Activity Report 2011

Team DNET

Dynamic Networks

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

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Networks and Telecommunications

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Team DNET

Keywords: Dynamic Networks, Graph Theory, Social Networks, Sensor Networks, Wireless Networks, Distributed Algorithms

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2. Overall Objectives

2.1. Overall Objectives

The main goal of the D-NET team is to lay solid foundations to the characterization of dynamic networks, and to the field of dynamic processes occurring on large scale interaction networks. In order to develop tools of practical relevance in real-world settings, we propose to ground our methodological studies on real data sets obtained through large scale in situ experiments.

Let us consider the example of health science and public health policy. The spread of infectious diseases remains an urgent public health issue. All spreading models validity crucially depend on our ability to understand and describe the interactions among individuals in the population. Building this knowledge requires the availability of individuals interaction records. Only recently it has become possible to study large scale interaction networks, such as collaboration networks, e-mail or phone call networks, sexual contacts networks, *etc.* This has prompted many research efforts in complex network science, mainly in two directions. First, attention has been paid to the network structure, considered as static graphs. Second, a large amount of work has focused on the study of spreading models in complex networks, which has highlighted the role of the network topology on the dynamics of the spreading. However, the dynamics of the networks, *i.e.*, topology changes, and in the networks, *e.g.*, spreading processes, are still generally studied separately. There is therefore an important need developing tools and methods for the joint analysis of both dynamics.

The D-NET project emphasizes the cross fertilization between these two research lines which should definitively lead to considerable advances. The D-NET project has the following fundamental goals:

1. To develop distributed measurement architectures based on sensor networks in order to capture physical phenomena in space and time;
2. To develop the study of dynamic interaction networks, through the design of specific tools targeted at characterizing and modeling their dynamic properties.
3. To study dynamic processes occurring in dynamic networks, such as spreading processes, taking into account both the dynamics of and in the network structure.
4. To apply these theoretical tools to large scale experimental data sets.
5. to set up and foster multidisciplinary collaborations in order to study these interaction networks in their original context.

Most activity on complex networks has up to now focused on static networks, the characterization of their structure, and the understanding of how their structure influences dynamic processes such as spreading phenomenon. The important step that the D-NET project wants to undertake is to consider that the networks themselves are dynamic entities. Their topologies evolve and adapt in time, possibly driven by or in interaction with the dynamic process unfolding on top of it. Measuring this dynamic is now affordable mainly thanks to the deployment of sensor networks that can be deployed close to the physical interacting objects. As an example, in the MOSAR context, sensors measure contacts between individuals. The resulting data set is an opportunity to develop analysis methods and tools directly connected to real-world situations and adapted to the specific context from where the data set is issued. Still in the MOSAR context, a better understanding of dynamic processes on dynamic interaction networks should help the development of appropriate response measures and protocols to the spreading of AMRB.

The D-NET project therefore addresses both very fundamental and very applied aspects that are tightly linked. On one hand, to develop knowledge in the networking field, in order to provide a better understanding of dynamic graphs. This fundamental work is grounded on real world large scale dynamic networks. On the other hand, to help develop a better understanding of the physical objects and networks that are studied. This point requires the joint study of both dynamics of the network and in the network, and requires a tied collaboration with the research disciplines where the objects come from.

The impact of the research developed in D-NET goes beyond the context of disease spreading studied within the MOSAR context, thanks to the inherent interdisciplinary of the complex networks research field. Dynamic processes on dynamic networks are indeed present in numerous fields, including rumor spreading in social networks, opinion formation, fashion phenomena, the innovation diffusion in a population, *etc.* The spread of computer viruses may take place through email networks or bluetooth connections, which are both dynamical. The development of efficient algorithms for information spreading in wireless/P2P/DTN networks should also be improved by the understanding of the dynamics of these networks and their temporal properties. The study of all these processes should benefit from the tools developed in this project. It represents an important opportunity to study real-world dynamic processes occurring on interaction networks whose dynamics can be measured.

2.2. Highlights

2.2.1. HiKoB

Guillaume Chelius is a founder of the the HiKoB company, created the 4th of July 2011 , an innovative startup in the field of sensor networking and embedded communicating measure. HiKoB employs 3 persons by the end of 2011.

2.2.2. Fellows

DNET conducts theoretical and experimental research on social networks. In order to gain a better understanding of their structure and the dynamics of information diffusion on such networks, and validate the notion of *cohesion* of a group of nodes ('friends in the Facebook language) we launched Fellows an experimentation on Facebook. We introduce a novel way to automatically generate groups of friends, using only the information on "who knows who" within a user's Facebook friends. By analyzing her/him Facebook connections, we are able to compute several groups/communities of friends. The user is able to create instantly corresponding Friend Lists on Facebook, and therefore have a better control on the diffusion of his/her publications.

2.2.3. 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€ 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. FIT is a joind porject between UPMC, CNRS, INRIA, Telecom, LSIIT. It will be composed of distributed facility, heterogeneous devices, complementary components and be made of a Network Operations Center, a Cognitive Radio Tesbed, several Embedded Communication Objects Testbed that will upgrade an dextend the existing SensLAB sites and several Wireless OneLab Testbed.
BEST PAPERS AWARDS :
[24] **ASONAM 2011**. Q. WANG, E. FLEURY.

3. Scientific Foundations

3.1. Sensor network, distributed measure and distributed processing

Participants: Guillaume Chelius, Eric Fleury, Andreea Chis, Clément Burin des Rosiers, Sandrine Avakian, Guillaume Roche, Fabien Jammes.

Glossary

Sensor network for distributed embedded measure. In order to gather information on the dynamic of a specific physical phenomena, a distributed embedded measure must be performed. The quality of the measure is crucial and largely impacts the analysis. Moreover, by conducing and controlling the measure and its bias during the experiment, one may adapt and optimize the analysis.

Sensors networks offer an efficient way to measure physical phenomena at various space and time scales. The important challenge is to take advantage of a communicating sensor node that can be associated to a physical object in order to design a large scale distributed measurement system that can monitor and sense the physical world. Given a target application, the goal is to design adequate sensor nodes and to set up the way they communicate, cooperate and collect their data in order to fulfill the application constraints. Fulfilling this goal requires the development of theoretical and practical techniques to help the dimensioning and deployment of such distributed sensing tools, to manage the distributed measures and to perform efficient and reliable distributed computing on top of the network. With these main tasks in mind, we define the following objectives:

Design of a global sensing tool. Based on the deployment context, we should propose a methodology to design the most appropriate and accurate measurement architecture that matches the application constraints. Heterogeneity is a fundamental, beneficial quality of distributed sensing tool, not just a problem to overcome. Heterogeneous sensing systems are more immune to the weaknesses of sensing modalities and more robust against defective, missing, or malicious data sources than even carefully designed homogeneous systems. However, data heterogeneity also presents main challenges when trying to integrate data from many different sensors.

Measure characterization and dimensioning. Measure characterization and dimensioning must take into account the different correlations in space and time that exist between all sensors. It must also handle the various time scales that may exist in the measures. The challenge is due to the heterogeneous data resolution. Moreover, data is generally multi modal and multi scale with possible irregularities and offer much correlation in time and/or space. Data sets collected by various sensors may be characterized by the lack of most common simple statistical properties such as stationary, linearity, or Gaussianity. Relevant time scales may be difficult to identify, or may even not exist. Observed properties have non-trivial relations and even the choice of the time scale granularity that should be used in the measure and the analysis is a complex problem as it may bias the analysis in an uncontrolled way.

In-network distributed processing. As some computation can be delocalized closer to the sensed phenomena, in the sensor nodes, space/time correlations can be exploited in order to optimize the amount of data sent through the network.

3.2. Statistical Characterization of Complex Interaction Networks

Participants: Guillaume Chelius, Eric Fleury, Adrien Friggeri.

Glossary

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.

The dynamics of complex networks often exhibit no preferred time scale or equivalently involve a whole range of scales and are characterized by a scaling or scale invariance property. Another important aspect of network dynamics resides in the fact that the sensors measure information of different nature. For instance, in the MOSAR project, inter-individual contacts are registered, together with the health status of each individual, and the time evolution of the resistance to antibiotics of the various strains analyzed. Moreover, such information is collected with different and unsynchronized resolutions in both time and space. This property, referred to as multi-modality, is generic and central in most dynamical networks. With these main challenges in mind, we define the following objectives.

From "primitive" to "analyzable" data: Observables. The various and numerous modalities of information collected on the network generate a huge "*primitive*" data set. It has first to be processed to extract "*analyzable data*", which can be envisioned with different time and space resolutions: it can concern either local quantities, such as the number of contacts of each individual, pair-wise contact times and durations, or global measures, *e.g.*, the fluctuations of the average connectivity. The first research direction consists therefore in identifying, from the "primitive data", a set of "analyzable data " whose relevance and meaningfulness for the analysis of network dynamic and network diffusion phenomena will need to be assessed. Such " analyzable data " needs also to be extracted from large " primitive data " set with " reasonable " complexity, memory and computational loads.

Granularity and resolution. The corresponding data will take the form of time-series, "condensing" network dynamics description at various granularity levels, both in time and space. For instance, the existence of a contact between two individuals can be seen as a link in a network of contacts. Contact networks corresponding to contact sequences aggregated at different analysis scales (potentially ranging from hours to days or weeks) can be built. However, it is so far unclear to which extent the choice of the analysis scale impacts the relevance of network dynamics description and analysis. An interesting and open issue lies in the understanding of the evolution of the network from a set of isolated contacts (when analyzed with low resolution) to a globally interconnected ensemble of individuals (at large analysis scale). In general, this raises the question of selecting the adequate level of granularity at which the dynamics should be analyzed. This difficult problem is further complicated by the multi-modality of the data, with potentially different time resolutions.

(non-)Stationarity. Stationarity of the data is another crucial issue. Usually, stationarity is understood as a time invariance of statistical properties. This very strong definition is difficult to assess in practice. Recent efforts have put forward a more operational concept of relative stationarity in which an observation scale is explicitly included. The present research project will take advantage of such methodologies and extend them to the network dynamics context.

The rationale is to compare local and global statistical properties at a given observation scale in time, a strategy that can be adapted to the various time series that can be extracted from the data graphs so as to capture their dynamics. This approach can be given a statistical significance via a test based on a data-driven characterization of the null hypothesis of stationarity.

Dependencies, correlations and causality. To analyze and understand network dynamics, it is essential that (statistical) dependencies, correlations and causalities can be assessed among the different components of the " analyzable data ". For instance, in the MOSAR framework, it is crucial to assess the form and nature of the dependencies and causalities between the time series reflecting e.g., the evolution along time of the strain resistance to antibiotics and the fluctuations at the inter-contact level. However, the multimodal nature of the collected information together with its complex statistical properties turns this issue into a challenging task. Therefore, Task1 will also address the design of statistical tools that specifically aim at measuring dependency strengths and causality directions amongst mutivariate signals presenting these difficulties. The objective is to provide elements of answers to natural yet key questions such as : Does a given property observed on different components of the data result from a same and single network mechanism controlling the ensemble or rather stem from different and independent causes? Do correlations observed on one instance of information (e.g., topological) command correlations for other modalities? Can directionality in correlations (causality) be inferred amongst the different components of multivariate data? These should also shed complementary lights on the difficulties and issues associated to the identification of " important " nodes or links...

3.3. Theory and Structural Dynamic Properties of dynamic Networks

Participants: Guillaume Chelius, Christophe Crespelle, Eric Fleury, Qinna Wang.

Glossary

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

To go further in the Classical graph notions like the definition of path, connected components and k-core have to be revisited in this context. Advanced properties need also to be defined in order to apprehend the intrinsic dynamic structural issues of such dynamic graphs. The notion of communities (dense group of nodes) is important in any social / interaction network context and may play an important role within an epidemic process. To transpose the static graph community concept into the dynamical graph framework is a challenging task and appears necessary in order to better understand how the structure of graphs evolves in time. In these context we define the following objectives:

Toward a dynamic graph model and theory. We want to design new notions, methods and models for the analysis of dynamic graphs. For the static case, graph theory has defined a vast and consistent set of notions and methods such as paths, flows, centrality measures. These notions and methods are completely lacking for the study of dynamic graphs. We aim at providing such notions in order to study the structure of graphs evolving in time and the phenomenon taking place on these dynamic graphs. Our approach relies on describing a dynamic graph by a series of graphs which are the snapshots of the state of the graph at different moments of its life. This object is often poorly used : most works focuss on the structure of each graph in the series. Doing so, one completely forget the relationships between the graphs of the series. We believe that these relationships encompass the essence of the structure of the dynamic and we place it at the very center of our approach. Thus, we put much effort on developping graph notions able to deal with a series of graphs instead of a dealing with a single graph. These notions must capture the temporal causality of the series and the non trivial relationships between its graphs. Our final goal is to provide a set of the notions and indicators to describe the dynamics of a network in a meaningful way, just like complex networks theory does for static complex networks.

Dynamic communities. The detection of dynamic communities is particularly appealing to describe dynamic networks. In order to extend the static case, one may apply existing community detection methods to successive snapshots of dynamic networks. This is however not totally satisfying for two main reasons: first, this would take a large amount of time (directly proportional to the data span); moreover, having a temporal succession of independent communities is not sufficient and we loose valuable information and dependencies. We also need to investigate the temporal links, study the time granularity and look for time periods that could be compressed within a single snapshot.

Tools for dynamic graph visualization. Designing generic and pure graph visualization tools is clearly out of the scope of the D-NET project. Efficient graph drawing tools or network analysis toolkit/software are now available (e.g., GUESS, TULIP, Sonivis, Network Workbench). However, the drawback of most softwares is that the dynamics is not taken into account. Since we will study the hierarchy of dynamics through the definition of communities we plan to extend graph drawing methods by using the communities' structures. We also plan to handle the time evolution in the network analysis toolkit. A tool like TULIP is well designed and could be improved by allowing operations (selection, grouping, sub graph computation...) to take place on the time dimension as well.

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 makes 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 D-NET 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 project we are collaborating with the team of Pr. Didier GUILLEMOT (Inserm/Institut. Pasteur/Université de Versailles). Within the TUBEXPO project, we are collaborating with Pr. Jean-Christopge Lucet (Professeur des universités Paris VII – Praticien hospitalier APHP).

4.2. Complex networks

In the last ten years, the study of complex networks has received an important boost with large interdisciplinary efforts aimed at their analysis and characterization. Two main points explain this large activity: on the one hand, many systems coming from very different disciplines (from biology to computer science) have a convenient representation in terms of graphs; on the other hand, the ever-increasing availability of large data sets and computer power have allowed their storage and manipulation. Many maps have emerged, describing many networks of practical interest in social science, critical infrastructures, networking, and biology. The D-NET project targets the study of dynamically evolving networks, from the point both of their structure and of the dynamics of processes taking place on them.

4.3. Biologging

The research conducted in the D-NET project finds direct applications in the domain of bio-logging. Bio-logging consists in equipping animals with tracking and sensing devices such that its mobility, environmental conditions and social interactions can be monitored. In the Dispop project and in collaboration with the DEPE of the IPHC, the D-NET project is active in the biologging field, more particularly on three principal topics : the design of efficient sensing devices, also called biologgers, the conception of a generic trajectometry software and the design of analytical tools for the study of social interactions in an animal population.

4.4. Biomechanics, physiology and sport

The research conducted in the D-NET project finds direct applications in the domains of bio-mechanics, physiology and sport. In the context of the SensTools project, the D-NET has contributed to the design of a distributed multi-sensor architecture that can be worn by an individual and that records bio-mechanical, physiological and environmental data. The deployment of this architecture took place during the 25th Marathon des Sables.

5. Software

5.1. WSNet

Participant: Guillaume Chelius [correspondant].

WSnet is a wireless sensor network simulator that was designed to offer the following features:

- a modular, flexible and accurate simulation of the radio physical medium;
- support for the simulation of environmental phenomena;
- support for interaction between nodes and their environment (sensor-actuator architecture);
- interconnection with the sensor platform emulator WSim to support the distributed emulation of wireless sensor networks.

WSNet is currently in its second release. The number of WSNet users is still growing and several research works reference the software. Many pointers can be found on the project website. Maintenance and support of the software is handled by the D-NET project but also by several contributors from the CITI laboratory (INSA de Lyon), Orange R&D. The WSNet community is quietly spreading in France as well as abroad.

5.2. WSNet-3

Participant: Guillaume Chelius [correspondant].

Driven by the feedback gathered among WSNet users, we have started the development of the third WSNet release. While still private, the project web page is available. The objectives behind this new development is:

- to ease the simulation of new radio architectures / standards : *e.g.* MIMO schemes, UWB, multi-interfaces system;
- to ease the writing of new modules through the use of *High Level Languages* such as Python or Ruby for the development of protocols, *etc* ;
- to ease the debugging and compilation of results during a simulation.

These developments are handled by a core of developers from different affiliations (INSA de Lyon, Orange R&D, INRIA) lead by the D-NET team.

5.3. Sensor Network Tools: drivers, OS and more

Participants: Guillaume Chelius, Eric Fleury [correspondant], Clément Burin des Rosiers, Sandrine Avakian, Guillaume Roche.

As a outcomes of the ANR SensLAB project and the INRIA ADT SensTOOLS and SensAS, several softwares (from low level drivers to OSes) were delivered and made available to the research community. The main goal is to lower the cost of developing/deploying a large scale wireless sensor network application. All software are gathered under the SensLAB web site: http://www.senslab.info/ web page where one can find:

- low C-level drivers to all hardware components;
- ports of the main OS, mainly TinyOS, FreeRTOS and Contiki;
- ports and development of higher level library like routing, localization.

6. New Results

6.1. Exposure to diffusion in dynamic networks

In many contexts, complex networks are subject to diffusion phenomenon, like spreading of epidemics in human groups or the diffusion of information in social networks. Often, the underlying network is dynamic, that is, his links change along time. Clearly, the dynamics of links has an influence on the diffusion phenomenon taking place over the network. A first step to understand these relationship is to determine which nodes of the dynamic network are more likely to be reached by a diffusion process. We designed new notions of exposure in order to do it, based either on contacts, paths or flows in a dynamic network. In particular, the notion of dynamic flow, which we introduced, has given interesting preliminary results. We computed the exposition scores of nodes of real world dynamic networks and showed that it is correlated to the likelihood of nodes to be affected by a diffusion in the classical SI model.

6.2. Aggregation of temporal graph series

A very natural and extensively used way to represent a dynamic network, where links change along time, is to build a graph series : the series of snapshots of the network taken at different time of its evolution. The way to do so is to aggregate all the contact information on a time window into a single graph : that is, we put an edge between u and v in the graph if they are in contact at least once during the considered time window. Doing so for disjoint windows of equal length which cover the whole period of study, we obtain a series of graphs representing the dynamics of the network. A question remain : how one should choose the length of the aggregation window? The problem is critical since depending on the choice made, the properties of the dynamic network are different and the conclusion derived from its analysis may change. We design a systematic method to estimate the maximum possible aggregation length. Up to our knowledge, this is the first method addressing the problem. It is based on activity rate of dynamic paths in the dynamics. On a dynamic path, only some time steps are used to move within the network. When the aggregation time is short, the activity rate of paths is close to zero and it tends to 1 when this time grow until the whole period of experiments. Between the two behaviors, we showed that there is a phase transition that we interpret as the moment when the properties of the dynamics are distorted because of the too long aggregation time.

6.3. Characterizing changes in dynamic networks

Very often, dynamic networks are described as time series of graphs. Many works focus on analyzing or capturing into models the properties of the graphs of the series. This approach has a clear limitation : it looses the relationships between the different graphs of the series, which however contain a key information on the dynamics. In order to get more insight in the relationships between the graphs of the series, we analyzed the structure of we call the difference graphs. The difference graph of two consecutive graphs G_1, G_2 of the series is the graph whose edge set is the symmetric difference of the edge sets of G_1 and G_2. In other words, this is exactly the graph of the pairs whose adjacency relationship changed from G_1 to G_2. We showed that the structure of difference graphs is very particular : their edges are concentrated around a small number of vertices. This shows that the changes between two graphs of the series are not spread everywhere in the network, but are due to changes of the neighborhood of only a small number of nodes of the network. We could show this fact by computing a graph parameter called Minimum Vertex Cover (MVC), which is Np-complete to compute. Using a preprocessing step, we could compute the exact value of this parameter for all difference graphs of real world series. We obtained that the value of the MVC on difference graphs is very small compared to the expected value on a random graph with same density. We also showed that the most commen models of dynamic networks do not capture this property of concentration of edges in the difference graphs of the series. Our result shed light on the way dynamic networks evolve and open the way to significant improvement of existing models.

6.4. Community detection: dynamic and overlapping

Overlapping community detection is a popular topic in complex networks. Comparing to disjoint community structure, overlapping community structure is more reasonable to describe networks at a macroscopic level. Overlaps shared by communities play an important role in combining different communities. We propose two different approaches to detect overlaps: fuzzy community detection and overlapping community detection. The former estimates membership degree of node belonging to community, and the latter allows node to be shared by communities. In this paper, a fuzzy detection and a clique optimization are introduced. Experimental studies in synthetic networks show fuzzy detection yields meaningful information in stability and hierarchy of communities. And clique optimization is efficient in capturing overlapping nodes. Applications in real networks whose community structure is not well-known find that overlapping clusters found by our fuzzy detection can provide different views than general overlapping nodes in characterize overlaps.

Although community detection has drawn tremendous amount of attention across the sciences in the past decades, no formal consensus has been reached on the very nature of what qualifies a community as such. We take an orthogonal approach by introducing a novel point of view to the problem of overlapping communities. Instead of quantifying the quality of a set of communities, we choose to focus on the intrinsic community-ness of one given set of nodes. To do so, we propose a general metric on graphs, the cohesion, based on counting triangles and inspired by well established sociological considerations. The model has been validated through a large-scale online experiment called Fellows in which users were able to compute their social groups on Facebook and rate the quality of the obtained groups. By observing those ratings in relation to the cohesion we assess that the cohesion is a strong indicator of users subjective perception of the community-ness of a set of people.

6.5. Cross-Layer Optimization for Software Layer to Physical Device layer Mapping

We develope a generic method for mapping software state machines used in protocol stacks and communication layers directly to hardware communication devices using their specifications. The proposed method can handle power modes and timing constraints imposed by hardware devices in order to optimize the software code running on top of the device. This property allows the use of the hardware device in its lowest power consumption mode while making sure that real time constraints are met. To validate the merit of the proposed method, the generated code and power consumption gain, we evaluate the optimizations that can be done on a

BMAC medium access control layer used in wireless sensor networks using a large scale experimental testbed. The results show that an average energy consumption gain of up to 60% at the radio level can be achieved.

7. Contracts and Grants with Industry

7.1. Contracts with Industry

A bilateral contract has been signed between the DNET INRIA team and ACT750 to formalize their collaboration in the context of churn prediction.

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. ESPAD (FEDER)

Participants: Guillaume Chelius, Sandrine Avakian, Guillaume Roche.

The ESPAD (Embedded Sport Performance Analysis Data) is bio-mechanics / physiology logging project funded by FEDER. The goal is to contributed to the design of a distributed multi-sensor architecture that can be worn by an individual and that records bio-mechanical, physiological and environmental data.

8.2. National Initiatives

8.2.1. Complex Networks Metrology (RNSC)

Participant: Christophe Crespelle.

D-NET is a member of the project Complex Networks Metrology involving LIP6 (Université Paris 6), LSIIT (Université de Strasbourg) and LIP (ENS de Lyon, Université Lyon 1). The project, funded by RNSC (Réseau National des Systèmes Complexes), started in January 2011 and ended in December 2011. Its goal is to design rigorous methods for measuring complex networks. The originality of our appraoch is to lead measurements dedicated to a specific property instead of trying to get a complete view of the network, which has been showed to lead to significant biases in the obtained view. Its major domain of application is Internet measurements.

8.2.2. SensLAB (ANR)

Participants: Eric Fleury [Prime Investigator], Guillaume Chelius.

The purpose of the SensLAB project is to deploy a very large scale open wireless sensor network platform. SensLAB's main and most important goal is to offer an accurate and efficient scientific tool to help in the design, development, tuning, and experimentation of real large-scale sensor network applications. The sensLAB platform is distributed among 4 sites and is composed of 1,024 nodes. Each location hosts 256 sensor nodes with specific characteristics in order to offer a wide spectrum of possibilities and heterogeneity. The four test beds are however part of a common global testbed as several nodes will have global connectivity such that it will be possible to experiment a given application on all 1K sensors at the same time.

8.2.3. FLab (ANR)

Participants: Eric Fleury, Sandrine Avakian.

As proposed by initiatives in Europe and worldwide, enabling an open, general-purpose, and sustainable large-scale shared experimental facility will foster the emergence of the Future Internet. There is an increasing demand among researchers and production system architects to federate testbed resources from multiple autonomous organizations into a seamless/ubiquitous resource pool, thereby giving users standard interfaces for accessing the widely distributed and diverse collection of resources they need to conduct their experiments. The F-Lab project builds on a leading prototype for such a facility: the OneLab federation of testbeds. OneLab pioneered the concept of testbed federation, providing a federation model that has been proven through a durable interconnection between its flagship testbed PlanetLab Europe (PLE) and the global PlanetLab infrastructure, mutualizing over five hundred sites around the world. One key objective of F-Lab is to further develop an understanding of what it means for autonomous organizations operating heterogeneous testbeds to federate their computation, storage and network resources, including defining terminology, establishing universal design principles, and identifying candidate federation strategies. On the operational side, F-Lab will enhance OneLab with the contribution of the unique sensor network testbeds from SensLAB, and LTE based cellular systems. In doing so, F-Lab continues the expansion of OneLab?s capabilities through federation with an established set of heterogeneous testbeds with high international visibility and value for users, developing the federation concept in the process, and playing a major role in the federation of national and international testbeds. F-Lab will also develop tools to conduct end-to-end experiments using the OneLab facility enriched with SensLAB and LTE.

F-Lab is a unique opportunity for the French community to play a stronger role in the design of federation systems, a topic of growing interest; for the SensLAB testbed to reach an international visibility and use; and for pioneering testbeds on LTE technology.

8.2.4. SensAS (INRIA ADT)

Participants: Eric Fleury [Prime Investigator], Guillaume Chelius [scientific correspondant of the SENSBIO work package].

The ambition of SensAS is to deploy wireless sensor and actuator applications. From the strong expertise gather in MOSAR, SensLAb and SensTOOLS, the goal is to transfer and help other INRIA research team to deploy their own application, not in the restricted networking area: flying drones, robots fleet, biologging, health, management?

8.2.5. DyVi (INRIA ARC)

Participants: Eric Fleury [Prime Investigator], Qinna Wang, Adrien Friggeri.

The goal of the ARC DyVi is to build a foundation for dynamic graph theory in order to be able to describe properties and design efficient and specific algorithmic for dynamic graph and overlapping communities The goal is to be able to tackle multi time scale visualization tools based on TULIP, to implement data structure / handling / time scale aggregation / browsing within the TULIP software developed by the INRIA GRAVITE team. We also target epidemic process visualization in order to be able to run and "see" dynamic processes on dynamic networks

8.3. European Initiatives

8.3.1. Collaborations in European Programs, except FP7

Program: FP6 - LSH

Project acronym: MOSAR

Project title: Mastering hOSpital Antimicrobial Resistance and its spread into the community

Duration: 2008 – 2012

Coordinator: INSERM

Other partners: University of Antwerp (Belgium), National Medicines Institute (Poland), August Pi i Sunyer biomedical research Institute (Spain), University Medical Center Utrecht (Netherlands), University of Geneva Hospitals (Swisslands), Tel Aviv Medical Center (Israel), Health Protection Agency (UK), Medical school of Paris 12 University (France), Pasteur Institute (France), Inserm-Transfert (France), Ingen Biosciences (France), BiologischeAnalysensystemGmbH (Germany), AmpTec GmbH (Germany), Array-On GmbH (Germany)

Abstract: MOSAR is an Integrated Project supported for 5 years by the European Commission under the Life Science Health Priority of the Sixth Framework Program. Infections caused by antimicrobial-resistant bacteria (AMRB) account for an increasing proportion of healthcare-associated infections, particularly in high-risk units such as intensive care units and surgery; patients discharged to rehabilitation units often remain carriers of AMRB, contributing to their dissemination into longer-term care areas and within the community. The overall objective of MOSAR is to gain breakthrough knowledge in the dynamics of transmission of AMRB, and address highly controversial issues by testing strategies to combat the emergence and spread of antimicrobial resistance, focusing on the major and emerging multi-drug antimicrobial resistant microorganisms in hospitals, now spreading into the community. Microbial genomics and human response to carriage of AMRB will be integrated with health sciences research, including interventional controlled studies in diverse hospital settings, mathematical modeling of resistance dynamics, and health economics. Results from MOSAR will inform healthcare workers and decision-makers on strategies for anticipating and mastering antimicrobial resistance.

8.4. International Initiatives

8.4.1. Visits of International Scientists

- Thi Ha Duong Phan, Academy of Science and Technology in Vietnam, was in visit in the D-NET team for one month in June 2011.
- Renaud Lambiotte, University of Namur in Belgium, was in visit in the D-NET team in November 2011.
- Mariano Beiro, Universidad de Buenos Aires, was in visit in the DNET team for 4 months.
- Duc Thinh Nguyen, Intitut de la Francophonie pour l'Informatique in Hanoï (Vietnam), made his Master internship in the D-NET team for six months from March to September 2011.

8.4.2. Participation In International Programs

8.4.2.1. STIC AMSUD

Project 09STIC04, Dynamics of Layered Complex Networks, between the LNCC in Brazil (Prime Investigator is Artur Ziviani), UFMG in Brazil, Universidad de Buenos Aires in Argentina, UPMC in France and INRIA. The goal is to develop a better understanding of the issues involved in dealing with dynamic graphs and their applicability to real-world complex networks. We also establish a thematic and collaborative research network between the partners of this project involving complementary backgrounds to deal with the challenges of investigating complex network systems.

8.4.2.2. Inria/FAPERJ

Project CoDyN (Complex Dynamic Networks) between LNCC and DNET/INRIA. The main goal of the CoDyN project is to lay solid foundations to the characterization of dynamically evolving networks, and to the field of dynamical processes occurring on large scale dynamic interaction networks.

8.4.2.3. PICS CNRS – Combinatorial Structures for Complex Network Modeling

Participant: Christophe Crespelle.

D-NET is a member of a PICS project of the CNRS between the Academy of Science and Technology in Vietnam and the Laboratoire d'Informatique de Paris 6 (LIP6) and Université Claude Bernard Lyon 1 in France. The project started on january 2010 and will end in december 2012. Its goal is to design models of complex networks that are able to capture at the same time two of their most relevant properties : their heterogeneous degree distribution and their high local density. The goal is to provide very general models that do not make stronger assumptions on the structure of the graphs to be modeled. Our approach is based on the overlapping structure of cliques in complex networks and uses mainly tools coming from combinatorics, graph theory and statistics.

9. Dissemination

9.1. Animation of the scientific community

- Eric Fleury was a member of the Interdisciplinary Workshop on Information and Decision in Social Networks scientific committee, MIT.
- Eric Fleury was a member of the CFIP program committee.
- Eric Fleury was co chair of the Social networks, from structures to politics workshop.
- Eric Fleury was a member of the 20th International Conference on Computer Communications and Networks (ICCCN 2011) program committee.
- Eric Fleury was a topic chair for Euro-Par 2011
- Eric Fleury was an invited speaker at the research summer school "*école Intelligence Ambiante* " (Lille, France).
- Eric Fleury was an invited speaker at the "*Journées thématiques Rescom Réseaux de Capteurs et leurs applications*.
- Eric Fleury has participated in the event All connected, an investigation on new numerical usages, co production with CCSTI Grenoble – La Casemate / Universcience – Cité des sciences et de l'industrie. The exhibition is an action of the NANOYOU project (FP7/2007-2013)
- Guillaume Chelius was an invited speaker at the at the IN'Tech Seminar on smart objects (Grenoble, France).
- Guillaume Chelius was an invited speaker at the at the "*modèles et algorithms*" seminar at INRIA Paris-Rocquencourt (Paris, France).
- Guillaume Chelius was an invited speaker at the at the "*Conf'Lunch* "seminar at INRIA Rennes-Bretagne Atlantique (Rennes, France).
- Guillaume Chelius has participated with the HiKoB startup to the "*Rencontres INRIA Industrie*" on healthcare @ home (Paris, France)
- Guillaume Chelius has participated with the HiKoB startup to the "*Grenoble Innovation Fair*" 2011 (Grenoble, France)

9.1.1. Leadership within scientific community

- Christophe Crespelle was member of the Ph.D. jury of Assia Hamzaoui (LIP6, Université Paris 6, France).
- Christophe Crespelle was member of the Ph.D. jury of Xiaomin Wang (LIP6, Université Paris 6, France).
- Eric Fleury was member was member the HDR jury of Anthony Busson (Université Paris Sud, France).

- Eric Fleury was member was member the HDR jury of Nathalie Mitton (Université de Lille – INRIA Nord Europe, France).
- Eric Fleury was member was member the Ph.D. jury and reviewer of the Ph.D. of Lamia Benamara (LIP6, UPMC, France).
- Eric Fleury was member was member the Ph.D. jury and reviewer of the Ph.D. of Thomas Aynaud (LIP6, UPMC, France).
- Eric Fleury was member was member the Ph.D. jury and reviewer of the Ph.D. of Dorian Mazauric (Université de Nice – INRIA Sophia Antipolis, France).
- Eric Fleury was member was member the Ph.D. jury and reviewer of the Ph.D. of Oussama Allali (LIP6, UPMC, France).
- Eric Fleury was Vice President of the expert committee for the ANR INFRA call
- Eric Fleury is a member of the national PES board for the computer science section.
- Eric 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.
- Eric Fleury is in the in the steering committee of the IXXI – Rhône Alpes Complex Systems Institute.
- Eric Fleury has been an expert for the Fund for Scientific Research - FNRS.
- Guillaume Chelius is a member of the IXXI – Complex Systems Institute scientific board.

9.2. Teaching

9.2.1. Teaching by Christophe Crespelle

Licence : Algorithmique et programmation procédurale, 48h, niveau L1, Université Claude Bernard Lyon 1, France

Master : Architecture de sécurité des réseaux, 37h, niveau M2, Université Claude Bernard Lyon 1, France

Master : Sécurité et sûreté de fonctionnement, 12h, niveau M2, Université Claude Bernard Lyon 1, France

Master : Recherche opérationnelle, 24h, niveau M1, Université Claude Bernard Lyon 1, France

Master : Réseaux du futur, 12h, niveau M2, Université Claude Bernard Lyon 1, France

Master : Grands graphes de terrain, 18h, niveau M2, ENS de Lyon, France

9.2.2. Teaching by Eric Fleury

Eric Fleury is a professor at ENS Lyon in the Computer Science Department since 2007. The ENS de Lyon is one of the four Ecoles normales supérieures in France.

Licence : "Introduction to Algorithm" and "Architecture, System and Networking".

Eric Fleury is in charge for the CS department of the option in modeling complex systems.

Since September 2009, Eric Fleury is the Head of the Computer Science Department at ENS de Lyon.

9.2.3. Teaching by Guillaume Chelius

Master : *Wireless Networks* class in the Master 2 System and Networks, IFI (Hanoi, Vietnam)

Master :Algorithms for Networks and Communications in the Fundamental Computer Sciences Master at Department of computer science of ENS Lyon (Lyon, France)

9.2.4. PhDs

PhD in progress : Andreea Chis, Methods and tools for the compilation and software optimization of wireless embedded systems dedicated to applications, October 2007 - January 2012, E. Fleury and A. Fraboulet

PhD in progress : Qinna Wang, Uncovering overlapping dynamic communities, October 2008 - march 2012, E. Fleury

PhD in progress : Adrien Friggeri, Exploring Socially Cohesive Communities, September 2009 - October 2012, E. Fleury and G. Chelius

PhD in progress : Lucie Martinet, iBird: Individual Based Investigation of Resistance Dissemination, September 2011, E. Fleury and C. Crespelle

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