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Activity Report 2016

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

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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

[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.

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: Christophe Crespelle, Éric Fleury, Paulo Gonçalves Andrade, Márton Karsai, Sarah de Nigris, Sarra Ben Alaya, Hadrien Hours.

Evolving networks can be regarded as "*out of equilibrium*" systems. Indeed, their dynamics is 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 organisation 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 [70].

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 Â« diffusion wavelets Â» and Â« diffusion maps Â» pushed forward at Yale and Duke [54]. 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, *e.g.*, ([65] and references therein). Other viewpoints can be found as well, including multi-resolution Markov models [73], Bayesian networks or distributed processing over sensor networks [64]. Such approaches can be particularly successful for handling static graphs and unveiling aspects of their organisation 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 [55].

3.2. Theory and Structure of dynamic Networks

Participants: Christophe Crespelle, Éric Fleury, Anthony Busson, Márton Karsai.

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 [67]. 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 behavior of complex networks [67], [58], [74], [63], to describe the observed structural and temporal heterogeneities [52], [58], [53], to detect and measure emerging community structures [56], [71], [72], to see how the functionality of networks determines their evolving structure [62], and to determine what kinds of correlations play a role in their dynamics [59], [61], [66].

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 [69]. 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 synthesizing 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 [60] and its co-evolution with ongoing processes like spreading phenomena,

synchronisation, evolution of consensus, random walk etc. [60], [68]. 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, Paulo Gonçalves Andrade, Isabelle Guérin Lassous.

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. In the MOSAR/iBird project we are collaborating with the team of Pr. Didier Guillemot (Inserm/Institut. Pasteur/Université de Versailles). Within the TUBEXPO and ARIBO projects, we are collaborating with Pr. Jean-Christopge Lucet (Professeur des université Paris VII, Praticien hospitalier APHP).

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.

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Network Science Semester

Dante organised in 2016 a full semester on Network Science (https://project.inria.fr/netspringlyon/) in conjunction with the SiSyPhe team at ENS de Lyon, the Centre de Physique Théorique of Marseille, the Excellence Laboratory MILYON and the Institute of Scientific Interchange of Turino. This program intends to cover both the basics of and recent advances in Network Science. These questions, which are in the focus of contemporary network science, set the scope of the actual proposal where we aim to bring together world-known experts from the fields of mathematics, physics, signal processing, computer science, social science, epidemiology and linguistic to discuss and enhance our understanding about the interaction between the structure,

evolution, and coupled dynamical processes of complex networks. The semester gathered 2 workshops and 1 conference. during the two workshop, 14 invited speakers spend time within Dante in short or long visit. Members of Dante also organised in June Socionet (http://www.socionet2016.fr) for young researchers and focus on the interdisciplinary meeting on social network: description, data, modelling, interpretation. It was a great success with a Datathon organised by the PhD student and PostDoc of DANTE.

5.1.2. Frutfull collaboration with GranData (http://www.grandata.com/)

Grandata integrates first-party and telco partner data to understand key market trends, predict customer behaviour, and deliver novel business results. We have published several papers [12], [41], [36], [11], [10] in collaboration with them on the socioeconomic correlations and stratification in social-communication networks, on the impact of university admission on freshmen' social egocentric network, on the correlations of consumption patterns in social-economic networks but also to validate DTN like protocols by taking benefits of the density and locality of urban communication patterns.

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
- URL: https://gforge.inria.fr/projects/grasp/

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: Gaetan Harter and Frédéric Saint-Marcel
- 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: Frédéric Saint-Marcel
- URL: https://github.com/iot-lab/iot-lab-gateway

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

6.6. Data analysis tools

6.6.1. Twitter link predictions

FUNCTIONAL DESCRIPTION

Inference, study and prediction of the dynamics of the Twitter mention network

- Participants: Hadrien Hours, Eric Fleury and Márton Karsai
- Contact: Márton Karsai
- URL: https://github.com/HadrienHours/TwitterMentionNetworkLinkPrediction

6.7. Platforms

6.7.1. FIT IoT-LAB

FUNCTIONAL DESCRIPTION

IoT-LAB provides full control of network IoT nodes and direct access to the gateways to which nodes are connected, allowing researchers to monitor nodes energy consumption and network-related metrics, e.g. end-to-end delay, throughput or overhead. The facility offers quick experiments deployment, along with easy evaluation, results collection and analysis. Defining complementary testbeds with different node types, topologies and environments allows for coverage of a wide range of real-life use-cases.

- Partner: FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Researchâs âÃquipements dâExcellenceâ (Equipex) research grant programme. Th eFIT consortium is composed of: Université Pierre et Marie Curie (UPMC), Inria, Université de Strasbourg, Institut Mines Télécom and CNRS
- Contact: Éric Fleury
- URL: https://www.iot-lab.info/

7. New Results

7.1. Graph & Signal Processing

Participants: Sarra Ben Alaya, Éric Fleury, Paulo Gonçalves Andrade.

7.1.1. Isometric graph shift operator]

Following up the PhD work of Benjamin Girault [57], we demonstrated in [26] that the isometric graph shift operator we originally proposed, does have a vertex-domain interpretation as a diffusion operator using a polynomial approximation. We showed that its impulse response exhibits an exponential decay of the energy way from the impulse, demonstrating localisation preservation. Additionally, we formalised several techniques that can be used to study other graph signal operators.

7.2. Performance analysis and networks protocols

Participants: Mohammed Amer, Thomas Begin, Anthony Busson, Éric Fleury, Paulo Gonçalves Andrade, Yannick Léo, Isabelle Guérin Lassous, Philippe Nain, Huu Nghi Nguyen, Laurent Reynaud.

7.2.1. Use of large scale CDR for protocol performance evaluation and modelling

In [11] we use large scale CDR (Call Data Records) coming from a nationwide cellular telecommunication operator during a two month period to validate several DTN approaches for conveying SMS traffic in dense urban areas taking benefits of the density of users and the mobility of the users. We study a mobile dataset including 8 Million users living in large urban area. This gives us a precise estimation of the average transmission time and the global performance of our approach. Our analysis shows that after 30 min, half of the SMS are delivered successfully to destination. In [10], we study the temporal activity of a user and the user movements. At the user scale, the usage is not only defined by the amount of calls but also by the userâs mobility. At a higher level, the base stations have a key role on the quality of service. From a very large Call Detail Records (CDR) we first study call duration and inter-arrival time parameters. Then, we assess user movements between consecutive calls (switching from a station to another one). Our study suggests that user mobility is pretty dependent on user activity. Furthermore, we show properties of the inter-call mobility by making an analysis of the call distribution.

7.2.2. End-to-end delay

Because of the growing complexity of computer networks, a new paradigm has been introduced to ease their design and management, namely, the SDN (Software-defined Networking). In particular, SDN defines a new entity, the controller that is in charge of controlling the devices belonging to the data plane In order to let the controller take its decisions, it must have a global view on the network. This includes the topology of the network and its links capacity, along with other possible performance metrics such delays, loss rates, and available bandwidths. This knowledge can enable a multi-class routing, or help guarantee levels of Quality of Service. In [33], [20], [42], we proposed new algorithms that allow a centralised entity, such as the controller in an SDN network, to accurately estimate the end-to-end delay for a given flow in its network. The proposed methods are passive in the sense that they do not require any additional traffic to be run. Through extensive simulations, we show that these methods are able to accurately estimate the expectation and the standard deviation of end-to-end delays.

In [14] we investigated the traversal time of a file across N communication links subject to stochastic changes in the sending rate of each link. Each link's sending rate is modelled by a finite-state Markov process. Two cases, one where links evolve independently of one another (N mutually independent Markov processes), and the second where their behaviours are dependent (these N Markov processes are not mutually independent) were considered. A particular instance where the above is

7.2.3. Circumventing the complexity of multi-server queues

Many real-life systems can be viewed as instances of multi-server queues. However, when the number of servers is high (say more than 16) and the arrival or/and service process exhibit high variability, current state-of-the-art solutions often become intractable due to the combinatorial growth of the underlying state space of the Markov chain. We proposed two efficient, fast and easy-to-implement approximate solutions to deal with *G/G/c*-like queues in [4], [2]. Our solutions rely the use of an original, though incomplete, state description that heavily breaks the complexity of multi-server queues. We have extensively validated our approximations against discrete-event simulation for several QoS performance metrics such as mean sojourn time and blocking probability with excellent results.

7.2.4. Wi-Fi networks optimization

Densification of Wi-Fi networks has led to the possibility for a station to choose between several access points (APs). On the other hand, the densification of APs generates interference, contention and decreases the global throughput as APs have to share a limited number of channels. Optimizing the association step between APs and stations can alleviate this problem and increase the overall throughput and fairness between stations. We proposed original solutions [23], [22] to this optimization problem based on two contributions. First, we modeled the association optimization problem assuming a realistic share of the medium between APs and stations and among APs when using the 802.11 DCF (Distributed Coordination Function) mode. Then, we introduced a local search algorithm to solve this problem through a suitable neighborhood structure. We show that the classical approaches in the literature, based on a time based fairness scheme, is less efficient than our solution when the number of orthogonal channels is limited. Also, we show through a large set of simulations and scenarios that our models are able to capture the real throughputs of Wi-Fi networks.

7.2.5. Controlled mobility in wireless networks

In this work, we have investigated the application of an adapted controlled mobility strategy on self-propelling nodes, which could efficiently provide network resource to users scattered on a designated area. In [7], we describe an adapted controlled mobility strategy and detail the design of our Virtual Force Protocol (VFP) which allows a swarm of vehicles to track and follow hornets to their nests, while maintaining connectivity through a wireless multi-hop communication route with a remote ground station used to store applicative data such as hornet trajectory and vehicle telemetry. In [43], we design a physics-based controlled mobility strategy, which we name the extended Virtual Force Protocol (VFPe), allowing self-propelled nodes, and in particular here unmanned aerial vehicles, to fly autonomously and cooperatively. In this way, ground devices scattered on the operation site may establish communications through the wireless multi-hop communication routes formed by the network of aerial nodes. In [28], we design a virtual force-based controlled mobility scheme, named VFPc, and evaluate its ability to be jointly used with a dual packet-forwarding and epidemic routing protocol. In particular, we study the possibility for end-users to achieve synchronous communications at given times of the considered scenarios.

7.3. Modeling of Dynamics of Complex Networks

Participants: Christophe Crespelle, Éric Fleury, Márton Karsai, Yannick Léo, Philippe Nain, Matteo Morini.

7.3.1. Data Driven studies on socioeconomic data and communication networks

The study of correlations between the social network and economic status of individuals is difficult due to the lack of large-scale multimodal data disclosing both the social ties and economic indicators of the same population. Thanks to our collaboration with GranData, we close this gap through the analysis of coupled datasets recording the mobile phone communications and bank transaction history of one million anonymised individuals living in a Latin American country. From this large scale data set based on a representative, society-large population we empirically demonstrate some long-lasting hypotheses on socioeconomic correlations, which potentially lay behind social segregation, and induce differences in human mobility. More precisely, in [12] we show that wealth and debt are unevenly distributed among people in agreement with the Pareto principle; the observed social structure is strongly stratified, with people being better connected to others of their own socioeconomic class rather than to others of different classes; the social network appears to have assortative socioeconomic correlations and tightly connected âricher clubsâ; and that individuals from the same class live closer to each other but commute further if they are wealthier. In [41], we show that typical consumption patterns are strongly correlated with identified socioeconomic classes leading to patterns of stratification in the social structure. In addition we measure correlations between merchant categories and introduce a correlation network, which emerges with a meaningful community structure. We detect multivariate relations between merchant categories and show correlations in purchasing habits of individuals. Our work provides novel and detailed insight into the relations between social and consuming behaviour with potential applications in recommendation system design. In [36] we provide insight about the effects of marking events on the structure and the dynamics of egocentric networks. More precisely, we study the impact

of university admission on the composition and evolution of the egocentric networks of freshmen. In other words, we study whether university helps to build connections between egos from different socioeconomic classes, or new social ties emerge via homophilic effects between students of similar economic status. Finally, in [44],

7.3.2. Generalisation of multilayer and temporal graphs

In [16] we introduce the concept of MultiAspect Graph (MAG) as a graph generalisation that we prove to be isomorphic to a directed graph, and also capable of representing all previous generalisations of multilayer and temporal networks. In our proposal, the set of vertices, layers, time instants, or any other independent features are considered as an aspect of the MAG. For instance, a MAG is able to represent multilayer or time-varying networks, while both concepts can also be combined to represent a multilayer time-varying network and even other higher-order networks. Since the MAG structure admits an arbitrary (finite) number of aspects, it hence introduces a powerful modelling abstraction for networked complex systems. In [17] we develop the algebraic representation and basic algorithms for MultiAspect Graphs (MAGs). In particular, we show that, as a consequence of the properties associated with the MAG structure, a MAG can be represented in matrix form. Moreover, we also show that any possible MAG function (algorithm) can be obtained from this matrix-based representation. This is an important theoretical result since it paves the way for adapting well-known graph algorithms for application in MAGs. We present a set of basic MAG algorithms, constructed from well-known graph algorithms, such as degree computing, Breadth First Search (BFS), and Depth First Search (DFS).

Multilayer networks arise in scenarios when a common set of nodes form multiple networks via different co-existing, and sometimes interdependent means of connectivity. In [6] we studied the threshold on the occupation density in the individual network layers for long-range connectivity to emerge in a large multilayer network. For a multilayer network formed via merging M random instances of a graph G with site-occupation probability q in each layer, we showed that when q exceeds a threshold $q_c(M)$, a giant connected component appears in the M-layer network. We showed that $q_c(M) \lesssim \sqrt{-\ln(1-p_c)}/\sqrt{M}$, where p_c is the bond percolation threshold of G, and $q_c(1) \equiv q_c$ is by definition the site percolation threshold of G. We found $q_c(M)$ exactly for when G is a large random graph with any given node-degree distribution. We calculated $q_c(M)$ numerically for various regular lattices, and obtained an exact lower bound for the kagome lattice. Finally, we established an intriguing close connection between the aforesaid multilayer percolation model and the well-studied problem of site-bond (or, mixed) percolation, in the sense that both models provide a bridge between the traditional independent site and independent bond percolation models. Using this connection, and leveraging some analytical approximations to the site-bond critical region developed in the 1990s, we derived an excellent general approximation to the multilayer threshold $q_c(M)$ for regular lattices, which are not only functions solely of the p_c and q_c of the respective lattices, but also closely match the true values of $q_c(M)$ for a large class of lattices, even for small (single-digit) vales of M.

7.3.3. User-based representation of dynamical multimodal public transportation networks

In this project published as an invited paper [9], we provide a novel user-based representation of public transportation systems, which combines representations, accounting for the presence of multiple lines and reducing the effect of spatial embeddedness, while considering the total travel time, its variability across the schedule, and taking into account the number of transfers necessary. After the adjustment of earlier techniques to the novel representation framework, we analyse the public transportation systems of several French municipal areas and identify hidden patterns of privileged connections. Furthermore, we study their efficiency as compared to the commuting flow. The proposed representation could help to enhance resilience of local transportation systems to provide better design policies for future developments.

7.3.4. Local cascades induced global contagion

In this paper [8] we analyse and model product adoption dynamics in the world's largest voice over internet service, the social network of Skype. We provide empirical evidence about the heterogeneous distribution of fractional behavioural thresholds, which appears to be independent of the degree of adopting egos. We show that the structure of real-world adoption clusters is radically different from previous theoretical expectations,

since vulnerable adoptions induced by a single adopting neighbour appear to be important only locally, while spontaneous adopters arriving at a constant rate and the involvement of unconcerned individuals govern the global emergence of social spreading.

7.3.5. Asymptotic theory of time-varying social networks with heterogeneous activity and tie allocation

In this work [15] we empirically characterise social activity and memory in seven real networks describing temporal human interactions in three different settings: scientific collaborations, Twitter mentions, and mobile phone calls. We find that the individuals' social activity and their strategy in choosing ties where to allocate their social interactions can be quantitatively described and encoded in a simple stochastic network modelling framework. The Master Equation of the model can be solved in the asymptotic limit. The analytical solutions provide an explicit description of both the system dynamic and the dynamical scaling laws characterising crucial aspects about the evolution of the networks. The analytical predictions match with accuracy the empirical observations, thus validating the theoretical approach. Our results provide a rigorous dynamical system framework that can be extended to include other processes shaping social dynamics and to generate data driven predictions for the asymptotic behaviour of social networks.

7.3.6. Link prediction in the Twitter mention network

In this project [35] we analyse a large Twitter data corpus and quantify similarities between people by considering the set of their common friends and the set of their commonly shared hashtags in order to predict mention links among them. We show that these similarity measures are correlated among connected people and that the combination of contextual and local structural features provides better predictions as compared to cases where they are considered separately.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

8.1.1. 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 âbig dataâ to social relationships and human behaviour) to identify market trends and predict customer actions. Leading telecom and financial services firms are using Grandataâs Social Universe product to transform âbig dataâ 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.

8.1.2. STACC, Skype/Microsoft Labs

Participant: Márton Karsai [correspondant].

The Software Technology and Applications Competence Centre (STACC) is a research and development centre conducting high-priority applied research in the field of data mining and software and services engineering. Together with Skype/Microsoft Labs, STACC maintains a long lasting research collaboration with Márton Karsai (DANTE) on the modelling the adoption dynamics of online services.

8.2. Inria Alcatel-Lucent Bell Labs joint laboratory

Participants: Isabelle Guérin Lassous, Paulo Gonçalves Andrade, Thomas Begin, Éric Fleury [correspondant].

The main scientific objectives of the collaboration within the framework Inria Alcatel-Lucent Bell Labs joint laboratory is focused on network science:

- to design efficient tools for measuring specific properties of large scale complex networks and their dynamics;
- to propose accurate graph and dynamics models (*e.g.*, generators of random graph fulfilling measured properties);
- to use this knowledge with an algorithmic perspectives, for instance, for improving the QoS of routing schemes, the speed of information spreading, the selection of a target audience for advertisements, etc.

8.3. Bilateral Grants with Industry

8.3.1. Orange R&D

Participant: Isabelle Guérin Lassous.

A contract has been signed between Inria and France Télécom for the PhD supervision of Laurent Reynaud. The PhD thesis subject concerns mobility strategies for fault resilience and energy conservation in wireless networks.

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. Equipex FIT (Futur Internet of Things)

Participant: Éric Fleury [correspondant].

FIT is 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 5.8Ã¢ÂÂ¬ÃÅ¡ million grant from the French government Running from 22.02.11 – 31.12.2019. 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.

9.1.1.2. ANR GRAPHSIP (Graph Signal Processing)

Participants: Paulo Gonçalves Andrade [correspondant], Éric Fleury, Thomas Begin, Sarra Ben Alaya, Hadrien Hours.

An increasing number of application areas require the processing of massive datasets. These data can often be represented by graphs in order to encode complex interactions. When data vectors are associated with graph vertices, a so-called graph signal is obtained. The processing of such graph signals includes several open challenges because of the nature of the involved information. Indeed graph theory and signal and image processing methodologies do not combine readily. In particular, such a combination requires new developments, allowing classical signal processing methods to work on irregular grids and non Euclidean spaces. Considering the significant success of classical signal processing tools, it appears essential to generalise their use to graph signals. The GRAPHSIP project aims at developing a set of advanced methods and algorithms for the processing of graph signals: multi-scale transforms and solutions of variational problems on graphs. The major outcomes of this project are expected to lead to significant breakthroughs for graph data processing. The project will also focus on two novel applications on instances of graph signals: brain networks and 3D colour point clouds. They will exemplify and illustrate the proposed methodological advances on emerging applications.

9.1.1.3. ANR INFRA DISCO (DIstributed SDN COntrollers for rich and elastic network services)

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

The DANTE team will explore the way SDN (Software Designed Network) can change network monitoring, control, urbanisation and abstract description of network resources for the optimisation of services. More specifically, the team will address the issues regarding the positioning of SDN controllers within the network, and the implementation of an admission control that can manage IP traffic prioritisation.

9.1.1.4. ANR REFLEXION (REsilient and FLEXible Infrastructure for Open Networking)

Participants: Thomas Begin [correspondant], Anthony Busson, Isabelle Guérin Lassous, Guillaume Artero Gallardo, Zidong Su.

The DANTE team will work on the monitoring of NFV proposing passive and light-weight metrology tools. They will then investigate the modelling of low-level resources consumptions and finally propose methods to dynamically allocate these resources taking into account performance constraints.

9.1.1.5. ANR CONTINT CODDDE

Participants: Éric Fleury [correspondant], Christophe Crespelle, Márton Karsai, Hadrien Hours.

It is a collaborative project between the ComplexNetwork team at LIP6/UPMC; Linkfluence and Inria Dante. The CODDDE project aims at studying critical research issues in the field of real-world complex networks study:

- How do these networks evolve over time?
- How does information spread on these networks?
- How can we detect and predict anomalies in these networks?

In order to answer these questions, an essential feature of complex networks will be exploited: the existence of a community structure among nodes of these networks. Complex networks are indeed composed of densely connected groups of that are loosely connected between themselves.

The CODDE project will therefore propose new community detection algorithms to reflect complex networks evolution, in particular with regards to diffusion phenomena and anomaly detection.

These algorithms and methodology will be applied and validated on a real-world online social network consisting of more than 10 000 blogs and French media collected since 2009 on a daily basis (the dataset comprises all published articles and the links between these articles).

9.1.1.6. ANR SoSweet

Participants: Jean Pierre Chevrot, Éric Fleury, Márton Karsai [correspondant], Jean-Philippe Magué.

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 linguistics 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.

9.1.1.7. ANR DylNet

Participants: Jean Pierre Chevrot, Éric Fleury [correspondant], Márton Karsai.

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 (≈ 150) 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 childrenâs 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. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. EMBERS

Title: Enabling a Mobility Back-End as a Robust Service

Programm: H2020

Duration: December 2015 - November 2018

Coordinator: UPMC

Partners:

Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)

Technische Universitat Berlin (Germany)

Universite Pierre et Marie Curie - Paris 6 (France)

Ubiwhere Lda (Portugal)

Inria contact: Eric Fleury

EMBERS will bring to market a back-end for smart city mobility that is developed by a European small enterprise based upon its smart parking and smart traffic management products that two municipalities in Portugal currently deploy. The Mobility Back-end as a Service (MBaaS) replaces such all-in-one systems, in which a municipality purchases the full set of components from a single vendor. Instead, the city manager can purchase best-of-breed devices and apps developed by third parties, with the only constraint being that they interoperate with the back-end via a free, open, smart city mobility API. This domain-specific API lowers barriers to entry for app and device developers, making it easier for innovative SMEs to enter the market. Furthermore, the API is offered via a variety of generic interfaces, including oneM2M, ETSI M2M, OMA LWM2M, and FIWARE NGSI. EMBERS thus clears the way for developers and to municipalities that have adopted any one of these potential emerging machine-to-machine (M2M) communication standards. Beyond its primary goal of bringing the MBaaS to market, EMBERS will stimulate development of an entire ecosystem around the MBaaS smart city mobility API. Separating out the back-end from the other components will, however, require rigorous testing. EMBERS will experiment with the system on two testbeds that are part of the FIRE OneLab facility: the FUSECO Playground, for M2M communications, and FIT IoT-LAB, for wireless sensor devices. EMBERS will host a hackathon and an app challenge to bring in third party developers. The project will also include three demonstrators by third parties via an open call. These activities will contribute back to FIRE by demonstrating successful experimentation by SMEs developing close-to-market products. The project will also conduct real world pilots in two or more cities as a final step in bringing the MBaaS to market.

9.2.1.2. ARMOUR

Title: Large-Scale Experiments of IoT Security & Trust (Project nÂ°688237)

Programm: H2020

Duration: 2015 Dec to 2018

Coordinator: UPMC

Partners:

Synelixis Lyseis Pliroforikis Automatismou & Tilepikoinonion Monoprosopi EPE (Greece)

Smartesting Solutions & Services (France)

Unparallel Innovation, Lda (Portugal)

Easy Global Market (France)

ODIN Solutions (Spain)

Universite Pierre et Marie Curie - Paris 6 (France)

Inria contact: Eric Fleury

ARMOUR will provide duly tested, benchmarked and certified Security & Trust solutions for large-scale IoT using upgraded FIRE large-scale IoT/Cloud testbeds properly-equipped for Security & Trust experimentations. ARMOUR takes the top large-scale FIT IoT-LAB testbed â a FIRE OpenLAB / FIT IoT LAB facility â and enhances it as to enable experimentally-driven research on a key research dimension: large-scale IoT Security & Trust. Presently, no proper installations exist to experiment IoT Security & Trust on large-scale conditions; ARMOUR will develop and install such capability.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Declared Inria International Partners

Taiwan, ACADEMIA SINICA & IIIS. Signature of a MoU in the framework of IoT-LAB.

Algorithms research group of the University of Bergen, Norway. PICS project of CNRS on graph editing problems for analysis and modeling of complex networks.

9.3.1.2. Informal International Partners

University of Namur: Department of Mathematics/Naxys (Belgium). Collaboration with Renaud Lambiotte on dynamical processes on dynamical networks and communities detections.

Aalto University: Department of Biomedical Engineering and Computational Science (Finland). Collaboration with Jari Saramaki on modeling temporal networks and community like modular structure

Central European University (Hungary). Collaboration with János Kertész on modeling complex contagion phenomena.

ISI Foundation (Italy). Collaboration with Laetitia Gauvin on multiplex networks and transportation systems

University of South California (USA). Collaboration with Antonio Ortega on Graph Signal Processing

University of Pennsylvania (USA). Collaboration with Alejandro Ribeiro on Graph Signal Processing

LNCC, Petropolis (Brazil). Collaboration with Arthur Ziviani on Temporal Graph modeling ans algorithms.

College of Information and Computer Sciences at the University of Massachusetts Amherst.

University of California, Santa Cruz (USA). Collaboration with Alexandre Brandwajn on the solutions to multi-server queues.

9.3.2. Participation in Other International Programs

9.3.2.1. PHC Peridot

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

Framework for Control and Monitoring of Wireless Mesh Networks (WMN) using Software-Defined Networking (SDN). The main objective of this project is propose mechanisms and modifications in the SDN architecture, specifically in the OpenFlow, which allow SDN mechanisms to operate over WMN considering the dynamic network topology that WMN may experience and some other relevant characteristics. The project will involve devising mechanisms for controlling mesh switches through controllers in a wireless environment, which will require developing novel and WMN-specific rules, actions and commands. The project will involve proposing mechanism that consider dynamic environment of WMN along with providing redundancy in the network. Besides, there is a requirement to have an adaptive measurement API for WMN. This is the second objective of our research project. The proposed measurement API will enable the network operators to monitor network traffic over WMN which may be content-specific or host-specific. This is a joint project between DANTE and M. A. Jinnah University, Islamabad. It started in June 2015 and will end in June 2018.

9.3.2.2. STIC AMSUD UCOOL: Understanding and predicting human demanded COntent and mObiLity
Participants: Éric Fleury, Márton Karsai, Christophe Crespelle.

Finding new ways to manage the increased data usage and to improve the level of service required by the new wave of applications for smartphones is an essential issue nowadays. The improved understanding of user mobility (i.e. the context they experience) and the content they demand is of fundamental importance when looking for solutions for this problem in the modern communication landscape. The resulting knowledge can help at the design of more adaptable networking protocols or services as well as can help determining, for instance, where to deploy networking infrastructure, how to reduce traffic congestion, or how to fill the gap between the capacity granted by the infrastructure technology and the traffic load generated by mobile users.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Jacob Eisenstein

Date: May 2016

Institution: Georgia Tech (USA)

Alfred Hero

Date: May 2016

Institution: University of Michigan (USA)

Kimmo Kaski

Date: May 2016

Institution: Aalto University (Finland)

Nicola Perra

Date: June 2016

Institution:Greenwich University (England)

Alejandro Ribeiro

Date: June 2016

University of Pennsylvania (US)

János Kertész

Date: June-July 2016

Central European University (Hungary)

9.4.2. Visits to International Teams

9.4.2.1. Sabbatical programme

Begin Thomas

Date: Sep 2015 - Aug 2016

Institution: DIVA lab – University of Ottawa (Canada) on a CNRS grant and Inria sabbatical grant.

Christophe Crespelle

Date: Sep 2015 - Aug 2016

Institution: Institute of Mathematics, Vietnam Academy of Science and Technology, Hanoi (Vietnam) on a CNRS grant.

9.4.2.2. Research Stays Abroad

- Márton Karsai stayed 1 month at Aalto University Espoo, Finland
- Christophe Crespelle stayed 2 weeks at University of Bergen, Norway

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. General Chair, Scientific Chair

- Jean Pierre Chevrot, Éric Fleury, Márton Karsai, Jean-Philippe Magué were scientific chairs of the Workshop on Data Driven Approach to Networks and Language.
- Éric Fleury, Márton Karsai and Paulo Gonąlves were scientific chairs of the Workshop on Processes On and Of Networks.

10.1.1.2. Member of the Organizing Committees

- Éric Fleury, Mátrton Karsai and Laetitia Lecot were on the Organizing committee for the Network Science Thematic Semester
- Márton Karsai was in the organising committee of Computational Social Science: from social contagion to collective behaviour ECCS 2016 Satellite.

10.1.2. Scientific Events Selection

10.1.2.1. Chair of Conference Program Committees

- Isabelle Guérin Lassous was the general chair of ACM PE-WASUN 2016.
- Márton Karsai was the one of the program chairs of the conferences Do2Net, ComplexNetworks2016, D2NetLang, CSS2016.

10.1.2.2. Member of the Conference Program Committees

- Éric Fleury was on the PC of the conference ComplexNet, of the Conference on Complex Networks: From Theory to Interdisciplinary Applications, SensorNet 2017 and CoRes 2016.
- Márton Karsai was on the PC of the conferences NetSci-X 2016, IC2S2 2016, CompleNet 2016, WebSci16, Do2Net, AlgoTel 2016, ComplexNetworks2016, D2NetLang 2016, DyNo 2016 IEEE/ACM ASONAM 2016, CCS 2016, SocInfo 2016, CSS 2016, Contagion'16, COMPLEX NETWORKS 2016
- Isabelle Guérin Lassous was on the PC of: ACM MSWiM 2016, ICC 2016, Globecom 2016, ISCC 2016 and MedHocNet 2016.
- Thomas Begin was on the PC of: IEEE LCN 2016.
- Christophe Crespelle was on the PC of WG 2016.

10.1.2.3. Reviewer

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).
- Jean Pierre Chevrot, K. Drager (U. of Hawaii), P. Foulkes (U. of York) are the chief editors of a special issue in the journal TopiCS in Cognitive Science on the theme "Sociolinguistic variation and cognitive science, coordination".
- Philippe Nain is Editor-in-Chief of Performance Evaluation (Elsevier)

10.1.3.2. Reviewer - Reviewing Activities

- Márton Karsai was acting as 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,
- Jean-Pierre Chevrot was acting as reviewer for he journal Animal Behavior.

10.1.4. Invited Talks

- Márton Karsai gave invited talks at NetSciX'16 (January 2016, Wroclaw, Poland), Workshop on mechanisms underlying local to global signals in networks (19 May 2016, Lyon, France), HOMS NetSci'16 Satellite (30 May 2016, Seoul, Korea), Social Connectome NetSci'16 Satellite (30 May 2016, Seoul, Korea), SocioNet'16 workshop ENS Lyon (8 June 2016, Lyon, France), Coarse-graining of Complex Systems CCS'16 Satellite (21 September 2016, Amsterdam, The Netherlands), BURSTINESS in human behaviour and other natural phenomena, CCSÃ16 Satellite (21 September 2016, Amsterdam, The Netherlands), PhD course on Network Science (guest lecturer) Uppsala University, Department of Information Technology (18 November 2016, Uppsala, Sweden).
- Éric Fleury gave a invited talk at ISI foundation, Torino Italy and SocioNet'16 workshop ENS Lyon (8 June 2016, Lyon, France).
- Thomas Begin gave an invited talk at Diva Lab, University of Ottawa, Canada.
- Jean Pierre Chevrot gave two invited talks Ã the University of Oslo (Norway) at the Workshop Bridging gaps: Conceptual and epistemological approaches, Center for Multilingualism in Society across the Lifespan (MultiLing)
- Christophe Crespelle gave an invited talk at the Vietnam Institute for Advanced Studies in Mathematics, Hanoi, and the University of Bergen, Norway.

10.1.5. Leadership within the Scientific Community

10.1.6. Scientific Expertise

- Isabelle Guérin Lassous is a member of the research committee of the Milyon labex.
- Isabelle Guérin Lassous was a member of the HCERES evaluation committee of the IRISA laboratory.
- Isabelle Guérin Lassous is vice-chair of the HCERES evaluation committee of the LORIA laboratory.
- Isabelle Guérin Lassous was a member of the National Committee of the CNRS, section 06.
- Éric Fleury is member of the Inria senior research position (DR2) jury and junior research position (CR2/CR1)
- Éric Fleury has been an expert for the Fund for Scientific Research - FNRS.
- Éric Fleury has been a member of evaluation panels as part of the French National Research Agencyâs (ANR) for ANR.
- Éric Fleury is member of the Inria Evaluation Committee.
- Éric Fleury is Co-chair of the Networking group ResCom of the CNRS GDR ASR. He is also a member of the scientific committee of the GDR ASR.
- Márton Karsai was reviewer for ANR, H2020 FET Open RIA.
- Philippe Nain is the coordinator of the "Strategic Technology Monitoring & Prospective Studies Inria Unit".
- Jean-Pierre Chevrot reviewed a ten-year track application for the University of New Mexico (UNM, US)

10.1.7. Research Administration

- Paulo Gonçalves is scientific liaison officer for international relations in Inria Research Centre of Rhône-Alpes.
- Paulo Gonçalves was scientific correspondent of the International Relations for the Computer Science Department at ENS Lyon. Responsibility ended in September 2016.
- Paulo Gonçalves is a member of the executive committee of the Milyon labex and referent for its valorisation committee.
- Christophe Crespelle is member of the steering committee of the IXXI - Rhône-Alpes Complex Systems Institute.
- Isabelle Guérin Lassous is vice-chair 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 Vice-president of the Thesis Commission at LIP.
- Anthony Busson is member of the committee of “Ecole Doctorale” 512 in computer science and mathematics.
- Éric Fleury is Deputy Scientific Delegate for Inria Grenoble Rhône Alpes
- Éric Fleury is in the in the Executive Committee of the IXXI â Rhône-Alpes Complex Systems Institute.
- Éric Fleury is member of the Council of the LIP laboratory.
- Éric Fleury is a member of the executive committee of the Milyon labex.
- Anthony Busson is the vice president of the thesis committee of the LIP laboratory.
- Thomas Begin is an elected member of the Council of the LIP laboratory.
- Jean Pierre Chevrot is member of the steering committee of the IXXI - Rhône-Alpes Complex Systems Institute.
- Márton Karsai is the co-responsible for the M2 master program in Modelling of Complex Systems at ENS Lyon
- Márton Karsai is the elected council member of the Complex System Society (2015-)
- Márton Karsai is the elected member of the steering committee of the IXXI Complex System Institute (2016-)

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

10.2.1.1. Teaching by Éric Fleury

Éric Fleury is Professor at the Computer Science department of ENS de Lyon and holds a Inria chair.

Master: CR15 - Complex Networks, 18H, M2, ENS de Lyon, France

10.2.1.2. Teaching by Márton Karsai

Márton Karsai is Associate Professor at the Computer Science department of ENS de Lyon and holds a Inria chair.

Master: CR15 - Complex Networks, 21H, M2, ENS de Lyon, France

Master: Dynamical Processes on Networks, 6H, M2, ENS de Lyon, France

Master: Modeling Social Systems, 9H, M2, ENS de Lyon, France

Master: Complex Networks 16H, Collegio Carlo Alberto, Torino Italy (guest lecturer)

10.2.1.3. Teaching by Paulo Gonçalves

Engineering school CPE-Lyon (years 3-5): Signal Processing (80 hours/yr)

10.2.1.4. Teaching by Isabelle Guérin Lassous

Professor at Université Claude Bernard Lyon 1 in the Computer Science department since 2006. She lectures at the University.

Master: "Networking", 20h, Master (M1), University Lyon 1, France

Master: "QoS and Multimedia Networks", 30h, Master (M2), University Lyon 1, France

Master: "Wireless Networks", 15h, Master (M2), University Lyon 1, France

Master: "Introduction to Networking", 30h, Master (M2), University Lyon 1, France

10.2.1.5. Teaching by Anthony Busson

Professor at the IUT (Institut Universitaire de Technologie) of Université Claude Bernard Lyon 1 in the computer science department since 2012.

Master: "MPLS", 6h, Master (M2), University Lyon 1, France

DUT: full service (192h) in networking, opertaing-systems, and programmation.

10.2.1.6. Teaching by Thomas Begin

Assistant Professor at Université Claude Bernard Lyon 1 in the Computer Science department since 2009.

Master: "Networking", 20h, Master (M1), University Lyon 1, France

Master: "Advanced networks", 20h, Master (M2 SRIV), University Lyon 1, France

Master: "Computer networks", 20h, Bachelor (L3), University Lyon 1, France

Master: "Introduction to Networking", 30h, Master (M2 CCI), University Lyon 1, France

Master: "Distributed systems", 10h, Master (M1), University Lyon 1, France

10.2.1.7. Teaching by Christophe Crespelle

Assistant Professor at Université Claude Bernard Lyon 1 in the Computer Science department since 2009.

Master: "Complex networks", 15h, Master (M2), ENS de Lyon, France

Master: "Introduction to Computer Science", 30h, Master (M2), ENS de Lyon, France

Bachelor: "Combinatorial Optimisation", 18h, Bachelor (4th year), Vietnam National University in Hanoi, Vietnam

10.2.1.8. Teaching by Philippe Nain

University of Massachusetts at Amherst: graduate course on "Performance Modelling of Communication Networks and Distributed Systems" (32 hours).

10.2.2. Supervision

PhD defense: Yannick Léo, Deep dive into social network and economic data: a data driven approach for uncovering temporal ties, human mobility and socioeconomic correlations, ENS de Lyon, Dec 2016, Éric Fleury, Christophe Crespelle and Márton Karsai.

PhD in progress: Sarra Ben Alaya, Multi-scale classification and analysis of data on networks. Nov. 2015, P. Gonçalves (P. Borgnat, co-advisor)

PhD in progress: Esteban Bautista Ruiz, Statistical Graph Signal Processing. P. Gonçalves (P. Abry, co-advisor). Started Sept. 1st, 2016.

PhD in progress: Laurent Reynaud, Optimised mobility strategies for wireless networks. March 2013, I. Guérin Lassous

PhD in progress: Huu-Nghi Nguyen, Admission control in SDN networks. April 2014, T. Begin and A. Busson and I. Guérin Lassous

PhD in progress: Mohammed Amer, WiFi network management: a SDN approach. January 2015, A. Busson and I. Guérin Lassous

PhD in progress: Matteo Morini, New tools for understanding the dynamics of social networks, Oct 2013, E. Fleury, P. Jensen and M. Karsai

PhD in progress: Samuel Unicomb, Spreading processes on temporal networks, Oct 2016, E. Fleury and M. Karsai

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

PhD in progress: Marija Stojanova, Performance Modelling of IEEE 802.11 networks , Oct 2016, T. Begin

PhD in progress: Imen Achour, Data Dissemination Protocols for Vehicular Ad hoc Networks, informal supervising by A. Busson with T. Bejaoui and S. Tabbane (Supcom - Tunis)

10.2.3. Juries

- Isabelle Guérin Lassous was a member of the HDR examination boards of Christoph Neumann at Technicolor/Université de Rennes 1 and Frédéric Le Mouël at INSA de Lyon.
- Isabelle Guérin Lassous was a member of the Ph.D thesis examination board of Guillaume Gaillard at INSA de Lyon.
- Éric Fleury was member and reviewer of the HdR examination board of Tommasso Venturini at ENS de Lyon.
- Éric Fleury was president of the PhD examination boards of Michal Krol at UGA.
- Anthony Busson was member of the PhD examination boards of Lyad Cherif at Université Paris XI. December 2016.
- Anthony Busson was member of the PhD examination boards of Saiefeddine Bouallegue at Sup'Com / University of Carthage. June 2016.
- Anthony Busson was member of the mid-term examination boards for the PhD of Tu Lam Thanh at Supélèc. November 2016.

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