IN PARTNERSHIP WITH:
CNRS

Ecole normale supérieure de Lyon

Université Claude Bernard (Lyon 1)

Activity Report 2015

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:

1.2. - Networks
1.2.4. - QoS, performance evaluation
1.2.5. - Internet of things
1.2.6. - Sensor networks
1.2.9. - Social Networks
3.4.1. - Supervised learning
3.5. - Social networks
3.5.1. - Analysis of large graphs
5.9. - Signal processing
5.9.4. - Signal processing over graphs
7.10. - Network science
7.9. - Graph theory

Other Research Topics and Application Domains:

2.3. - Epidemiology
6. - IT and telecom
6.3.4. - Social Networks
6.4. - Internet of things
9.4.1. - Computer science
9.4.5. - Data science
9.5.8. - Linguistics

1. Members

Research Scientist

Paulo Gonçalves Andrade [Inria, Senior Researcher, HdR]

Faculty Members

Éric Fleury [Team leader, ENS Lyon, Professor, Inria Chair, HdR]
Thomas Begin [Univ. Lyon I, Associate Professor (research leave at University of Ottawa, Canada since Septembre 2015)]
Anthony Busson [Univ. Lyon I, Associate Professor]
Jean Pierre Chevrot [Univ. Grenoble II, Professor, from Sep 2015]
Christophe Crespelle [Univ. Lyon I, Associate Professor (research leave at Institute of Mathematics, Vietnam Academy of Science and Technology since Septembre 2014)]
Isabelle Guérin Lassous [Univ. Lyon I, Professor, HdR]
Márton Karsai [ENS Lyon, Associate Professor, Inria Chair]

PhD Students

Mohammed Amer [Gouvernement Algérien]
Sarra Ben Alaya [ENS de Lyon, from Nov 2015]
Benjamin Girault [Inria, until Dec. 2015]

Yannick Leo [ENS de Lyon]
Lucie Martinet [ENS de Lyon, until Nov 2015]
Matteo Morini [Università degli Studi di Torino]
Huu Nghi Nguyen [ENS de Lyon]
Laurent Reynaud [France Telecom]
Thiago Wanderley Matos de Abreu [ENS de Lyon, until March 2015]

Post-Doctoral Fellows
Guillaume Artero Gallardo [ENS Lyon, from Jul 2015]
Hadrien Hours [CNRS, from Nov 2015]
Yongjun Liao [Inria, from Jul 2015]

Visiting Scientists
Imen Achour Mtar [foreign university, from Apr 2015 until Jul 2015]
Tommaso Panini [Università degli Studi di Torino, until Jan 2015]
Prasan Kumar Sahoo [Chang Gung Univ., invited professor at Univ. Lyon I, Jul 2015]
Amir Qayyum [M. A. Jinnah University, Sep. 2015]

Administrative Assistants
Virginie Bouyer [Inria, until Apr 2015]
Laetitia Lecot [Inria]

Others
Willy Bechier [ENS Lyon, internship, from Jun 2015 until Jul 2015]
Floran Berthaud [Univ. Lyon I, internship, from Nov 2014 until Jan 2015]
Omar Dahmani [Inria, Master internship, from Feb 2015 until Jul 2015]

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.

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

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

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

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

3. Research Program

3.1. Graph-based signal processing

Participants: Christophe Crespelle, Éric Fleury, Paulo Gonçalves Andrade, Márton Karsai, Benjamin Girault, 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 [66].

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 [50]. 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.*, ([61] and references therein). Other viewpoints can be found as well, including multi-resolution Markov models [69], Bayesian networks or distributed processing over sensor networks [60]. 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 [51].

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 [63]. 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 [63], [54], [70], [59], to describe the observed structural and temporal heterogeneities [48], [54], [49], to detect and measure emerging community structures [52], [67], [68], to see how the functionality of networks determines their evolving structure [58], and to determine what kinds of correlations play a role in their dynamics [55], [57], [62].

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 [65]. 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 [56] and its co-evolution with ongoing processes like spreading phenomena, synchronisation, evolution of consensus, random walk etc. [56], [64]. 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 modeling 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 modeling 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 characterize the topology and temporal behavior 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 behavior of very complicated systems.

In this endeavor 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 anonymized 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 (anonymized) 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. MOSAR results published

The joint analysis of carriage and Close proximity interactions (CPIs) showed that CPI paths linking incident cases to other individuals carrying the same strain (i.e. possible infectors) had fewer intermediaries than predicted by chance ($P < 0.001$), a feature that simulations showed to be the signature of transmission along CPIs. Additional analyses revealed a higher dissemination risk between patients via healthcare workers than via other patients. In conclusion, S. aureus transmission was consistent with contacts defined by electronically collected CPIs, illustrating their potential as a tool to control hospital-acquired infections and help direct surveillance [19], [18].

5.1.2. Time-varying social networks

. We introduce a temporal network model with adjustable community structure and emergent weight-topological correlations via the extension of the activity-driven time-varying network model. the model These model take into account: i) reinforcement processes to model memory-driven interaction dynamics of individuals; ii) focal and cyclic closure to capture patterns responsible for the emerging community structure,; iii) a node removal process. Using this temporal network model we demonstrate the effect of the scalable community structure and social reinforcement on information spreading, which co-evolves with the time-varying interactions [16].

5.1.3. Stationarity for graph signals

In a series of published works [14], [40], [36], [24], we formalised the concept of stationarity for graph signals. First, we had to introduce a new definition of graph-shift operator that, in contrast to the current alternatives, is isometric. Then, based on this operator preserving the L^2-norm of graph signals, we were able to rigorously characterise the statistical property of wide sense stationarity for graph signals. Stationarity is a central concept in the theory of signal and image processing but was still lacking for graph signals. This contribution should now foster the development of a mathematically sound framework for graph signal processing.

5.1.4. Awards

FIT IoT Lab and OneLab received the best demo award at TRIDENTCOM 2015, 10th EAI International Conference on Testbeds and Research Infrastructures for the Development of Networks & Communities, Vancouver, Canada, June 24–25, 2015.

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: http://perso.ens-lyon.fr/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: Éric 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: Éric 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. 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: Frédéric Saint-Marcel

6.6. Queueing Systems

KEYWORDS: Performance Evaluation - Queueing Models
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/

6.7. WSNet

KEYWORD: Network simulator
FUNCTIONAL DESCRIPTION

The WSNet-3.0 project objective is to develop the next evolution of the WSNet simulator. It 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.

- Participants: Rodrigue Domga Komguem, Quentin Lampin, Alexandre Mouradian and Fabrice Valois
- Partner: CEA-LETI
- Contact: Fabrice Valois
- URL: https://gforge.inria.fr/projects/wsnet-3/

6.8. Platforms

6.8.1. 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 Research's "Équipements d'Excellence" (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: Paulo Gonçalves Andrade, Éric Fleury, Benjamin Girault, Sarra Ben Alaya.

Isometric Graph shift operator. In [14], [40], we proposed a new shift operator for graph signals, enforcing that our operator is isometric. Doing so, we ensure that as many properties of the time shift as possible get carried over. Finally, we show that our operator behaves reasonably for graph signals.

Stationary graph signals. We extended the concept of stationary temporal signals to stationary graph signals [24]. We introduced the concept of strict sense stationary and wide sense stationary graph signals as a statistical invariance through an isometric graph translation. Using these definitions, we proposed a spectral characterisation of WSS graph signals allowing to study stationarity using only the spectral components of a graph signal. Finally, we applied this characterisation to a synthetic graph in order to study a few important stochastic graph signals. Also, using geographic data, we analysed data from a graph set of weather stations and showed evidence of stationarity in the temperature signal [36].

Community mining with graph filters for correlation matrices. Communities are an important type of structure in networks. Graph filters, such as wavelet filter-banks, have been used to detect such communities as groups of nodes more densely connected together than with the outsiders. When dealing with times series, it is possible to build a relational network based on the correlation matrix. However, in such a network, weights assigned to each edge have different properties than those of usual adjacency matrices. As a result, classical community detection methods based on modularity optimisation are not consistent and the modularity needs to be redefined to take into account the structure of the correlation from random matrix theory. In our contribution [34], we addressed how to detect communities from correlation matrices, by filtering global modes and random parts using properties that are specific to the distribution of correlation eigenvalues. Based on a Louvain approach, an algorithm to detect multiscale communities was also developed, which yields a weighted hierarchy of communities. The implementation of the method using graph filters was also discussed.

A strong Tauberian theorem for characteristic functions. In [20], we showed that a characteristic function which can be approximated at 0 by any polynomial of order n is actually n-times differentiable at 0. This fact is exploited to strengthen a tauberian-type result by Lukacs and provides the theoretical basis for a wavelet based non-parametric estimator of the tail index of a distribution. This work is a technical improvement of our previous contribution [53].

Fractal Analysis of Fetal Heart Rate Variability. The fetal heart rate (FHR) is commonly monitored during labor to detect early fetal acidosis. FHR variability is traditionally investigated using Fourier transform, often with adult predefined frequency band powers and the corresponding LF/HF ratio. However, fetal conditions differ from adults and modify spectrum repartition along frequencies. The study we reported in [12] questioned the arbitrariness definition and relevance of the frequency band splitting procedure, and thus of the calculation of the underlying LF/HF ratio, as efficient tools for characterising intrapartum FHR variability. Then, we showed that the intrapartum FHR is characterised by fractal temporal dynamics and promotes the Hurst parameter as a potential marker of fetal acidosis. This parameter preserves the intuition of a power frequency balance, while avoiding the frequency band splitting procedure and thus the arbitrary choice of a frequency separating bands. The study also shows that extending the frequency range covered by the adult-based bands to higher and lower frequencies permits the Hurst parameter to achieve better performance for identifying fetal acidosis.

7.2. Performance analysis and networks protocols

Participants: Paulo Gonçalves Andrade, Thomas Begin, Anthony Busson, Isabelle Guérin Lassous, Laurent Reynaud, Thiago Wanderley Matos de Abreu.

Global computing-network-visualisation. The PetaFlow application aims to contribute to the use of high performance computational resources for the benefit of society. To this goal the emergence of adequate information and communication technologies with respect to high performance computing-networking-visualisation and their mutual awareness is required. In the work published in [5], we present the developed technology and the algorithms that we applied to a real global peta-scale data intensive scientific problem with social and medical importance, i.e. human upper airflow modeling.

Performance analysis of multi-hop flows in IEEE 802.11 networks Multi-hop wireless networks are often regarded as a promising means to extend the limited coverage area offered by WLANs. However, they are usually associated with poor and uncertain performance in terms of available bandwidth and packet losses, which clearly stands as a limitation to their use. In [7], we consider the performance evaluation of a multi-hop path (also called chain), based on the IEEE 802.11 DCF. The proposed modeling framework is constructive and versatile, so that it can handle various types of multi-hop wireless paths, including scenarios with two flows in opposite directions, and topologies where nodes are exposed to the well-known hidden node problem. The models derived from our framework are conceptually simple, easy to implement and produce generally accurate results for the attained goodput of flows, as well as the datagram loss probability. Typical relative errors for these two quantities are below a few percent. Also, fundamental phenomena occurring in multi-hop wireless networks such as performance collapse and starvation, are well captured by the models.

Passive Measurement-based Estimator for the Standard Deviation of the End-to-End Delay. Emerging architectures for computer networks such as SDN aim at offering a better handling of flows with stringent requirements of QoS. On the one hand, operators would benefit from a detailed description of common network performance (e.g., end-to-end delay and end-to end loss ratio) including their first two moments, namely mean and standard deviation. Indeed, for many applications, the variability in the end-to-end delay (e.g., jitter) deeply affects the actual QoS experienced by a flow. On the other hand, the cost and nuisance associated with the instrumentation, the measurements, and the computations must be kept as low as possible. This typically prevents the availability of end-to-end measurements. In [30], we propose an algorithm to estimate the second moment of the end-to-end delay experienced by the packets of a flow based only on delay measurements locally collected by the network nodes. Our solution estimates the standard deviation of the end-to-end delay in an easy and computationally efficient way. Based on thousands of simulations using a real-life trace, our solution is found to be accurate, typically differing by only a few percent from the actual value of the standard deviation of the end-to-end delay.

Design of a force-based controlled mobility on aerial vehicles for pest management. Vespa velutina, also known as the Asian hornet, is considered as an invasive species out of its native zone. In particular, since it preys on honey bees, its recent progression in Europe could soon pose a significant risk to the local apiculture activity. European beekeepers are therefore investigating adapted control strategies, including V. velutina nest destruction. Unfortunately, nest location pinpointing generally follows a manual process which can prove tedious, time-consuming and inaccurate. In [31], we propose the use of a network of micro aerial vehicles featuring autonomous and cooperative flight capabilities. 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 order to achieve the mission objectives with a minimum of vehicles, we identify through simulations appropriate value for the key parameters of VFP and discuss the obtained network performance.

Channel assignment in IEEE 802.11-based substitution networks. A substitution network is a rapidly deployable wireless network that provides a backup solution to quickly react to failures on an existing network. We assume that the substitution network uses Wi-Fi technology and that wireless routers are equipped with several Wi-Fi cards. The problem, addressed in this work, deals with the channel assignment to these wireless interfaces. In this particular context, there is only one source-destination pair for which paths are known in advance. It is then possible to derive an objective function, function of the channel assignment, that very precisely reflects the overall throughput that can be achieved in this network. This problemis formulated through a linear optimization problem for which we propose different heuristics. Simulation results, performed with ns-3, consider several scenarios, and compare our heuristics to the optimum. Simulations show that, with only a few wireless cards, the throughput is signifficantly increased. Also, we show that the objective function fits to the throughput measured with ns-3.

Performance evaluation and message dissemination in vehicular networks. Vehicular Ad-Hoc Network (VANET) is becoming a promising technology for improving the efficiency and the safety of Intelligent Transportation Systems (ITS). Smart vehicles are expected to continuously exchange a huge amount of data either through safety or non-safety messages dedicated for road safety or infotainment and passenger comfort applications, respectively. In this context we proposed two contributions: the estimation of the capacity offered by the wireless network [13] in order to dimension the applications, and the proposal of an efficient message dissemination protocol [25].

Performance Evaluation of Cloud Computing Centers with General Arrivals and Service. Cloud providers need to size their systems to determine the right amount of resources to allocate as a function of customer's needs so as to meet their SLAs (Service Level Agreement), while at the same time minimizing their costs and energy use. Queueing theory based tools are a natural choice when dealing with performance aspects of the QoS (Quality of Service) part of the SLA and forecasting resource utilization. The characteristics of a cloud center lead to a queueing system with multiple servers (nodes) in which there is potentially a very large number of servers and both the arrival and service process can exhibit high variability. We propose to use a G/G/c-like model to represent a cloud system and assess expected performance indices. Given the potentially high number of servers in a cloud system, we present an efficient, fast and easy-to-implement approximate solution. We have extensively validated our approximation against discrete-event simulation for several QoS performance metrics such as task response time and blocking probability with excellent results. We apply our approach to examples of system sizing and our examples clearly demonstrate the importance of taking into account the variability of the tasks arrivals and thus expose the risk of under- or over-provisioning if one relies on a model with Poisson assumptions [8].

Prediction of the System Performance from components models. In this paper we consider the problem of combining calibrated performance models of system components in order to predict overall system performance. We focus on open workload system models, in which, under certain conditions, obtaining and validating the overall system performance measures can be a simple application of Little's law. We discuss the conditions of applicability of such a simple validation methodology, including examples of successful application, as well as examples where this approach fails. Additionally, we propose to analyze the deviations between the model predictions and system measurements, so as to decide if they correspond to "measurement noise" or if an important system component has not been correctly represented. This approach can be used as an aid in the design of validated system performance models [26].

7.3. Modeling of Dynamics of Complex Networks

Participants: Christophe Crespelle, Éric Fleury, Márton Karsai, Yannick Leo, Matteo Morini.

Non-Altering Time Scales for Aggregation of Dynamic Networks into Series of Graphs [29] Many dynamic networks coming from real-world contexts are *link streams*, i.e. a finite collection of triplets (u, v, t) where u and v are two nodes having a link between them at time t. A great number of studies on these objects start by aggregating the data on disjoint time windows of length Δ in order to obtain a series of graphs on which are made all subsequent analyses. Here we are concerned with the impact of the chosen Δ on the obtained graph series. We address the fundamental question of knowing whether a series of graphs formed using a given Δ faithfully describes the original link stream. We answer the question by showing that such dynamic networks exhibit a threshold for Δ, which we call the *saturation scale*, beyond which the properties of propagation of the link stream are altered, while they are mostly preserved before. We design an automatic method to determine the saturation scale of any link stream, which we apply and validate on several real-world datasets.

Termination of the Iterated Strong-Factor Operator on Multipartite Graphs [10] The clean-factor operator is a multipartite graph operator that has been introduced in the context of complex network modelling. Here, we consider a less constrained variation of the clean-factor operator, named strong-factor operator, and we prove that, as for the clean-factor operator, the iteration of the strong-factor operator always terminates, independently of the graph given as input. Obtaining termination for all graphs using minimal constraints on the definition of the operator is crucial for the modelling purposes for which the clean-factor operator has been introduced. Moreover we show that the relaxation of constraints we operate not only preserves termination but also preserves the termination time, in the sense that the strong-factor series always terminates before the clean-factor series.

On the Termination of Some Biclique Operators on Multipartite Graphs [9] We define a new graph operator, called the *weak-factor graph*, which comes from the context of complex network modelling. The weak-factor operator is close to the well-known clique-graph operator but it rather operates in terms of bicliques in a multipartite graph. We address the problem of the termination of the series of graphs obtained by iteratively applying the weak-factor operator starting from a given input graph. As for the clique-graph operator, it turns out that some graphs give rise to series that do not terminate. Therefore, we design a slight variation of the weak-factor operator, called *clean-factor*, and prove that its associated series terminates for all input graphs. In addition, we show that the multipartite graph on which the series terminates has a very nice combinatorial structure: we exhibit a bijection between its vertices and the chains of the inclusion order on the intersections of the maximal cliques of the input graph.

Directed Cartesian-Product Decomposition [11]. In this paper, we design an algorithm that, given a directed graph G and the Cartesian-product decomposition of its underlying undirected graph $\widetilde{G}$, produces the directed Cartesian-product decomposition of G in linear time. This is the first time that the linear complexity is achieved for this problem, which has two major consequences. Firstly, it shows that the directed and undirected versions of the Cartesian-product decomposition of graphs are linear-time equivalent problems. And secondly, as there already exists a linear-time algorithm for solving the undirected version of the problem, combined together, it provides the first linear-time algorithm for computing the directed Cartesian-product decomposition of a directed graph.

An $O(n^2)$ time Algorithm for the Minimal Permutation Completion Problem [28] We provide an $O(n^2)$ time algorithm computing a minimal permutation completion of an arbitrary graph $G = (V, E)$, i.e., a permutation graph $H = (V, F)$ on the same vertex set, such that $E \subseteq F$ and F is inclusion-minimal among all possibilities.

Linearity is Strictly More Powerful than Contiguity for Encoding Graphs [27] Linearity and contiguity are two parameters devoted to graph encoding. Linearity is a generalisation of contiguity in the sense that every encoding achieving contiguity k induces an encoding achieving linearity k, both encoding having size $\Theta(k.n)$, where n is the number of vertices of G. In this paper, we prove that linearity is a strictly more powerful encoding than contiguity, i.e. there exists some graph family such that the linearity is asymptotically negligible in front of the contiguity. We prove this by answering an open question asking for the worst case linearity of a cograph on n vertices: we provide an $O(\log n/ \log\log n)$ upper bound which matches the previously known lower bound.

Socioeconomic correlations in communication networks [37], [38] In this work we study the socioeconomic structure of a communication network by combining mobile communication records and bank credit informations of a large number of individuals living in Mexico. We provide empirical evidences about present economic unbalances suggesting not only the distribution of wealth but also the distribution of debts to follow the Pareto principle. Further we study the internal and interconnected structure of socioeconomic groups. Through a weighted core analysis we signal assortative correlations between people regarding their economic capacities, and show the existence of "rich-clubs" indicating present social stratification in the social structure. This project is ongoing with final results expected in 2016.

Detecting global bridges in networks [15] The identification of nodes occupying important positions in a network structure is crucial for the understanding of the associated real-world system. Usually, betweenness centrality is used to evaluate a node capacity to connect different graph regions. However, we argue here that this measure is not adapted for that task, as it gives equal weight to "local" centers (i.e. nodes of high degree central to a single region) and to "global" bridges, which connect different communities. This distinction is important as the roles of such nodes are different in terms of the local and global organisation of the network structure. In this paper we propose a decomposition of betweenness centrality into two terms, one highlighting the local contributions and the other the global ones. We call the latter bridgeness centrality and show that it is capable to specifically spot out global bridges. In addition, we introduce an effective algorithmic implementation of this measure and demonstrate its capability to identify global bridges in air transportation and scientific collaboration networks.

Collective attention in the age of (mis)information [17] We study, on a sample of 2.3 million individuals, how Facebook users consumed different information at the edge of political discussion and news during the last Italian electoral competition. Pages are categorized, according to their topics and the communities of interests they pertain to, in a) alternative information sources (diffusing topics that are neglected by science and main stream media); b) online political activism; and c) main stream media. We show that attention patterns are similar despite the different qualitative nature of the information, meaning that unsubstantiated claims (mainly conspiracy theories) reverberate for as long as other information. Finally, we categorize users according to their interaction patterns among the different topics and measure how a sample of this social ecosystem (1279 users) responded to the injection of 2788 false information posts. Our analysis reveals that users which are prominently interacting with alternative information sources (i.e. more exposed to unsubstantiated claims) are more prone to interact with false claims.

The Scaling of Human Contacts in Reaction-Diffusion Processes [22] We present new empirical evidence, based on millions of interactions on Twitter, confirming that human contacts scale with population sizes. We integrate such observations into a reaction-diffusion metapopulation framework providing an analytical expression for the global invasion threshold of a contagion process. Remarkably, the scaling of human contacts is found to facilitate the spreading dynamics. Our results show that the scaling properties of human interactions can significantly affect dynamical processes mediated by human contacts such as the spread of diseases, and ideas.

From calls to communities: a model for time varying social networks [16] Social interactions vary in time and appear to be driven by intrinsic mechanisms, which in turn shape the emerging structure of the social network. Large-scale empirical observations of social interaction structure have become possible only recently, and modelling their dynamics is an actual challenge. Here we propose a temporal network model which builds on the framework of activity-driven time-varying networks with memory. The model also integrates key mechanisms that drive the formation of social ties - social reinforcement, focal closure and cyclic closure, which have been shown to give rise to community structure and the global connectedness of the network. We compare the proposed model with a real-world time-varying network of mobile phone communication and show that they share several characteristics from heterogeneous degrees and weights to rich community structure. Further, the strong and weak ties that emerge from the model follow similar weight-topology correlations as real-world social networks, including the role of weak ties.

Kinetics of Social Contagion [21] Diffusion of information, behavioural patterns or innovations follows diverse pathways depending on a number of conditions, including the structure of the underlying social network, the sensitivity to peer pressure and the influence of media. Here we study analytically and by simulations a general model that incorporates threshold mechanism capturing sensitivity to peer pressure, the effect of 'immune' nodes who never adopt, and a perpetual flow of external information. While any constant, non-zero rate of dynamically-introduced innovators leads to global spreading, the kinetics by which the asymptotic state is approached show rich behaviour. In particular we find that, as a function of the density of immune nodes, there is a transition from fast to slow spreading governed by entirely different mechanisms. This transition happens below the percolation threshold of fragmentation of the network, and has its origin in the competition between cascading behaviour induced by innovators and blocking of adoption due to immune nodes. This change is accompanied by a percolation transition of the induced clusters.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

8.1.1. HiKoB

Participant: Éric Fleury.

A bilateral contract has been signed between the DANTE Inria team and HiKoB to formalise their collaboration in the context of the Equipex FIT (Futur Internet of Things) 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 5.8 euros 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.

8.1.2. 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 behavior) 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. As a part of this collaboration Carlos Sarraute (Grandata - R&D Director) visited the Dante team on November and Yannick Leo (DANTE - PhD student) visited Grandata office in Buenos Aires in 2014 December.

8.1.3. 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 modeling 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.

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 5.8â¬Âš 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

Participants: Paulo Gonçalves Andrade, 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 prioritization.

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.

The DANTE team will work on the monitoring of NFV proposing passive and light-weight metrology tools. They will then investigate the modeling 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 RESCUE

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

In the RESCUE project, we investigate both the underlying mechanisms and the deployment of a substitution network composed of a fleet of dirigible wireless mobile routers. Unlike many projects and other scientific works that consider mobility as a drawback, in RESCUE we use the controlled mobility of the substitution network to help the base network reduce contention or to create an alternative network in case of failure. The advantages of an on-the-fly substitution network are manifold: Reusability and cost reduction; Deployability; Adaptability.

The RESCUE project addresses both the theoretical and the practical aspects of the deployment of a substitution network. From a theoretical point of view, we will propose a two-tiered architecture including the base network and the substitution network. This architecture will describe the deployment procedures of the mobile routing devices, the communication stack, the protocols, and the services. The design of this architecture will take into account some constraints such as quality of service and energy consumption (since mobile devices are autonomous), as we want the substitution network to provide more than a best effort service. From a practical point of view, we will provide a proof of concept, the architecture linked to this concept, and the necessary tools (*e.g.*, traffic monitoring, protocols) to validate the concept and mechanisms of on-the-fly substitution networks. At last but not least, we will validate the proposed system both in laboratory testbeds and in a real-usage scenario.

9.1.1.7. ANR FETUSES

Participant: Paulo Gonçalves Andrade.

The goals of this ANR project consist in the development of statistical signal processing tools dedicated to per partum fetal heat rate characterization and acidosis detection, and are organized as follows: *(i)* construction of a large dataset of per partum fetal heart rate recordings, which is well documented and of significant clinical value; *(ii)* Developments of adaptive (*e.g.* data driven) algorithms to separate data into trend (deceleration induced by contractions) and fluctuation (cardiac variability) components; *(iii)* Developments of algorithms to characterize the non stationary and multifractal properties of per partum fetal heart rate ; *(iv)* Acidosis detection and assessment using the large datasets; *(v)* Algorithm implementation for performing tests in real clinical situations. ANR is a joint project between DANTE, the Physics Lab of ENS de Lyon (SiSyPhe team) and the *Hôpital Femme-Mère-Enfant* of Bron (Lyon). Fetuses started in january 2012 and ended in june 2015.

9.1.1.8. ANR SoSweet

Participants: Éric Fleury, Márton Karsai.

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 behaviors. 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. 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: 2015, Dec to 2019

Coordinator: UPMC

Partners: UPMC, LIP6, France; UBIWHERE Lda, Portugal; Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung, Germany; Technische Universitaet Berlin, Germany; Inria, France

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.

9.2.1.2. ARMOUR

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

Programm: H2020

Duration: 2015 Dec to 2018

Coordinator: UPMC

Partners: UPMC, LIP6, France; Synelixis Lyseis Pliroforikis Automatismou & Tilepikoinonion Monoprosopi EPE, Greece; Smartesting Solutions & Services, France; Unparallel Innovation, Lda, Portugal; Easy Global Market, France; ODIN Solutions, Spain;

Inria contact: Eric Fleury

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 – a FIRE OpenLAB / FIT IoT LAB facility – 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

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

UPC (Spain): Department of Telematic Engineering. Collaboration with Monica Aguilar Igartua and Luis J. de la Cruz Llopis on vehicular and community networks.

University of Bergen: Institute of Computer Science (Norway). Collaboration with Pinar Heggernes on graph editing problems for analysis and modeling of complex networks.

Ecole Polytechnique Fédérale de Lausanne (Switzerland). Collaboration with Pierre Vandergheynst on Graph Signal Processing

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

Algorithms group: University of Bergen, Institute of Computer Science (Norway).

Collaboration with Pinar Heggernes on graph editing problems for analysis and modeling of complex networks.

Algorithmics group: University of Konstanz, Department of Computer and Information Science (Germany).

Collaboration with Ulrik Brandes on graph editing problems for analysis and modeling of complex networks.

9.3.1.1. Declared Inria International Partners

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

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 predictin 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

Sahoo Prasan Kumar

Date: July 2015

Institution: Chang Gung University (Taiwan)

9.4.2. Visits to International Teams

9.4.2.1. Sabbatical programme

Begin Thomas

Date: Sep 2015 - Aug 2016

Institution: University of Ottawa (Canada)

Thomas Begin is on a research leave at DIVA lab - University of Ottawa - Canada for the 2015 - 2016 academic year. This leave is funded through a CNRS grant (délégation CNRS) & Inria grant (Sabatic grant).

Christophe Crespelle

Date: Sep 2015 - Aug 2016

Institution: Institute of Mathematics, Vietnam Academy of Science and Technology (Vietnam)

Christophe Crespelle is in CNRS delegation for academic year 2015-2016 at the Institute of Mathematics, Vietnam Academy of Science and Technology, Hanoï

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific events organisation

10.1.1.1. Member of the organizing committees

- Paulo Gonçalves was president of the organising committee of the 25th conference GRETSI 2015 on Signal and Image Processing. The conference was held at ENS de Lyon on Sept. 8-11, 2015 and gathered 550 participants.
- Paulo Gonçalves was co-organiser of the special session on *Methodologies for Signal Processing on Graphs* at Eusipco 2015.

10.1.2. Scientific events selection

10.1.2.1. Chair of conference program committees

- Paulo Gonçalves is officer of the local liaison board of EURASIP

10.1.2.2. Member of the conference program committees

- Thomas Begin is PC member of IEEE LCN 2015
- Christophe Crespelle is PC member of MARAMI 2015
- Christophe Crespelle is PC member of IEEE NetSciCom 2015
- Isabelle Guérin Lassous is PC member, in 2015, of ACM MSWiM, IEEE ICDCS, IEEE ICC, IEEE Globecom, IEEE ISCC, ACM PE-WASUN and MedHocNet
- Anthony Busson is PC member of FNC 2015, ISNCC 2015.

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).

10.1.4. Invited talks

- Eric Fleury gave a keynote lecture at the 4th International Conference on Sensor Networks (Sensornet in coopration with ACM) and a panel on smart cities.
- Eric Fleury gave a keynote at the 11th Asian Internet Engineering Conference (AINTEC in cooperation with ACM) and a tutorial to the 26th Asian School.
- Eric Fleury gave a invited talk at the inaugural workshop EPFL/Inria
- Eric Fleury gave a seminar talk for the LIG Keynote Speech
- Anthony Busson gave a seminar talk at the Institute of Mathematics (Hanoi)

10.1.5. Leadership within the scientific community

- Isabelle Guérin Lassous is member of the CNRS National Committee for section 06 (Computer Science).
- 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.

10.1.6. Scientific expertise

- Christophe Crespelle is expert for NAFOSTED (Vietnamese national agency for funding research)
- Isabelle Guérin Lassous is a member of the research committee of the Milyon labex.
- Isabelle Guérin Lassous was a member of the selection committee of ENS Cachan
- Éric Fleury is member of the Inria senior research position (DR2) jury
- Éric Fleury is member of the Starting Research Position and Advanced Research position jury
- 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 Agency's (ANR) for ANR.

10.1.7. Research administration

- Paulo Gonçalves is scientific liaison officer for international relations in Inria Research Centre of Rhône-Alpes.
- Paulo Gonçalves is scientific correspondent of the International Relations for the Computer Science Department at ENS Lyon.
- Paulo Gonçalves is a member of the executive committee of the Milyon labex.
- 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.
- Éric Fleury is Deputy Scientific Delegate for Inria Grenoble Rhône Alpes
- Éric Fleury is in the in the Executive Committee of the IXXI – 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.

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

Licence/Master : Alter-disciplinary course, Complexe network: an interdisciplinary approche 6H, L3, M1, M2, ENS de Lyon, France

10.2.1.2. Teaching by Thomas Begin

Licence : "Networks", 18h, Bachelor (L3), University Lyon 1, France

Master : "Networking", 63h, Master (M1), University Lyon 1, France

Master : "Advanced Networks", 50h, Master (M2), University Lyon 1, France

Master : "Computer Networks", 12h, Master (M1), ENS de Lyon, France

10.2.1.3. Teaching by Paulo Gonçalves

Engineering school (year 3-5) : Statistical Signal Processing (80 hours/yr)

10.2.1.4. Teaching by Christophe Crespelle

Master : C. Crespelle, "Chordal graphs: structure and algorithms", 10h, SEAMS Internatioanl School on Combinatorics, Hanoi, Vietnam

10.2.1.5. 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

10.2.1.6. 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

Master : "Réseaux spontanés avancés", 17h, Master (M2), University Lyon 1 - Université Nationale du Vietnam, France-Vietnam

Master : "Palm Calculus and networking applications", 18h, Master (M1) - Institute of Mathematics - Hanoi

10.2.2. Supervision

- PhD defense: Benjamin Girault, Signal processing on graph: Contributions to an emerging field. ENS de Lyon, Dec. 1 2015. E. Fleury and P. Gonçalves
- PhD defense: Lucie Martinet, Dynamic complex networks: characterisation and diffusion properties in hospital context. ENS de Lyon, Sep. 18th 2015, E. Fleury and C. Crespelle
- PhD defense: Elie Rotenberg, An approach for a reliable estimation of the properties of the Internet topology. University Pierre et Marie Curie, Jan 8th 2015, M. Latapy and C. Crespelle
- PhD defense: Thiago Wanderley Matos de Abreu, Modeling and analysis of IEEE 802.11-based chains performance. University Lyon 1, March 5th 2015, T. Begin and I. Guérin Lassous
- PhD defense: Sabrine Naimi, “Gestion de la mobilité dans les réseaux Ad Hoc par anticipation des métriques de routage”. University Paris 11, July 22th 2015, Véronique Vèque and Anthony Busson.
- PhD defense: Peng GUAN, Stochastic Geometry Analysis of LTE-A Networks. University Paris 11, Dec. 2015, Marco Di Renzo and Anthony Busson.
- PhD defense: Wei LU, Stochastic Geometry Analysis of relay-aided LTE-A cellular networks. University Paris 11, Dec. 2015, Marco Di Renzo and Anthony Busson.
- 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: Yannick Leo, Diffusion process and community structure in complex nerworks, Oct. 2013, E. Fleury, C. Crespelle, and M. Karsai
- PhD in progress: Laurent Reynaud, Optimized 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

10.2.3. Juries

- Paulo Gonçalves was member of the PhD examination board of: Nadia Khalfa-Cheick;
- Paulo Gonçalves was reviewer and member of the PhD examination board of: Hadrien Hours.
- Christophe Crespelle was member of the PhD examination board of Pham Van Trung, Vietnam Academy of Science and Technology.
- Isabelle Guérin Lassous was reviewer of the PhD examination boards of: Guillaume Artero Gallardo, University of Toulouse ; Nicolas Boillot, University of Franche-Comté ; Georgios Z. Papadopoulos, University of Strasbourg ; Andrés Marcelo Vázquez Rodas, Universitat Politécnica de Catalunya, Spain;

- Isabelle Guérin Lassous was chair of the PhD examination boards of: Liviu-Octavian Varga, University of Grenoble ; Moussa Traore, University of Toulouse;
- Isabelle Guérin Lassous was member of the PhD examination boards of: Baher Mawlawi, INSA de Lyon ; Denis Carvin, University of Toulouse.
- Eric Fleury was chair of the PhD examination board of: Diala Naboulsi, INSA de Lyon;
- Eric Fleury was member of the HdR examination board of Michaël Hauspie, Université Lille 1.
  HDR MrHauspie

11. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] B. GIRAULT. *Signal Processing on Graphs - Contributions to an Emerging Field*, Ecole normale supérieure de lyon - ENS LYON, December 2015, https://tel.archives-ouvertes.fr/tel-01256044

[2] L. MARTINET. *Real Dynamic Networks : Characterisation and Diffusion Properties in Hospital Contexts*, Ecole normale supérieure de lyon - ENS LYON, September 2015, https://tel.archives-ouvertes.fr/tel-01208023

Articles in International Peer-Reviewed Journals

[3] I. ACHOUR, T. BEJAOUI, A. BUSSON, S. TABBANE. *SEAD: A simple and efficient adaptive data dissemination protocol in vehicular ad-hoc networks* , in "Wireless Networks", September 2015, 11 p. [*DOI :* 10.1007/S11276-015-1050-9], https://hal.inria.fr/hal-01242289

[4] C. ADJIH, E. BACCELLI, E. FLEURY, G. HARTER, N. MITTON, T. NOEL, R. PISSARD-GIBOLLET, F. SAINT-MARCEL, G. SCHREINER, J. VANDAELE, T. WATTEYNE. *FIT IoT-LAB: A Large Scale Open Experimental IoT Testbed – A valuable tool for IoT deployment in Smart Factories*, in "IEEE ComSoc Multimedia Technical Committee E-Letter", December 2015, https://hal.inria.fr/hal-01208387

[5] A. ANCEL, I. ASSENMACHER, K. I. BABA, J. CISONNI, Y. FUJISO, P. GONÇALVES, M. IMBERT, K. KOYAMADA, P. NEYRON, N. KAZUNORI, O. HIROYUKI, A.-C. ORGERIE, X. PELORSON, B. RAFFIN, N. SAKAMOTO, E. SAKANE, S. WADA, S. SHIMOJO, A. VAN HIRTUM. *PetaFlow: a global computing-networking-visualisation unitwith social impact*, in "International Research Journal of Computer Science", April 2015, vol. 2, n^{o} 4, https://hal.inria.fr/hal-01231826

[6] S. BARBU, A. NARDY, J.-P. CHEVROT, B. GUELLAÏ, L. GLAS, J. JUHEL, A. LEMASSON. *Sex Differences in Language Across Early Childhood: Family Socioeconomic Status does not Impact Boys and Girls Equally*, in "Frontiers in Psychology", December 2015, vol. 6, 10 p. [*DOI :* 10.3389/FPSYG.2015.01874], https://hal.inria.fr/hal-01244841

[7] 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, https://hal.archives-ouvertes.fr/hal-01246822

[8] A. BRANDWAJN, T. BEGIN. *Performance Evaluation of Cloud Computing Centers with General Arrivals and Service*, in "IEEE Transactions on Parallel and Distributed Systems", January 2016, https://hal.archives-ouvertes.fr/hal-01241713

[9] C. CRESPELLE, M. LATAPY, T. H. D. PHAN. *On the termination of some biclique operators on multipartite graphs*, in "Discrete Applied Mathematics", 2015, vol. 195, pp. 59–73 [*DOI :* 10.1016/J.DAM.2015.02.006], http://hal.upmc.fr/hal-01200865

[10] C. CRESPELLE, T. H. D. PHAN, H. TRAN-THE. *Termination of the Iterated Strong-Factor Operator on Multipartite Graphs*, in "Theoretical Computer Science", 2015, vol. 571, pp. 67-77, https://hal.inria.fr/hal-01241925

[11] C. CRESPELLE, E. THIERRY. *Computing the Directed Cartesian-Product Decomposition of a Directed Graph from its Undirected Decomposition in Linear Time*, in "Discrete Mathematics", 2015, vol. 338, n° 12, pp. 2393-2407, https://hal.inria.fr/hal-01241939

[12] M. DORET, J. SPILKA, V. CHUDÁČEK, P. GONÇALVES, P. ABRY. *Fractal Analysis and Hurst Parameter for Intrapartum Fetal Heart Rate Variability Analysis: A Versatile Alternative to Frequency Bands and LF/HF Ratio*, in "PLoS ONE", August 2015, e0136661 [*DOI :* 10.1371/JOURNAL.PONE.0136661], https://hal.inria.fr/hal-01245438

[13] 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, 15 p. [*DOI :* 10.1109/TVT.2015.2474156], https://hal.archives-ouvertes.fr/hal-01217564

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

[15] P. JENSEN, M. MORINI, M. KARSAI, T. VENTURINI, A. VESPIGNANI, M. JACOMY, J.-P. COINTET, P. MERCKLÉ, E. FLEURY. *Detecting global bridges in networks*, in "Journal of Complex Networks", October 2015 [*DOI :* 10.1093/COMNET/CNV022], https://hal.inria.fr/hal-01206166

[16] G. LAURENT, J. SARAMÄKI, M. KARSAI. *From calls to communities: a model for time varying social networks*, in "European Physical Journal B: Condensed Matter and Complex Systems", November 2015, vol. 301, 10 pages, 5 figures, https://hal.inria.fr/hal-01203177

[17] D. MOCANU, L. ROSSI, Q. ZHANG, M. KARSAI, W. QUATTROCIOCCHI. *Collective attention in the age of (mis)information*, in "Computers in Human Behavior", October 2015, vol. 51, misinformation, attention patterns, false information, social response [*DOI :* 10.1016/J.CHB.2015.01.024], https://hal.inria.fr/hal-00960353

[18] T. OBADIA, L. OPATOWSKI, L. TEMIME, J.-L. HERRMANN, E. FLEURY, P.-Y. BOËLLE, D. GUILLEMOT. *Interindividual Contacts and Carriage of Methicillin-Resistant Staphylococcus aureus: A Nested Case-Control Study*, in "Infection Control and Hospital Epidemiology", April 2015, pp. 1-8 [*DOI :* 10.1017/ICE.2015.89], https://hal.inria.fr/hal-01144892

[19] T. OBADIA, R. SILHOL, L. OPATOWSKI, L. TEMIME, J. LEGRAND, A. THIÉBAUT, J.-L. HERRMANN, E. FLEURY, D. GUILLEMOT, P.-Y. BOËLLE. *Detailed Contact Data and the Dissemination of Staphylococcus aureus in Hospitals*, in "PLoS Computational Biology", March 2015, vol. 11, n° 3, pp. 1-16 [*DOI :* 10.1371/JOURNAL.PCBI.1004170], https://hal.inria.fr/hal-01134050

[20] R. RIEDI, P. GONÇALVES. *A strong Tauberian theorem for characteristic functions*, in "Applied and Computational Harmonic Analysis", 2015, vol. 39, 6 p. [*DOI :* 10.1016/J.ACHA.2015.03.007], https://hal.inria.fr/hal-01245436

[21] Z. RUAN, G. INIGUEZ, M. KARSAI, J. KERTÉSZ. *Kinetics of Social Contagion*, in "Physical Review Letters", November 2015, vol. 218702, 8 pages, 4 figures + 8 pages Supplemental Material, https://hal.inria.fr/hal-01203176

[22] 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

Invited Conferences

[23] E. FLEURY, J. I. ALVAREZ-HAMELIN, A. BUSSON, M. KARSAI, Y. LEO, C. SARRAUTE. *Mobile Phone Network Datasets Analysis*, in "Asian Internet Engineering Conference (AINTEC) 2015", Bangkok, Thailand, November 2015, https://hal.inria.fr/hal-01230213

[24] B. GIRAULT. *Stationary Graph Signals using an Isometric Graph Translation*, in "Eusipco", Nice, France, August 2015, pp. 1531-1535, https://hal.inria.fr/hal-01155902

International Conferences with Proceedings

[25] I. ACHOUR, T. BEJAOUI, A. BUSSON, S. TABBANE. *A Redundancy based Protocol for Safety Message Dissemination in Vehicular Ad Hoc Networks*, in "The 82 nd IEEE Vehicular Technology Conference", Boston, United States, IEEE, September 2015, https://hal.inria.fr/hal-01242275

[26] T. BEGIN, A. BRANDWAJN. *Predicting the System Performance by Combining Calibrated Performance Models of its Components* , in "7th ACM/SPEC International Conference on Performance Engineering (ICPE)", Delft, Netherlands, March 2016, https://hal.archives-ouvertes.fr/hal-01241703

[27] C. CRESPELLE, T.-N. LE, P. KEVIN, T. H. D. PHAN. *Linearity is Strictly More Powerful than Contiguity for Encoding Graphs*, in "14th International Symposium on Algorithms and Data Structures – WADS 2015", Victoria, Canada, Lecture Notes in Computer Science, Springer, 2015, vol. 9214, pp. 212-223, https://hal.inria.fr/hal-01242024

[28] C. CRESPELLE, A. PEREZ, I. TODINCA. *An $O(n^2)$-time algorithm for the minimal permutation completion problem*, in "41st International Workshop on Graph-Theoretic Concepts in Computer Science - WG 2015", Munich, Germany, Lecture Notes in Computer Science, 2015, https://hal.inria.fr/hal-01242028

[29] Y. LEO, C. CRESPELLE, E. FLEURY. *Non-Altering Time Scales for Aggregation of Dynamic Networks into Series of Graphs*, in "11th International Conference on emerging Networking EXperiments and Technologies – CoNEXT 2015", Heidelberg, Germany, 11th International Conference on emerging Networking EXperiments and Technologies – CoNEXT 2015, 2015, https://hal.inria.fr/hal-01242035

[30] N. NGUYEN, T. BEGIN, A. BUSSON, I. GUÉRIN LASSOUS. *Towards a Passive Measurement-based Estimator for the Standard Deviation of the End-to-End Delay*, in "IEEE/IFIP Network Operations and Management Symposium (NOMS)", Istanbul, Turkey, April 2016, https://hal.archives-ouvertes.fr/hal-01241711

[31] L. Reynaud, I. Guérin Lassous, J.-O. Calvar. *Mobilité Contrôlée pour la poursuite de frelons*, in "ALGOTEL 2015 — 17èmes Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications", Beaune, France, June 2015, https://hal.archives-ouvertes.fr/hal-01147939

Conferences without Proceedings

[32] C. Adjih, E. Baccelli, E. Fleury, G. Harter, N. Mitton, T. Noel, R. Pissard-Gibollet, F. Saint-Marcel, G. Schreiner, J. Vandaele, T. Watteyne. *FIT IoT-LAB: A Large Scale Open Experimental IoT Testbed*, in "IEEE World Forum on Internet of Things (IEEE WF-IoT)", Milan, Italy, December 2015, https://hal.inria.fr/hal-01213938

[33] F. Berthaud, Y. Léo, C. Sarraute, A. Busson, E. Fleury. *Sms transmission using phone users density in big cities*, in "Fourth conference on the Analysis of Mobile Phone Datasets (NetMob 2015)", MIT Media Lab, United States, April 2015, https://hal.inria.fr/hal-01134379

[34] P. Borgnat, P. Gonçalves, N. T. Tremblay, N. Willaime-Angonin. *Community mining with graph filters for correlation matrices*, in "Asilomar Conference on Signals, Systems, and Computers", Monterey (CA), United States, November 2015, https://hal.inria.fr/hal-01245926

[35] J.-P. Chevrot, A. Nardy, E. Fleury, M. Karsai, J.-P. Magué. *Sociolinguistique et sciences cognitives: l'individu, le collectif et le réseau*, in "Journées FLORaL-PFC 2015 : la base de données Phonologie du Français Contemporain dans le champ phonologique", Paris, France, December 2015, https://hal.inria.fr/hal-01242405

[36] B. Girault, P. Gonçalves, E. Fleury. *Signaux stationnaires sur graphe : étude d'un cas réel*, in "Gretsi", Lyon, France, September 2015, 4 p. , https://hal.inria.fr/hal-01164379

[37] Y. Leo, E. Fleury, C. Sarraute, J. I. Alvarez-Hamelin, M. Karsai. *Socioeconomic correlations in communication networks*, in "Fourth conference on the Analysis of Mobile Phone Datasets (NetMob 2015)", MIT Media Lab, United States, April 2015, https://hal.inria.fr/hal-01134295

[38] Y. Leo, E. Fleury, C. Sarraute, J. I. Alvarez-Hamelin, M. Karsai. *Socioeconomic correlations in communication networks*, in "International Conference on Computational Social Science (ICCSS 2015)", Helsinki, Finland, June 2015, https://hal.inria.fr/hal-01135835

[39] J.-P. Magué, E. Fleury, M. Karsai, M. Quignard. *Caractérisation dialectale de variabilité linguistique sur Twitter*, in "Language, Cognition and Society (AFLiCo 6)", Grenoble, France, May 2015, https://hal.inria.fr/hal-01134428

Research Reports

[40] B. Girault, P. Gonçalves, E. Fleury. *Translation and Stationarity for Graph Signals*, École Normale Supérieure de Lyon ; Inria Rhône-Alpes ; Inria, April 2015, n^o RR-8719, https://hal.inria.fr/hal-01144991

Scientific Popularization

[41] E. Fleury, N. Mitton, T. Noel, C. Adjih. *FIT IoT-LAB: The Largest IoT Open Experimental Testbed*, in "ERCIM News", April 2015, n^o 101, 14 p. , https://hal.inria.fr/hal-01138038

Other Publications

[42] A. L. Laura, M. Karsai, L. Gauvin. *User-based representation of time-resolved multimodal public transportation networks*, January 2016, working paper or preprint, https://hal.inria.fr/hal-01249860

[43] J.-P. Magué, E. Fleury, M. Karsai, M. Quignard. *Dialectal characterization of linguistics variability on Twitter*, April 2015, 1st International Conference on Twitter for Research, Poster, https://hal.inria.fr/hal-01134441

[44] J.-P. Magué, E. Fleury, M. Karsai, M. Quignard. *Dialectal characterization of linguistics variability on Twitter*, June 2015, International Conference on Computational Social Science (ICCSS 2015), Poster, https://hal.inria.fr/hal-01134402

[45] J.-P. Magué, E. Fleury, M. Karsai, M. Quignard. *Social, geographical and linguistic structure of the French speaking Twitter community*, June 2015, International Conference on Network Science (NetSci2015), Poster, https://hal.inria.fr/hal-01136306

[46] E. Ubaldi, N. Perra, M. Karsai, A. Vezzani, R. Burioni, A. Vespignani. *Asymptotic theory for the dynamic of networks with heterogenous social capital allocation*, September 2015, (31 pages (main text: 11; SI: 20), 15 figures, 3 tables), https://hal.inria.fr/hal-01203181

[47] L. Weng, M. Karsai, N. Perra, F. Menczer, A. Flammini. *Attention on Weak Ties in Social and Communication Networks*, September 2015, working paper or preprint, https://hal.inria.fr/hal-01203175

References in notes

[48] R. Albert, A.-L. Barabási. *Statistical mechanics of complex networks*, in "Reviews of Modern Physics", 2002, vol. 74

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

[50] 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

[51] W. J. Fitzgerald, R. L. Smith, A. T. Walden. *Nonlinear and Nonstationary Signal Processing*, Cambridge University Press, Cambridge, 2001

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

[53] P. Gonçalves, R. Riedi. *Diverging moments and parameter estimation*, in "Journal of American Statistical Association", December 2005, vol. 100, n^{o} 472, pp. 1382–1393, Also Inria Technical Report RR-4647, 2002

[54] P. Holme, J. Saramäki. *Temporal networks*, in "Physics Reports", 2012, vol. 519, pp. 97-125

[55] 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

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

[57] 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

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

[59] 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

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

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

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

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

[64] 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

[65] 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

[66] 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

[67] 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

[68] Q. WANG, E. 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

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

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