Dir.)

PhD in progress: Mohamed Adbelwedoud LAFDAL, Inference of conflict graph in IEEE 802.11 networks. September 2017, A. Busson and I. Guérin Lassous

PhD in progress: Samuel UNICOMB, Spreading processes on temporal networks, Oct 2016, M. Karsai director

PhD in progress: Jacobo Levy ABITBOL, Information diffusion and language evolution on dynamical social networks, Oct 2016, M. Karsai director and E. Fleury

PhD in progress: Sicheng DAI, Dynamic Multilayer Network Modelling, M. Karsai director. Started October 1st, 2017.

PhD in progress: Gaetan FRUSQUE, *Modal Decompositions of Dynamic Graphs : Application in Neurosciences*, P. Gonçalves (Dir. and P. Borgnat, co-advisor). Started October 1st, 2017.

PhD in progress: Rémy GRÜNBLATT, Controlled mobility for UAV networks, October 2017, I. Guérin Lassous and O. Simonin.

PhD in progress: Dominique BARBE, From local to global learning, P. Gonçalves (Dir. with M. Sebban and P. Borgnat, co-advisors). Started October 1st, 2018.

PhD in progress: Nour el Houda BOUZOUITA, supervised by A. Busson and Hervé Rivano. Wi-Fi network Optimization through crowd sensing applications. November 2018 - November 2021.

10.2.3. Juries

Paulo Gonçalves was reviewer of the Ph.D thesis examination board of Xiaoyi MAI, Centrale Supelec, October 2019.

Paulo Gonçalves was member of the Ph.D thesis examination boards of Karina Ashurbekova (Université Grenoble Alpes, December 2019).

Isabelle Guérin Lassous was a reviewer of the Ph.D thesis examination boards of Fannia Pacheco (UPPA, November 2019) and Pierre Brunisholz (Université Grenoble Alpes, May 2019).

Isabelle Guérin Lassous was a reviewer of the HDR examination board of Géraldine Texier (IMT-Atlantique, December 2019).

Isabelle Guérin Lassous was the president of the Ph.D thesis examination boards of Marc Heinrich (Université de Lyon, July 2019) and Thierry Arrabal (Université Franche-Comté, November 2019).

Isabelle Guérin Lassous was the president of the HDR examination boards of Christophe Alias (ENS de Lyon, May 2019), Marton Karsai (ENS de Lyon, April 2019) and Razvan Stanica (INSA de Lyon, November 2019).

Isabelle Guérin Lassous was a member of the Ph.D thesis examination board of Jalal Rachad (Telecom Paris, December 2019).

Isabelle Guérin Lassous was a member of the HDR examination board of Katia Jaffres-Runser (INP Toulouse, July 2019).

Thomas Begin was a reviewer of the Ph.D. thesis examination board of Amira KAMLI, Télécom-ParisSud, October 2019.

Márton Karsai was the member of the Prix de Thèse Systm`es Complexes - Complex System Institute, July 2019

Márton Karsai was the member of the PhD jury of Jordam Cambe (ENS Lyon), October 2019

Anthony Busson was a reviewer of the Ph.D thesis examination board of Jalal Rachad (Telecom Paris, December 2019).

Anthony Busson was a reviewer of the Ph.D thesis examination board of Henri-Joseph Audeoud (Université Grenoble Alpes, December 2019).

10.3. Popularization

10.3.1. Internal or external Inria responsibilities

Isabelle Guérin Lassous has been the managing director of the Foundation Blaise Pascal until the end of June 2019. The objectives of the foundation are to promote mathematics and computer science and to attract young people to scientific fields like computer science and mathematics. The actions of the FBP focus on:

- a support to actors that promote mathematics and computer science via allocated funding based on call of proposals;
- a structuring of actors to increase the impacts of their actions, to coordinate the efforts and to share experiences;
- a development of innovative experiences via summer camps and clubs of mathematics and computer science.

10.3.2. Interventions

Isabelle Guérin Lassous participated to the project Science XX Elles organized by the association Femmes & Sciences, CNRS and Ecole Normale Supérieure de Lyon. A portrait has been realized and has been exhibited in from of the Musée des Confluences during La Fête de la Science in October 2019 (http://www.femmesetsciences.fr/lascience-taillexxelles/lyon/isabelle-guerin-lassous/. She also participated to a speed meeting with families visiting the Musée des Confluences during which she has promoting her research activity.

Isabelle Guérin Lassous spent one day in high school (lycée St Just in Lyon) to promote computer science and to present female computer scientists in from of terminal classes.

Isabelle Guérin Lassous participated to the Challenge Innovatech organized by the association Elles Bougent. She was a member of the selection committe who selected a scientific project designed by a group of young girls (in high school).

11. Bibliography

Major publications by the team in recent years

[1] T. BEGIN, B. BAYNAT, I. GUÉRIN-LASSOUS, T. ABREU. *Performance analysis of multi-hop flows in IEEE 802.11 networks: A flexible and accurate modeling framework*, in "Performance Evaluation", February 2016, vol. 96, pp. 12–32 [*DOI :* 10.1016/J.PEVA.2015.12.003], https://hal.archives-ouvertes.fr/hal-01246822

[2] A. BRANDWAJN, T. BEGIN. *Multi-server preemptive priority queue with general arrivals and service times*, in "Performance Evaluation", 2017 [*DOI :* 10.1016/J.PEVA.2017.08.003], https://hal.inria.fr/hal-01581118

[3] A. T. GIANG, A. BUSSON, A. LAMBERT, D. GRUYER. *Spatial capacity of IEEE 802.11p based VANET: models, simulations and experimentations*, in "IEEE Transactions on Vehicular Technology", January 2015 [*DOI :* 10.1109/TVT.2015.2474156], https://hal.archives-ouvertes.fr/hal-01217564

[4] B. GIRAULT, P. GONÇALVES, É. FLEURY. *Translation on Graphs: An Isometric Shift Operator*, in "IEEE Signal Processing Letters", December 2015, vol. 22, n^{O} 12, pp. 2416–2420 [*DOI :* 10.1109/LSP.2015.2488279], https://hal.inria.fr/hal-01221562

[5] M. KARSAI, G. IÑIGUEZ, K. KASKI, J. KERTÉSZ. *Complex contagion process in spreading of online innovation*, in "Journal of the Royal Society Interface", October 2014, vol. 11, 8 p. , 20140694 [*DOI :* 10.1098/RSIF.2014.0694], https://hal.inria.fr/hal-01100359

[6] T. OBADIA, R. SILHOL, L. OPATOWSKI, L. TEMIME, J. LEGRAND, A. C. THIÉBAUT, J.-L. HERRMANN, É. FLEURY, D. GUILLEMOT, P.-Y. BOELLE. *Detailed Contact Data and the Dissemination of Staphylococcus aureus in Hospitals*, in "PLoS Computational Biology", 2015, vol. 11, n^{O} 3, on behalf of the I-Bird study Group [*DOI :* 10.1371/JOURNAL.PCBI.1004170], http://hal.upmc.fr/hal-01134050

[7] M. TIZZONI, K. SUN, D. BENUSIGLIO, M. KARSAI, N. PERRA. *The Scaling of Human Contacts in Reaction-Diffusion Processes on Heterogeneous Metapopulation Networks*, in "Scientific Reports", October 2015, vol. 5, n^{O} 15111, https://hal.inria.fr/hal-01100351

Publications of the year

Doctoral Dissertations and Habilitation Theses

[8] E. BAUTISTA. *Laplacian Powers for Graph-Based Semi-Supervised Learning*, Ecole Doctorale en Informatique et Mathématiques de Lyon, November 2019, https://hal.inria.fr/tel-02437253

[9] M. KARSAI. *Computational Human Dynamics: People, Networks, and Collective Phenomena*, Ecole normale supérieure de Lyon ; Laboratoire de l'Informatique du Parallélisme, April 2019, Habilitation à diriger des recherches, https://hal.inria.fr/tel-02151333

Articles in International Peer-Reviewed Journals

[10] A. BALTZER, M. KARSAI, C. ROTH. *Interactional and Informational Attention on Twitter*, in "Information", August 2019, vol. 10, n° 8, pp. 1-16 [*DOI :* 10.3390/INFO10080250], https://halshs.archives-ouvertes.fr/halshs-02378190

[11] E. BAUTISTA, P. ABRY, P. GONÇALVES. *L^γ -PageRank for Semi-Supervised Learning*, in "Applied Network Science", 2019, pp. 1-20, forthcoming, https://hal.inria.fr/hal-02063780

[12] T. BEGIN, A. BUSSON, I. GUÉRIN-LASSOUS, A. BOUKERCHE. *Performance Analysis of Video on Demand in an IEEE 802.11p-based Vehicular Network*, in "Computer Communications", August 2019, vol. 146, pp. 174-185 [*DOI :* 10.1016/J.COMCOM.2019.08.006], https://hal.archives-ouvertes.fr/hal-02277855

[13] M. DEHGHAN, W. CHU, P. NAIN, D. TOWSLEY, Z.-L. ZHANG. *Sharing Cache Resources among Content Providers: A Utility-Based Approach*, in "IEEE/ACM Transactions on Networking", 2019, vol. 40, n° 8, pp. 1-14 [*DOI :* 10.1109/TNET.2018.2890512], https://hal.inria.fr/hal-01672961

[14] A. DUVAL, T. OBADIA, P.-Y. BOËLLE, É. FLEURY, J.-L. HERRMANN, D. GUILLEMOT, L. TEMIME, L. OPATOWSKI. *Close proximity interactions support transmission of ESBL-K. pneumoniae but not ESBL-E. coli in healthcare settings*, in "PLoS Computational Biology", May 2019, vol. 15, n° 5, e1006496 p. [*DOI :* 10.1371/JOURNAL.PCBI.1006496], https://www.hal.inserm.fr/inserm-02153937

[15] M. FOARE, N. PUSTELNIK, L. CONDAT. *Semi-Linearized Proximal Alternating Minimization for a Discrete Mumford-Shah Model*, in "IEEE Transactions on Image Processing", 2019, pp. 1-13, forthcoming [*DOI :* 10.1109/TIP.2019.2944561], https://hal.archives-ouvertes.fr/hal-01782346

[16] É. GUICHARD. *Cartographie et visualisation*, in "Annales des mines - Responsabilité et environnement", 2019, n° 94, pp. 38-41, https://halshs.archives-ouvertes.fr/halshs-02097578

[17] É. GUICHARD. *Les nouveaux maîtres de l'écriture du monde*, in "Contemporary French and Francophone Studies", 2019, vol. 23, n° 4, pp. 1-9, forthcoming, https://hal.archives-ouvertes.fr/hal-02310616

[18] F. HUA, C. RICHARD, C. JIE, H. WANG, P. BORGNAT, P. GONÇALVES. *Designing Convex Combination of Graph Filters*, in "IEEE Signal Processing Letters", 2019, forthcoming, https://hal.inria.fr/hal-02367868

[19] J. LEVY ABITBOL, É. FLEURY, M. KARSAI. *Optimal Proxy Selection for Socioeconomic Status Inference on Twitter*, in "Complexity", May 2019, vol. 2019, pp. 1-15 [*DOI :* 10.1155/2019/6059673], https://hal.inria.fr/hal-02388403

[20] Y. LÉO, C. CRESPELLE, É. FLEURY. *Non-altering time scales for aggregation of dynamic networks into series of graphs*, in "Computer Networks", 2019, vol. 148, pp. 108-119 [*DOI :* 10.1016/J.COMNET.2018.11.006], https://hal.inria.fr/hal-01969504

[21] F. PINOTTI, É. FLEURY, D. GUILLEMOT, P.-Y. BÖELLE, C. POLETTO. *Host contact dynamics shapes richness and dominance of pathogen strains*, in "PLoS Computational Biology", May 2019, vol. 15, n° 5, e1006530 p. [*DOI :* 10.1371/JOURNAL.PCBI.1006530], https://www.hal.inserm.fr/inserm-02153754

[22] B. RICAUD, P. BORGNAT, N. TREMBLAY, P. GONÇALVES, P. VANDERGHEYNST. *Fourier could be a Data Scientist: from Graph Fourier Transform to Signal Processing on Graphs*, in "Comptes Rendus Physique", September 2019, pp. 474-488 [*DOI :* 10.1016/J.CRHY.2019.08.003], https://hal.inria.fr/hal-02304584

[23] S. UNICOMB, G. IÑIGUEZ, J. KERTÉSZ, M. KARSAI. *Reentrant phase transitions in threshold driven contagion on multiplex networks*, in "Physical Review E ", October 2019, vol. 100, n^{o} 4, pp. 1192-1199 [*DOI :* 10.1103/PHYSREVE.100.040301], https://hal.inria.fr/hal-02388406

International Conferences with Proceedings

[24] L. ABDELWEDOUD, A. BUSSON, I. GUÉRIN-LASSOUS, M. FOARE. *A Passive Method to Infer the Weighted Conflict Graph of an IEEE 802.11 Network*, in "AdHoc-Now 2019 - 18th International Conference on Ad Hoc Networks and Wireless", Luxembourg, Luxembourg, October 2019, pp. 304-316 [*DOI :* 10.1007/978-3-030-31831-4_21], https://hal.inria.fr/hal-02404943

[25] *Best Paper*
R. FONTUGNE, E. BAUTISTA, C. PETRIE, Y. NOMURA, P. ABRY, P. GONÇALVES, K. FUKUDA, E. ABEN. *BGP Zombies: an Analysis of Beacons Stuck Routes*, in "PAM 2019 - 20th Passive and Active Measurements Conference", Puerto Varas, Chile, Springer, March 2019, pp. 197-209, Best paper award. [*DOI :* 10.1007/978-3-030-15986-3_13], https://hal.inria.fr/hal-01970596.

[26] R. GRÜNBLATT, I. GUÉRIN-LASSOUS, O. SIMONIN. *Simulation and Performance Evaluation of the Intel Rate Adaptation Algorithm*, in "MSWiM 2019 - 22nd ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems", Miami Beach, United States, ACM, November 2019, pp. 27-34 [*DOI :* 10.1145/3345768.3355921], https://hal.inria.fr/hal-02282508

[27] S. GUPTA, R. GRIBONVAL, L. DAUDET, I. DOKMANIĆ. *Don't take it lightly: Phasing optical random projections with unknown operators*, in "NeurIPS 2019 - Thirty-third Conference on Neural Information Processing Systems", Vancouver, Canada, December 2019, pp. 1-13, https://arxiv.org/abs/1907.01703 , https://hal.inria.fr/hal-02342280

[28] N. K. PANIGRAHY, P. BASU, P. NAIN, D. TOWSLEY, A. SWAMI, K. S. CHAN, K. K. LEUNG. *Resource Allocation in One-dimensional Distributed Service Networks*, in "MASCOTS 2019 - 27th IEEE International Symposium on the Modeling, Analysis, and Simulation of Computer and Telecommunication Systems", Rennes, France, October 2019, pp. 14-26 [*DOI :* 10.1109/MASCOTS.2019.00013], https://hal.inria.fr/hal-02267631

[29] G. VARDOYAN, S. GUHA, P. NAIN, D. TOWSLEY. *On the Capacity Region of Bipartite and Tripartite Entanglement Switching and Key Distribution*, in "QCRYPT 2019 - 9th International Conference on Quantum Cryptography", Montreal, Canada, August 2019, pp. 1-3, https://hal.inria.fr/hal-02424441

National Conferences with Proceedings

[30] D. BARBE, P. BORGNAT, P. GONÇALVES, M. SEBBAN. *Transport Optimal sous Contrainte de Régularité pour l'Adaptation de Domaines entre Graphes avec Attributs*, in "GRETSI 2019 - XXVIIème Colloque francophonede traitement du signal et des images", Lille, France, August 2019, pp. 1-4, https://hal.inria.fr/hal-02154883

[31] G. FRUSQUE, J. JUNG, P. BORGNAT, P. GONÇALVES. *Réduction de dimension tensorielle parcimonieuse: Application au clustering de connectivité fonctionnelle*, in "GRETSI 2019 - XXVIIème Colloque francophonede traitement du signal et des images", Lille, France, August 2019, pp. 1-4, https://hal.inria.fr/hal-02154888

[32] R. GRÜNBLATT, I. GUÉRIN-LASSOUS, O. SIMONIN. *Study of the Intel WiFi Rate Adaptation Algorithm*, in "CoRes 2019 - Rencontres Francophones sur la Conception de Protocoles, l'Évaluation de Performance et l'Expérimentation des Réseaux de Communication", Saint-Laurent-de-la-Cabrerisse, France, June 2019, pp. 1-4, https://hal.inria.fr/hal-02126333

[33] M. STOJANOVA, T. BEGIN, P. GONÇALVES. *Traitement du signal sur graphe pour modéliser les WLANs*, in "GRETSI 2019 - XXVIIème Colloque francophonede traitement du signal et des images", Lille, France, August 2019, pp. 1-4, https://hal.inria.fr/hal-02154891

Conferences without Proceedings

[34] L. ABDELWEDOUD, A. BUSSON, I. GUÉRIN-LASSOUS. *Inférence des poids d'un graphe des conflits modélisant un réseau Wi-Fi*, in "CoRes 2019 - Rencontres Francophones sur la Conception de Protocoles, l'Évaluation de Performance et l'Expérimentation des Réseaux de Communication", Saint-Laurent-de-la-Cabrerisse, France, June 2019, pp. 1-4, https://hal.archives-ouvertes.fr/hal-02122772

[35] J. P. ASTUDILLO LEO´N, T. BEGIN, A. BUSSON, L. J. DE LA CRUZ LLOPIS. *Towards a Distributed Congestion Control mechanism for Smart Grid Neighborhood Area Networks*, in "PE-WASUN 2019 - Sixteenth ACM International Symposium on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks", Miami, United States, ACM, November 2019, https://hal.archives-ouvertes.fr/hal-02309054

[36] J.-P. CHEVROT, J. LEVY ABITBOL, M. KARSAI, J.-P. MAGUÉ, É. FLEURY. *Variations du (ne) négatif du français dans Twitter. Que peut apporter l'étude des données massives aux questions de sociolinguistique ?*, in "CILPR 2019 - XXIXe Congrès international de linguistique et de philologie romanes", Copenhague, Denmark, July 2019, https://hal.archives-ouvertes.fr/hal-01970511

[37] G. FRUSQUE, J. JUNG, P. BORGNAT, P. GONÇALVES. *Sparse tensor dimensionality reduction with application to clustering of functional connectivity*, in "Wavelets and Sparsity XVIII", San Diego, United States, SPIE, December 2019, 22 p. [*DOI :* 10.1117/12.2529595], https://hal.archives-ouvertes.fr/hal-02399385

[38] P. STOCK, A. JOULIN, R. GRIBONVAL, B. GRAHAM, H. JÉGOU. *And the Bit Goes Down: Revisiting the Quantization of Neural Networks*, in "ICLR 2020 - Eighth International Conference on Learning Representations", Addis-Abeba, Ethiopia, February 2020, pp. 1-11, https://hal.archives-ouvertes.fr/hal-02434572

[39] M. STOJANOVA, T. BEGIN, A. BUSSON. *Modélisation des réseaux IEEE 802.11 : Diviser pour régner*, in "CoRes 2019 - Rencontres Francophones sur la Conception de Protocoles, l'Évaluation de Performance et l'Expérimentation des Réseaux de Communication", Saint Laurent de la Cabrerisse, France, June 2019, pp. 1-4, https://hal.archives-ouvertes.fr/hal-02121254

Scientific Books (or Scientific Book chapters)

[40] É. GUICHARD. *L'histoire et l'écriture numérique : approche technique, politique, épistémologique*, in "Histoire et numérique", S. LAMASSÉ, G. BONNOT (editors), Presses de la Sorbonne, 2019, pp. 1-18, forthcoming, https://hal.archives-ouvertes.fr/hal-01673099

[41] É. GUICHARD. *Digital Humanities do not exist*, in "Amériques / Europe, les Humanités numériques en partage? Enjeux, innovations et perspectives", C. ILLOUZ, A. HUERTA (editors), Presses de l'université de la Rochelle, 2020, forthcoming, https://hal.archives-ouvertes.fr/hal-02403315

[42] É. GUICHARD. *Parler du virtuel aux temps du numérique*, in "La technologie une et multiple", J.- C. BEAUNE, M. SALHAB (editors), La technologie une et multiple, Université Libano-Française (ULF) et Éditions universitaires du Liban, 2020, forthcoming, https://hal.archives-ouvertes.fr/hal-02403360

[43] T. VENTURINI, A. K. MUNK, M. JACOMY. *Actor-Network VS Network Analysis VS Digital Networks Are We Talking About the Same Networks?*, in "DigitalSTS: A Handbook and Fieldguide", 2019, https://hal.archives-ouvertes.fr/hal-01672289

[44] T. VENTURINI. *The Fish Tank Complex of Social Modelling on Space and Time in Understanding Collective Dynamics*, in "Frontiers of Social Science: A Philosophical Reflection", M. NAGATSU, A. RUZZENE (editors), Bloomsbury, May 2019, https://hal.archives-ouvertes.fr/hal-01672283

Other Publications

[45] J.-C. BERMOND, D. MAZAURIC, V. MISRA, P. NAIN. *Distributed Link Scheduling in Wireless Networks*, January 2019, working paper or preprint, https://hal.inria.fr/hal-01977266

[46] S. FOUCART, R. GRIBONVAL, L. JACQUES, H. RAUHUT. *Jointly Low-Rank and Bisparse Recovery: Questions and Partial Answers*, October 2019, https://arxiv.org/abs/1902.04731 - working paper or preprint, https://hal.inria.fr/hal-02062891

[47] G. FRUSQUE, J. JUNG, P. BORGNAT, P. GONÇALVES. *Sparse tensor dimensionality reduction with application to clustering of functional connectivity*, June 2019, working paper or preprint, https://hal.inria.fr/hal-02154903

[48] L. GAUVIN, M. GÉNOIS, M. KARSAI, M. KIVELÄ, T. TAKAGUCHI, E. VALDANO, C. L. VESTERGAARD. *Randomized reference models for temporal networks*, March 2019, https://arxiv.org/abs/1806.04032 - Simplified presentation of temporal network features, added figures to illustrate important concepts, and added a new example application of MRRMs, https://hal.archives-ouvertes.fr/hal-01817633

[49] R. GRIBONVAL, M. NIKOLOVA. *A characterization of proximity operators*, November 2019, https://arxiv.org/abs/1807.04014 - working paper or preprint, https://hal.inria.fr/hal-01835101

[50] Y. KALOGA, M. FOARE, N. PUSTELNIK, P. JENSEN. *Discrete Mumford-Shah on graph for mixing matrix estimation*, May 2019, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01948570

[51] S. LERIQUE, J. L. ABITBOL, M. KARSAI. *Joint embedding of structure and features via graph convolutional networks*, December 2019, https://arxiv.org/abs/1905.08636 - working paper or preprint, https://hal.inria.fr/hal-02388402

[52] A. B. MODIRI, M. KARSAI, M. KIVELÄ. *Efficient limited time reachability estimation in temporal networks*, December 2019, https://arxiv.org/abs/1908.11831 - Software implementation available at https://doi.org/10.5281/zenodo.3369893, https://hal.inria.fr/hal-02388408

[53] M. TORRICELLI, M. KARSAI, L. GAUVIN. *weg2vec: Event embedding for temporal networks*, December 2019, https://arxiv.org/abs/1911.02425 - working paper or preprint, https://hal.inria.fr/hal-02388409

[54] S. UNICOMB, G. IÑIGUEZ, J. KERTÉSZ, M. KARSAI. *Reentrant phase transitions in threshold driven contagion on multiplex networks*, March 2019, https://arxiv.org/abs/1901.08306 - 13 pages, 7 figures, https://hal.inria.fr/hal-02065731

References in notes

[55] R. ALBERT, A.-L. BARABÁSI. *Statistical mechanics of complex networks*, in "Reviews of Modern Physics", 2002, vol. 74

[56] A.-L. BARABÁSI. *The origin of bursts and heavy tails in human dynamics*, in "Nature", 2005, vol. 435, 207 p.

[57] R. R. COIFMAN, S. LAFON, A. B. LEE, M. MAGGIONI, B. NADLER, F. WARNER, S. W. ZUCKER. *Geometric diffusions as a tool for harmonic analysis and structure definition of data: Diffusion maps*, in "PNAS", 2005, vol. 102, n^{o} 21, pp. 7426-7431

[58] W. J. FITZGERALD, R. L. SMITH, A. T. WALDEN. *Nonlinear and Nonstationary Signal Processing*, Cambridge University Press, Cambridge, 2001

[59] S. FORTUNATO. *Community detection in graphs*, in "Physics Reports", 2010, vol. 486, pp. 75-174

[60] G. GAUMONT, M. PANAHI, D. CHAVALARIAS. *Reconstruction of the socio-semantic dynamics of political activist Twitter networks – Method and application to the 2017 French presidential election*, in "PLOS ONE", 2018, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0201879

[61] É. GUICHARD. *La philosophie des techniques revue à l'aune de l'internet et du numérique*, in "Le numérique en débat. Des nombres, des machines et des hommes", G. CHAZAL (editor), Éditions Universitaires de Dijon. Collection Sociétés, 2017, pp. 173–189, Preprint:http://barthes.enssib.fr/articles/Guichard-pensee-critique-culture-numerique-philo-technique.pdf

[62] P. HOLME, J. SARAMÄKI. *Temporal networks*, in "Physics Reports", 2012, vol. 519, pp. 97-125

[63] M. KARSAI, M. KIVELÄ, R. K. PAN, K. KASKI, J. KERTÉSZ, A.-L. BARABÁSI, J. SARAMÄKI. *Small But Slow World: How Network Topology and Burstiness Slow Down Spreading*, in "Phys. Rev. E", 2011, vol. 83

[64] M. KARSAI, N. PERRA, A. VESPIGNANI. *A. Random Walks and Search in Time-Varying Networks*, 2013, arXiv:1303.5966

[65] M. KIVELÄ, R. K. PAN, K. KASKI, J. KERTÉSZ, J. SARAMÄKI, M. KARSAI. *Multiscale Analysis of Spreading in a Large Communication Network*, in "J. Stat. Mech.", 2012

[66] L. KOVANEN, M. KARSAI, K. KASKI, J. KERTÉSZ, J. SARAMÄKI. *Temporal motifs in time-dependent networks*, in "J. Stat. Mech.", 2011

[67] G. KRINGS, M. KARSAI, S. BERNHARDSSON, V. BLONDEL, J. SARAMÄKI. *Effects of time window size and placement on the structure of an aggregated communication network*, in "EPJ Data Science", 2012, vol. 1, n^{o} 4

[68] Z. Q. LUO, M. GASTPAR, J. LIU, A. SWAMI. *Distributed Signal Processing in Sensor Networks*, in "IEEE Signal Processing Mag", 2006, vol. 23

[69] B. A. MILLER, N. T. BLISS, P. J. WOLFE. *Towards Signal Processing Theory for Graphs and Non-Euclidian Data*, in "ICASSP", Dallas, IEEE, 2010

[70] G. MIRITELLO, E. MORO, R. LARA. *Dynamical strength of social ties in information spreading*, in "Phys. Rev. E", 2011, vol. 83

[71] M. E. J. NEWMAN. *Networks: An Introduction,*, Oxford University Press, 2010

[72] N. PERRA, A. BARONCHELLI, D. MOCANU, B. GONÇALVES, R. PASTOR-SATORRAS, A. VESPIGNANI. *Random Walks and Search in Time-Varying Networks*, in "Physical review letters", 2012, vol. 109

[73] N. PERRA, B. GONÇALVES, R. PASTOR-SATORRAS, A. VESPIGNANI. *Activity driven modeling of time varying networks*, in "Scientific Reports", 2012, vol. 2, n^{o} 469

[74] D. SHUMAN, S. NARANG, P. FROSSARD, A. ORTEGA, P. VANDERGHEYNST. *The emerging field of signal processing on graphs: Extending high-dimensional data analysis to networks and other irregular domains*, in "Signal Processing Magazine, IEEE", May 2013, vol. 30, n^{o} 3, pp. 83–98

[75] G. TIBELY, L. KOVANEN, M. KARSAI, K. KASKI, J. KERTÉSZ, J. SARAMÄKI. *Communities and beyond: mesoscopic analysis of a large social network with complementary methods*, in "Phys. Rev. E", 2011, vol. 83

[76] Q. WANG, É. FLEURY, T. AYNAUD, J.-L. GUILLAUME. *Communities in evolving networks: definitions, detection and analysis techniques*, in "Dynamics of Time Varying Networks", N. GANGULY, A. MUKHERJEE, B. MITRA, F. PERUANI, M. CHOUDHURY (editors), Springer, 2012, http://hal.inria.fr/hal-00746195

[77] A. S. WILLSKY. *Multiresolution Statistical Models for Signal and Image Processing*, in "Proceedings of the IEEE", 2002, vol. 90

[78] K. ZHAO, M. KARSAI, G. BIANCONI. *Entropy of Dynamical Social Networks*, in "PLoS ONE", 2011, vol. 6, n^{o} 12