



**Regional Program STIC-AmSud
2016 Project Proposal (Research – Innovation)**

Basic Form

- This form, and the associated CVs, must be filled in English. Before filling the form, please read carefully the bases published in the STIC-AmSud site (<http://sticmathamsud.org/>).
- This form must be sent in **.pdf** by email to the STIC-AmSud Secretariat (contacto@sticmathamsud.org) by the project's International Coordinator.

A. General Information

A1	Project title
	Stochastic dynamics of large games and networks
A2	Acronym
	GENE
A3	Research domain
	Performance evaluation – Communication networks and protocols- Stochastic games – Mean-field Games- Resources allocations- Load balancing
	Project goals

	<p>The GENE project aims at contributing to the theory of the performance evaluation and control of modern communication networks, using tools of game theory, especially the so-called mean field games, probability theory and control theory.</p> <p>The research to be developed aims at combining different tools from quite different disciplines: scaling limits of stochastic processes, games dynamics and control theory, to obtain new insights significant contribution in the applied field of load balancing, resource allocation and decentralized control. A specific attention will be given to the notion of load balancing which is one of the hottest topics in applied mathematics in the last 3 years.</p> <p>The expertise of the different partners in these areas definitely forecasts a strong contribution to the current state-of-the-art.</p> <p>The main objectives of the GENE project are:</p> <ul style="list-style-type: none"> (i) to consolidate an already strong research and education relationship between the Probability group of the university of Buenos Aires (UBA, Argentina), the Engineering Faculties of UDELAR (Universidad de la República Uruguay) and ORT (ORT university) in South America and the CNRS (LAAS Toulouse) and the INRIA (MESCAL Grenoble) in France. (ii) to boost and to promote research bonds between the main research and graduate/post-graduate education institutions in Argentina and Uruguay (Universidad de Buenos Aires, UDELAR, ORT), as well as to expand the South American-French historical scientific collaboration by including both CNRS and INRIA, the major pillars of French scientific development. <p>The common roadmap for reaching these goals will be: (i) to organize project workshops and internships in partner institutions in order to build a common knowledge map and common tools in the field of performance evaluation and optimal control of information systems and communication networks (ii) to disseminate joint results by publications in major international conferences or journals, (iii) to develop common guidance of PhD and postdocs.</p>
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	<p>Abstract</p>
	<p>Through the creation and consolidation of strong research and formation exchanges between Argentina, France and Uruguay, the GENE project will contribute to the fields of performance evaluation and control of communication networks, using tools of game theory, probability theory and control theory.</p> <p>Some of the challenges this project will address are:</p> <ul style="list-style-type: none"> - Mean-field games and their application to load balancing and resource allocations, - Scaling limits for centralized and decentralized load balancing strategies and implementation of practical policies for web servers farms, - Information diffusion and communication protocols in large and distributed wireless networks.

A6 Scientific coordinators at each institution			
South America A		South America B	
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A7	Other participating institutions	
	In South America	In France Institut National Polytechnique de Toulouse Coordinator Urtzi Ayesta (INP / IRIT)

A8	List of expected participants (name and affiliation and status : junior, senior)
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ORT University, Montevideo, Uruguay:

Coordinator: Prof Andrés Ferragut
Prof Fernando Paganini
Phd Student: Diego Goldsztajn

Universidad de la República, Montevideo, Uruguay:

Coordinator: Prof. Federico La Rocca.
Prof. Paola Bermolen,
PhD student Claudina Rattaro
PhD student Valeria Goicoechea

Universidad de Buenos Aires, Argentina:

Coordinator Dr Matthieu Jonckheere,
Prof. Ines Armendariz,
Prof. Pablo Groisman,
PhD student Manuel Saenz,
PhD student Maximiliano Altamirano,
PhD student Emmanuel Ferreyra

CNRS LAAS, Toulouse, France,

Coordinator: Dr Balakrishna Prabhu, LAAS
Dr. (postdoc) Manu Gupta, (IRIT-CNRS)
PhD student Santiago Durán.

INP, Toulouse, France,

Coordinator: Dr. Urtzi Ayesta (INP & IRIT-CNRS)
Dr. Maaïke Verloop, (INP & IRIT-CNRS)
Dr. Tejas Bodas (postdoc), (INP & IRIT CNRS)
Phd student Elene Anton (INP & IRIT CNRS)

INRIA, Grenoble, France:

Coordinator : Dr Nicolas Gast
Dr Bruno Gaujal

A9	International Project Coordinator (to be chosen among the Scientific Coordinators mentioned in A6)
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	Matthieu Jonckheere
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B. Project Details

B1. Project guidelines

The GENE project aims at strengthening the collaboration between the participating institutions: UBA, ORT, UdelaR, CNRS and INRIA. The collaboration between the partners is a well-established one for some of the partners (UBA with UdelaR and CNRS) and between many of the researchers involved (with a solid history of common publications). This collaboration is both based on a common research line on performance evaluation and optimal control of communication networks and information systems, using probabilistic techniques and on a new line of research combining ideas coming from mean-field game theory and performance evaluation.

This translates in practice into parallel research tracks with cross fertilization and fruitful collaborations. In order to maintain the existing collaboration and to strengthen the new links we need to exchange students (internship students, PhD students with co-advising, post-doc students, etc.). We also need to have regular joint meetings which can be considered as milestones for our project where partners can exchange ideas and share results. Each institution is funding its own manpower (in particular PhD and postdoc students). The obtained fundings are not specifically dedicated to French-South America mobility. Therefore there is a need to support mobility in order to maintain and to strengthen the links between our organizations. We believe from our past experience that this collaboration will continue inspiring our research and that we will build a very strong and committed consortium with highly valuable and recognized results.

B2. Project description

Goals, motivation, methodology and contribution of each participating institution

Communication networks and information systems have become a fundamental component of the worldwide communication infrastructure. With servers farms with an order of 10^5 to 10^6 servers, academic applications like CERN or commercial ones like amazon demand efficient schemes to best take advantage of resources. A further expansion is expected in the future fostered by the rise of new applications such as social networks,

Communication networks and information systems are complex systems, huge in size and largely decentralized in its management. This in turn makes their control an extremely challenging task, yet of crucial importance from the users' experience point of view. The goal of this project is to develop novel mathematical tools for their optimal and decentralized control having a real impact on the design paradigms of future communication networks. The essential features of these systems, in particular their stochastic nature are captured through the mathematical models of stochastic networks, raising three fields of research:

- firstly evaluating the performance of network protocols and algorithms; this includes identifying critical regimes of functioning where the resources are best used without quality shortage,
- then determining close-to-optimal policies performing well at least in the previously identified critical regime,
- and lastly designing efficient decentralized controls allowing practical implementation of close-to-optimal policies.

More precisely, we plan to address these fields of research by the study of the following intertwined challenges:

- **Challenge 1: Stochastic Games and Mean Field Games**

Dynamic systems with online optimization have been the focus of a huge literature: Multi-armed bandits, dynamic power allocation, work stealing are all but a few well-known examples of such systems. When the optimization process is *user centric* -- where each user has her own utility function -- then the system becomes a *stochastic game*. Stochastic games are difficult to analyze on a mathematical level (strategies live in complex functional spaces) as well as algorithmic one (computing stable points is even more difficult than in static games). To analyze such game, one of the first property that has attracted interest is the existence of equilibria.

The history of game theory has been marked by milestone theorems concerning the existence of an equilibrium: The minimax theorem of Von Neumann [N28], that shows the existence of an equilibrium for finite zero sum games; the famous result of Nash [N51], showing the existence of an equilibrium in finite games; the folk theorem (see for example [FM86]) that characterizes Nash equilibria in repeated games or the mean-field game solution, introduced by Lasry and Lions [LL07], that shows the existence of equilibria in dynamic games with an infinite number of players. In our proposal falls, we will focus on mean-field games and their relation with stochastic games.

A first problem is to provide weak conditions on the game under which existence of a Nash equilibrium is guaranteed. This question has been investigated in the case where the state space is discrete in [GMS10]. A more general answer is given in [DGG16b] where the only condition for the existence is continuity of the utility function. This is rather satisfying since it mimics the condition for existence in static population games. A more practical problem is to provide effective construction of Nash equilibria. For general stochastic games this is a notoriously hard problem. Hope is permitted in the mean field case because the best response of one player is essentially an open-loop strategy. When the state space is finite, the best response can be seen as the solution of a Bellman equation (see [DGG17]). The solution is tractable when the problem has structural properties, such as modularity or convexity of the utilities.

The next question is to verify if the equilibria of the mean field game limit are limits of equilibria of finite stochastic games. In most cases the answer is yes, although technical conditions are needed for the limit to hold. An intriguing question is whether all equilibria of the finite stochastic game have limits. Several counterexamples show that this is not the case in general. These known counterexamples require a special structure: The associated finite static game has several Nash equilibria and the stochastic kernel is degenerated to a deterministic one [DGG16a]. The class of games where this discrepancy between finite stochastic games and mean field games occurs is still unknown and will be one the focus of our work.

Application area: Self Optimizing Networks

Research on mobile network analysis and optimization automation processes related to them is largely based on input from planning tools and/or network statistics (mainly counters).

In the case of planning tools, the optimization is an off-line centralized process. Furthermore, the planning data available from a tool already contain a number of errors/approximations and do not necessarily correspond to reality. This makes the results unsafe. As for network statistics (network counters that measure traffic), there are certain research efforts that provide results for handling of selected set of parameters in a specific network in near real time. These research results do not attempt an overall network resource optimization and are actually applicable under certain conditions and networks.

Our goal is also utilize information from planning tools and network statistics. Here, we plan to take a

decisive research step forward by using *user centric* approaches for optimization as well as *real time* measurements so that the actions of the users adapt to the current conditions. The on-line measurements can be combined with conventional planning and statistical data that can also be corrected on-line.

The difficulty to analyze such systems is similar to the complexity of multi-class processor sharing queues whose service rates vary over time and depend on the state of the queue. Such systems are known to be often intractable (see [BC83] for example).

The performance evaluation of such systems is often done under two limiting regime, usually terms fluid and quasi-stationary. The fluid limit assumes that the time scale of the variations of the activations of the base stations is much faster than the flow variations, so that each flow faces the average activity of the cells. The quasi-stationary limit, on the other hand, considers that the speed of variation of the base stations is so small that it can be frozen to its initial state.

While those approaches are extremely powerful to assess the capacity of the network, they are usually less pertinent for optimization purposes. Indeed, dynamic policies may take advantage of transient opportunities for transmission and the natural framework for online optimization is non-stationary. This is typically the case for fast fading channels. This non-stationarity happens at different time scales: from hours (traffic is higher during working hours), minutes (mobility of users) to seconds (slow fading and shadowing) and milliseconds (fast fading). We plan to take both limits into account in our study and to consider both of them together. The fluid limit as well as the quasi-stationarity limit can be studied using mean-field approximations of the behavior of the users (or devices).

[BC83] J.W. Cohen and O.J. Boxma, *Boundary Value Problems in Queueing System Analysis* (North-Holland Publ. Co., Amsterdam, 1983)

[DGG16a] Josu Doncel, Nicolas Gast, and Bruno Gaujal. *Are mean-field games the limits of finite stochastic games?* In The 18th Workshop on Mathematical performance Modeling and Analysis, Nice, France, June 2016.

[DGG16b] Josu Doncel, Nicolas Gast, and Bruno Gaujal. *Mean-Field Games with Explicit Interactions*. working paper or preprint, February 2016.

[DGG17] Josu Doncel, Nicolas Gast, and Bruno Gaujal. *A Mean-Field Game Analysis of SIR Dynamics with Vaccination*. working paper or preprint, 2017.

[FM86] Drew Fudenberg and Eric Maskin. *The folk theorem in repeated games with discounting or with incomplete information*. *Econometrica*, 54(3):533–554, 1986.

[GMS10] Diogo A. Gomes, Joana Mohr, and Rafael Rigo Souza. *Discrete time, finite state space mean field games*. *Journal de Mathématiques Pures et Appliquées*, 93(3):308 – 328, 2010.

[LL07] Jean-Michel Lasry and Pierre-Louis Lions. *Mean field games*. *Japanese Journal of Mathematics*, 2(1):229–260, 2007.

[N51] J. Nash. *Non-cooperative games*. *Annals of mathematics*, pages 286–295, 1951.

[N28] John von Neuman. *Zur theorie der gesellschaftspiel*. *Mathematische Annalen*, 100:295–320, 1928.

- **Challenge 2: Load balancing for large scale networks**

Load balancing is a critical component of several systems. Road traffic networks, data networks such as the Internet, multi-servers systems such as call centers, server farms, all require load balancing algorithms to ensure that the system resources are utilised in an optimal way.

The computation of the optimal load balancing policy for general stochastic networks is a notoriously hard problem. In order to circumvent the difficulty, two kinds of ideas were explored: (i) optimal policies in a sub-class of problems; and (ii) heuristics that are simple to implement and intuitively appealing. For example, Join-the-shortest-queue (JSQ) is optimal for exponential service time but requires the knowledge of the state of all the servers. In systems with thousands of servers it may not be feasible to obtain the whole state information when a request arrives. Thus, heuristics such as Power-of-d-choices (PDC) or Join-the-Idle-Queue (JIQ) were proposed. PDC requires to know the state of only D servers whereas JIQ knows that of the idle queues. They require less information than JSQ but are further away from optimality. The performance tradeoff between efficiency and level of information needed to achieve this level is far from being well understood. The main reason for this is because the performance evaluation of such algorithms is out of reach of the currently known techniques. This fact becomes even more evident for large systems with asymmetric server speeds and *blocking*.

Moreover, there is currently a great need of more decentralized (and hence practically implementable) schemes, allowing to deal with the massive amount of servers involved in the architecture of web-service companies.

Two types of ideas were historically employed to make progress on this front: considering large scale networks and obtaining asymptotic results using propagation of chaos (asymptotic independence which is essential for mean-field approximations) on the one hand (see [VDK96], [BLP12], [S15], for example) ; restricting the load balancing schemes to obtain more tractable reversible processes on the other hand [J06]. The attractive aspect of reversible processes is that they are applicable to Poisson arrivals and independent call durations, that is the analysis is insensitive to the call duration distribution and depends on a unique parameter: the traffic intensity.

In [JP16], these two ideas were combined to obtain to very precise results in *blocking* system which are typically out of reach with other methods. In turn, these results allow to give universal (i.e. valid for all job-size distributions) lower bound on performance. In particular, different asymptotic scalings for the blocking probability can be identified: an exponentially small blocking probability for sub-critical loads; a polynomial order in the critical regime; and a constant level for super-critical loads.

These results give a non-trivial upper bound on the blocking probability of the optimal load balancing scheme. Until one can obtain better bounds using some other heuristic, these results can be seen as the benchmark with which to compare the efficiency of a heuristic.

The main objective of this task is to explore the performance trade-off between information and optimality in different asymptotic regimes. For this the first we will obtain bounds using the insensitive schemes (Task 2.1) which will give us a benchmark performance with which we can compare different heuristics. The second step will be to propose heuristics to trade off performance and state informations (Task 2.2).

Task 2.1: Insensitive load-balancing for multi-class networks

The first task aims at generalising the results of [JP16] to multi-class systems as well as to networks. Given the complexity of the analysis of load balancing networks, most of the works we have mentioned above have focussed on a networks of parallel links, that is one or more dispatcher which can send to any of the servers. Some recent studies have looked at multiple dispatcher and parallel links [S15]. One can ask the same question in the context of more complex networks: given a graph and matrix of traffic demands, how does the blocking probability at different nodes behave asymptotically when the size of the network become large? More importantly, we aim to identify the hotspots or, in other words, the nodes that will have the largest blocking probability and hence more vulnerable to overload. This will help in proposing dimensioning buffer rules for networks. This network problem will be investigated for

insensitive load balancing algorithms. As mentioned above in before we are focussing on insensitive schemes because they are amenable to exact analysis. The results obtained also be used as upper bounds and performance benchmarks for other heuristics.

Task 2.2 Heuristics based on state information and performance tradeoff

It has been observed in large server farms that the delay of obtaining exact real-time state information from servers can cause clients to abort which then results in lost revenue. It is thus better to obtain state information in advance before the arrival of request. The JIQ policy [LXK11] was proposed to take this constraint into account. The servers inform the dispatcher when they become idle, and the dispatcher routes based on the knowledge of which servers are idle. Even though the information exchange is reduced, the dispatcher has to keep track of the state of $O(n)$ servers, where n is the number of servers. In the mean-field limit, JIQ is known to be optimal in the multi-router model as well [S15]. The main question we shall investigate in this task is whether the server can obtain asymptotically similar performance by keeping track of the state of $o(n)$ servers. To make the model tractable, we shall start with a Markovian system in which the servers send signals according to a Poisson process. The dispatcher has to decide how many of these message it keeps. If it keeps all the message then we fall back to the JIQ model. Our primary interest is in the size of the state information queue at the dispatcher and how this impacts the performance. The distance from the bounds obtained in Task 2.1 shall be used as the metric for performance loss. The tradeoff between the memory requirements at the dispatcher and the performance shall be investigated in different asymptotic regimes such as mean-field, Halfin-Whitt, NDS.

A second direction for heuristics is the Multi-Armed Bandit (MAB) approach for resource allocation pioneered by Whittle [W88] for restless bandits. In the load balancing example, the bandits correspond to servers, and restless indicates the fact the servers can change state between two decision instants of the dispatcher even if they no tasks were sent to these servers in the previous decision instant. In [LAV16], this approach was applied to load balancing schemes with a single dispatcher. In this task, we shall explore this heursitic approach to multiple dispatcher systems. The objective will be to obtain bounds on the performance loss in the different asymptotic regimes.

[BLP12] M. Bramson, Y. Lu, and B. Prabakhar. *Asymptotic independence of queues under randomized load balancing*. Queueing Syst, 71:247–292, 2012.

[J06] M. Jonckheere. *Insensitive versus efficient dynamic load balancing in networks without blocking*. Queueing Syst., 54(3):193–202, 2006.

[JP16] M. Jonckheere and B.J. Prabhu. *Asymptotics of Insensitive Load Balancing and Blocking Phases*. In Proc. of ACM SIGMETRICS 2016, Juan-les-Pins, France.

[LAV16] M. Larranaga, U. Ayesta, I.M. Verloop. *Dynamic control of birth-and-death restless bandits: application to resource-allocation problems*. IEEE/ACM Transactions on Netwoking. 2016

[LXK11] Y. Lu, Q. Xie, G. Kliot, A. Geller, J. Larus, and A. Greenberg. (2011). *Join-idle-queue: A novel load balancing algorithm for dynamically scalable web services*. Performance Evaluation 68, 1057--1071.

[S15] A. Stolyar. *Pull-based load distribution among heterogeneous parallel servers: the case of multiple routers*. ArXiv e-prints, 2015.

[VDK96] N. D. Vvedenskaya, R. L. Dobrushin, and F. I. Karpelevich. *Queueing system with selection of the shortest of two queues: An asymptotic approach*. Problems of Information Transmission, 32(1):15–27,

[W88] P. Whittle, *Restless bandits: Activity allocation in a changing world*. Journal of applied probability, pp. 287–298, 1988.

- **Challenge 3: Decentralized close-to-optimal communications in random graphs with hardcore interferences**

Let G a graph that represents interferences between users impeding a simultaneous communication (say with a central node). An independent set in this graph is defined as a set of nodes of G which are not adjacent and which can model a set of users allowed to communicate simultaneously.

Naturally, there are generally several independent sets on any given graph. It is a classical and important problem in graph theory to estimate the size the maximum possible cardinality of the independent sets of G while this has important consequence in many physics problems (for instance for the modeling of ultra-cold gases), in biology (adsorption phenomena) and in engineering (for instance for modeling the protocols related to wireless communications).

Finding an independent set of maximum cardinality (MIS) is well-known to be an NP-complete problem. As a consequence, several heuristics have been developed in the past for deterministic graphs. A particularly simple one is the so-called minimum-degree greedy algorithm [1] : select a vertex of minimum degree, delete that vertex and all of its neighbors from the graph, and repeat this process until the graph becomes empty. This algorithm is actually optimal on trees.

Analysis of explorations of independents sets in sparse random graphs have been considered for (fully) decentralized algorithms in [2,3,4].

Starting from these results, we aim at developing the following research program:

1) For sparse random graphs (constructed for instance using the configuration model) which can be reasonable models of real-life large wifi hot spots, we aim at proving (under additional adequate restrictions on the degree distributions) that the degree-greedy algorithm is asymptotically optimal.

This is a consequence of the tree-like local properties of the sparse graphs. This would be the first known asymptotically optimal algorithm for an important class of random graphs.

2) We aim at developing decentralized algorithms that behave similarly to the degree-greedy algorithm by learning dynamically (but locally) their neighborhoods. That would significantly improves the state of the art for the MIS problem on random graphs. A reasonable heuristic would be that each node approximately learns its neighborhood and adapts its rate (of trying to communicate) accordingly. We first aim at doing extensive simulations and then to prove that these heuristics give very good results for large graphs.

References:

[1] M. M. Halldorsson and J. Radhakrishnan, “Greed is good: Approximating independent sets in sparse and bounded-degree graphs,”

Algorithmica, vol. 18, no. 1, pp. 145–163, 1997.

[2] P. Bermolen, M. Jonckheere, and P. Moyal, “The jamming constant of uniform random graphs,” Stochastic Processes and their Applications, 2016.

[3] S. Janson, G. Brightwell, and M. Luczak, “The greedy independent set in a random graph with given degrees,” Random Structures Algorithms,

[4] N. C. Wormald, “Differential equations for random processes and random graphs,” Ann. Appl. Probab., vol. 5, no. 4, pp. 1217–1235, 11 1995.

Project scope

The scope of the GENE project is ambitious enough so as to provide strong contributions to the research community in the different addressed fields, without leaving aside the paramount goal of formation, collaboration and integration between our institutions and research groups.

The specific technical scope of project has been described above. We believe it contains objectives which are both ambitious and reachable.

As already underlined, partners of the GENE project have a solid collaboration framework already going on. An important goal is to develop new collaboration especially steaming from the cross analysis of large games and policies and to develop common guidance of PhD and postdocs.

Expected results

Formation of young researchers:

The formation of young researchers is a fundamental objective of this project, giving guarantees of continuation of the partnership on the long term. This integration will be achieved by encouraging a continuous flow of students and young scientists between partner institutions through: internships of engineering and master of science students in the partner institutions; co-advising of PhD students and/or post-doc studies in one of the partner institutions.

Dissemination of the results

We expect that the joint research line will result in a bunch of joint publications in international conferences and journals. The dissemination results will be considered as excellent if we reach the following objectives:

- 3 to 4 publications in the following well recognised journals or equivalent (Transactions on Networking, Mathematics of Operation Research, Annals of Applied Probabilities, Queuing Systems etc...)
- 3 to 4 publications in international workshops or conferences

We also expect that some participants will be associate editors of one or two special issues of an international journal and technical program chair of one or two workshops in relation with the main topics of GENE.

Preparation of future collaborations

One of the goals of the project is also to keep strengthening the scientific dialog between Europe and South America where both regions have common research interests. Our objective is to facilitate the participation of South American research teams in European projects, specifically in the field of telecommunications and networks

B3. Schedule, with main execution stages

Year 1

- **T0:** The starting date of the project is planned for January 2018, which corresponds to summer holidays in South-America.
- T0 + 2 (march 2018) – Kick-off meeting in Buenos Aires with one representant of each country (10 days stay at UBA from 1 senior research from CNRS + 10 days from two researchers from Montevideo)
- T0 + 2 (may 2018) – 15 days stay at ORT/UdelaR from 1 senior research from UTC.
- T0 + 6 (june 2018) - 4 weeks stay at UBA for 1 researcher from CNRS/INRIA

- T0 + 7 (july 2018) - Internal advancement reports.
- T0 + 9 (september 2018) - 3 to 4 weeks stay at CNRS/INRIA for 1 young researcher from UBA
- T0 + 12 (january 2019) – Evaluation report for GENE project, year 1.

Year 2

- T0 + 14 (march 2019) –3 to 4 weeks stay at CNRS/INRIA for 1 young researcher from UBA.
- T0 + 17 (june 2019) – 2 weeks stay at UBA for 1 researcher from CNRS/INRIA.
- T0 + 17 (june 2019) – 3 to 4 weeks stay at ORT/UDELAR for 1 senior researcher from CNRS/INRIA.
- T0 + 18 (july 2019) – Internal advancement reports.
- T0 + 20 (september 2019) – 3 to 4 weeks stay a UBA for 1 youngresearcher from ORT/UdelaR.
- T0 + 20 (september 2019) – 3 to 4 weeks stay at UdelaR for 1 senior researcher from CNRS/INRIA and one researcher from UBA.

B4. Contributions

Present contributions so as to highlight the role of each partner and the integration among partners.

Challenge 1: Stochastic games and mean-field games

Participating institutions: CNRS, INP, UBA and INRIA.

Contribution: Urtzi Ayesta (Toulouse), Maaïke Verloop (Toulouse), Bala Prabhu (Toulouse), Matthieu Jonckheere, Pablo Groisman (UBA), Emanuel Ferreyra, Manuel Saenz (PhD students UBA), Nicolas Gast, Bruno Gaujal (INRIA)

The researchers of INRIA involved in this project have an international expertise in stochastic games. The CNRS participants have a strong expertise in scheduling, control theory and their applications to communication systems and networking. The UBA participants have a strong expertise in probability theory applied to stochastic networks, particle systems, and queuing systems.

One of the main objectives is also to have a strong interaction of E. Ferreyra (Phd student of M. Jonckheere) with the INRIA group so that he can learn stochastic games from the best experts. Two research visits (one of M. Jonckheere and one of E. Ferreyra) have already been organized in 2016 to start this collaboration.

Finally strong links between the different groups have already been built as witnessed by the previous collaborations:

M. Jonckheere and B.J. Prabhu. *Asymptotics of Insensitive Load Balancing and Blocking Phases*. In Proc. of ACM SIGMETRICS 2016, Juan-les-Pins, France.

U. Ayesta, M. Erausquin, M. Jonckheere, I.M. Verloop, “Scheduling in a random environment: stability and asymptotic optimality”, IEEE/ACM Transactions on Networking, 21(1), 258-271, 2013.

U. Ayesta, M. Erausquin, M. Jonckheere, I.M. Verloop, “Stability and asymptotic optimality of opportunistic schedulers in wireless systems”, Proceedings of VALUETOOLS 2011.

M.Jonckheere, M. Feuillet and B. Prabhu, “Responding to traffic surges: Stochastic networks under time-space-priority scalings”, Stochastic Systems, 4, (2014), 1-30 (electronic) .

Challenge 2: Load balancing in large scale networks

Participant institutions: CNRS, INP and UBA.

Contribution: Matthieu Jonckheere (UBA Buenos Aires), Andres Ferragut (ORT), Maaïke Verloop (INP Toulouse), PhD student Emmanuel Ferreyra (UBA), Santiago Duran (LAAS)

Matthieu Jonckheere and Bala Prabhu worked together on this subject since 2015, while some more recent collaboration has been established with ORT.

The expertise and the relations between the research groups of LAAS and UBA has been already mentioned. The recent collaboration between UBA and ORT is reflected in the following submission:

D. Goldsztajn, A. Ferragut, F. Paganini, M. Jonckheere. “Controlling the number of active instances in a cloud environment”. Submitted to: Workshop on MATHematical performance Modeling and Analysis (MAMA 2017), in

Challenge 3: Decentralized close-to-optimal communications in random graphs with hardcore interferences

Participant institutions: Udelar, UBA and CNRS.

Contribution: Paola Bermolen (Montevideo), Matthieu Jonckheere (Buenos Aires), Ines Armendariz (Buenos Aires), Phd Student Manuel Saenz (UBA)

There already exists a fluid collaboration between UBA, Udelar and CNRS reflected in frequently courses and talks in both institutions and witnessed by the following publications. Manuel Saenz started his PhD on these topics and could benefit greatly from the expertise of both researchers from Montevideo and France.

- Paola Bermolen., Matthieu Jonckheere, Jaron Sanders, Scaling limits and generic bounds for exploration processes, submitted,
- Paola Bermolen, Matthieu Jonckheere, Pascal Moyal, The jamming constant of random graphs accepted in Stochastic Processes and Applications.
- P. Bermolen, F. Larroca, M Jonckheere, P. Moyal, Estimating the spatial reuse with configuration models accepted in TOMPECS

B5. Regional Aspects

Indicate how the activities will stimulate effective scientific interactions between all the participants.

The different partners have developed strong expertise in complementary fields that can be efficiently combined to produce research of international level on the topics proposed: the participants of INRIA have a strong expertise in stochastic games, the participants of UBA have a strong expertise in probability theory applied to stochastic networks, particle systems, and queuing systems. On the other hand, the participants of UDELAR and CNRS have a deep understanding of optimal control and networking aspects.

B6. Institutions and CVs of coordinators

Description of each participating institution, and curriculum vitae of each participant (maximum 2 pages per participant).

Institutions:

CNRS (LAAS and IRIT),

Located in Toulouse, France, LAAS is a large research unit of the CNRS, the French National Center for

Scientific Research, within the Department of Information and Engineering Sciences and Technologies. IRIT is a mixed research unit of CNRS. LAAS and IRIT are associated to the University of Toulouse (Université Paul Sabatier, Institut National Polytechnique de Toulouse, Institut National des Sciences Appliquées de Toulouse).

The research topics of LAAS and IRIT, fundamental or applied, are focused on the study of complex systems at different scales with a multidisciplinary and systemic vision and an integrative approach. With 600 researchers, university faculty, engineers, technicians, post-docs and PhD students, LAAS and IRIT are one of the key players in Systems research in the Midi-Pyrénées region, in France and in Europe.

INP

Created in 1969, Institut National Polytechnique de Toulouse (INPT) is a public French university that federates 7 engineering schools offering a very large choice of diplomas up to PhD. It hosts as well 19 research laboratories in partnership with CNRS and other universities of Toulouse. The involved partners are members of ENSEEIHT, a highly ranked French engineering school. The researchers of INPT/N7 have participated in various national projects (ACI WILDE, DARPA WNAN for developing the first prototype cognitive-radio multi-hop wireless network in the world; NS CTA, a collaborative alliance of approximately 30 institutions funded by US Army Research Laboratory for fundamental research in network science) and international projects (FP6 DistMO4WNet, GreenTouch). These activities were developed in collaboration with groups in France (INSA Lyon, INRIA teams) or abroad (Stevens I.T., UC Riverside, UMass).

Mescal INRIA

The goal of the Mescal project-team is to design and validate middleware and services in order to efficiently exploit large distributed infrastructures built on aggregation of commodity components and/or commodity clusters at metropolitan, national or international scale. Our applications are intensive scientific computations. The methodology used is based on the design of bricks that scale efficiently, using modeling and performance evaluation. of target architectures, software layers and applications.

The research efforts of Mescal are aimed at designing and implementing middleware for clusters and grids that scale efficiently. This includes deployment tools, batch schedulers and distributed file systems. The team's research directions also include modelling, simulation, evaluation and optimization of computation grids and more generally, of large discrete event systems, using deterministic as well as stochastic techniques.

The University of Buenos Aires (UBA)

UBA was founded 12th August 1821 . At present, it represents the largest university in Argentina and a world-class prestigious center of investigation. It provides for the training of professionals with over 6650 teachers and more than 100.800 students characterized by its strong commitment with society. It has very strong researchers in the field of mathematics and computer sciences.

Universidad ORT Montevideo

Universidad ORT Uruguay is the largest private university in Uruguay, with more than 10.000 students in five schools and several smaller institutes. It was granted university status by the Uruguayan Education Ministry on 1996. It is backed by a non-Profit civil association which is also a member of World ORT, one of the largest education non-government organization, with 250.000 students worldwide, present in more that 60 countries.

Currently, the university offers 63 diplomas, in undergraduate and graduate levels, including several in Engineering, like Computer Science and Electrical Engineering. The main educational goal is to convey two essential values: academic excellence and equal chances for students, offering access opportunities through several scholarship programs.

Universidad de la República (UDELAR)

UdelaR is the only public university in Uruguay and it is one of the main research centers in several areas. UDELAR together with other institutions and social actors also develops actions oriented to a valuable use of research and cultural diffusion. It is a public institution, autonomous, and co-conducted by their students, graduates and professors. It is the most important University in Uruguay, with more than 100.000 students, and covers most areas of knowledge.

CV of Scientific Coordinators at each institution

Andrés Ferragut

**** Contact Info:**

Address: Cuareim 1451, of. 415 Montevideo, Uruguay.

Phone: +598 29021505 ext. 1359

Email: ferragut@ort.edu.uy

Personal page: <http://fi.ort.edu.uy/6785/17/andres-ferragut.html>

**** Current Appointment**

2010-Present Associate Professor, Universidad ORT Uruguay.

Full time appointment in the Networking and Mathematics departments. Researcher, working in the Mathematics applied to Telecommunications and Energy (MATE) research group (<http://fi.ort.edu.uy/mate>)

**** Education**

2008-2011 -- PhD. in Electrical Engineering, Universidad de la República, Montevideo, Uruguay, Advisor: Dr. Fernando Paganini. Title: Resource Allocation in Networks from a Connection-Level Perspective

2004-2006 -- Research intern, Télécom Paris and France Télécom R&D, Paris, France.

1998-2004 -- Engineering degree, Universidad de la República, Montevideo, Uruguay.

****Professional activity**

*** Editorial work**

- Editor: IEEE/ACM Transactions on Networking (2017–2019).

- Technical Program Committee member: IFIP Performance 2015, QEST 2016, QEST 2017.

- Reviewer: IEEE/ACM Transactions on Networking, IEEE Transactions on Automatic Control,

- Computer Networks, Computer Communications, Performance Evaluation.

*** Consultory services**

- Consultant for BID-FOMIN: Proyecto Rayuela (Plan Ceibal): Design of a Monitoring and Evaluation System for the Ceibal Project. Uruguay.

- Consultant, Numetra Inc., EE.UU.: Design of a transport and distribution protocol for online video.

**** Awards**

- Researcher Level I, National Research System, Uruguay (2012-Present)

- First Prize for best doctoral dissertation in Electrical Engineering, National Academy of Engineering, Uruguay. (2012)

- Best Paper Award (co-author), Latin American Networking Conference. (2010)

- Best Paper Award (co-author), Latin American Networking Conference. (2008)
- Doctoral Scholarship, ANII, Uruguay. (2008)

**** Funded research**

-- 2016-2018: Optimization of energy storage in electrical markets with high renewable penetration, Funded by ANII - Innovation, Principal Investigator. In cooperation with CSI Ingenieros.

-- 2016-2017: Optimal power flow and storage in dynamical electrical networks, Funded by UTE (utility company), Team member.

-- 2016-2017: Optimal power flow for renewable energy integration, Funded by IADB, Team member.

*** Recent projects**

-- 2015-2016: Fluid analysis of network content dissemination and cloud systems, Funded by AFOSR–US, Co-Principal Investigator.

-- 2015-2016: Smart grids and markets with renewable energy, Funded by ANII – FSE, Team member.

-- 2013-2014: Content propagation in dynamic communication networks, Funded by ANII – FCE, Co-Principal Investigator.

-- 2012-2015: Content dynamics over the network cloud, Funded by AFOSR–US, Co-Principal Investigator.

**** Publications**

*** Selected articles**

1. A. Ferragut, F. Paganini, A. Wierman. "Controlling the variability of capacity allocations using service deferrals",

accepted in ACM Transactions on Modeling and Performance Evaluation of Computer Systems (2017).

2. F. Bliman, A. Ferragut, F. Paganini. "A macroscopic view of demand-side grid regulation through fluid queueing

models and H2 control", accepted in IEEE Transactions on Smart Grid (2017).

3. A. Ferragut, I. Rodríguez, F. Paganini. "Optimizing TTL caches under heavy-tailed demands", In Proc. of ACM

SIGMETRICS/Performance 2016, Antibes, France, Jun 2016.

4. A. Ferragut, F. Paganini. "Fluid models of population and download progress in P2P networks". IEEE Trans. on

Control of Network Systems, Vol. 3(1), pp. 34-45, May 2016.

5. A. Ferragut, F. Paganini. "Queueing analysis of peer-to-peer swarms: stationary distributions and their

limits". Performance Evaluation, Vol. 93, pp. 47-62, Nov. 2015.

6. M. Zubeldía, A. Ferragut, F. Paganini. "Neighbor selection for proportional fairness in P2P networks". Computer Networks, Vol. 83, pp. 249-264, Jun. 2015.

7. A. Ferragut, F. Paganini. "Network resource allocation for users with multiple connections: fairness and stability",

IEEE/ACM Trans. on Networking, Vol. 22(2), pp. 349-362, Apr. 2014.

8. M. Zubeldía, A. Ferragut, F. Paganini. "Overcoming Performance Pitfalls in Rate-Diverse High Speed WLANs",

Computer Networks, Vol. 57(17), pp. 3673-3685, 2013.

9. F. Paganini, A. Tang, A. Ferragut, L. Andrew, "Network Stability under Alpha Fair Bandwidth Allocation with General File Size Distribution", IEEE Trans. on Automatic Control, Vol. 57(3), pp. 579-591, Mar. 2012.

10. A. Ferragut, F. Paganini "Resource allocation over multirate wireless networks: A Network Utility Maximization perspective", Computer Networks, Vol. 55(11), pp. 2658-2674, Aug. 2011.

* In cooperation with project partners

1. D. Goldszajn, A. Ferragut, F. Paganini, M. Jonckheere. "Controlling the number of active instances in a cloud environment". Submitted to: Workshop on MATHematical performance Modeling and Analysis (MAMA 2017), in association with SIGMETRICS 2017.
2. A. Ferragut, M. Jonckheere, F. Paganini. "Processor sharing queues motivated by P2P networks", In Stochastic Networks 2014, Amsterdam, Netherlands, Jun 2014.

Federico Larroca

1 - Personal data

Birth date: November 20th, 1981.

Professional address (with telephone and e-mail): Facultad de Ingeniería, Universidad de la República. Julio Herrera y Reissig 565, Montevideo, Uruguay. +598 27110974. flarroca@fing.edu.uy. <http://iie.fing.edu.uy/personal/flarroca>.

Current job title and size of the research group: Profesor Agregado, grado 4. Equivalent to an Associate Professor. Member of the ARTES group (~12 members): <https://iie.fing.edu.uy/investigacion/grupos/artes/>.

2 - Highest obtained degree (with indication of place and date)

PhD on Computer Science and Networking (docteur en Informatique et Réseaux). Télécom ParisTech, France. October 2006 - December 2009.

3 - Professional activity in the last 5 years

From 2011 to 2016 I was Profesor Adjunto, grado 3 (equivalent to an Assistant Professor), also at the Facultad de Ingeniería, Universidad de la República. In 2016 I became Profesor Agregado, grado 4.

4 - Other duties/ positions

I started on Universidad de la República in 2004 as Teaching Assistant (Ayudante, grado 1, and Asistente, grado 2). After my PhD was defended, I got a Post-doc position in Télécom ParisTech during Q1 in 2010, after which I returned to Uruguay.

At Facultad de Ingeniería, I have been head of the Master and PhD programmes of Electrical Engineering from 2011 to 2016. I am also 'Vocal' (member of the organization committee) of the CYTED programme (Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo) since 2014.

5 - Awards, fellowships and external recognition

- 2012: I was designated Level 1 Researcher at Uruguay's National Researcher System (Sistema Nacional de Investigadores), which was revised and confirmed in 2015 for another three years period. The maximum is level 3.
- In 2010 I was appointed with a Full-Time regime by the Universidad de la República, based on my research production. This is revised and confirmed periodically.
- Two best paper awards (LANOMS 2009 and LANC 2007).

6 - Ongoing funded research projects with dates, titles, sources of funding

- Fluid limits, diffusion approximations and large deviations in large communication Systems (2017-2018). Principal Investigator: Paola Bermolen. Project funded by the 'Comisión Sectorial

de Investigación' (CSIC, Universidad de la República) through its 'Investigación y Desarrollo' programme.

- Research Group: ARTES (2014-2018). Principal Investigator: Pablo Belzarena. Project funded by the 'Comisión Sectorial de Investigación' (CSIC, Universidad de la República) through its 'Grupos de Investigación' programme.

7 - Projects approved in the last 5 years

- An open and free receiver for the Digital TV standard ISDB-T implemented under the paradigm of Software Defined Radio (2014-2015). Principal Investigator: Federico La Rocca. Project funded by the 'Dirección Nacional de Telecomunicaciones y Servicios de Comunicación Audiovisual' (DINATEL) through the 'Agencia Nacional de Investigación e Innovación' (ANII).
- Evaluation and Optimal Control of High-dimensional Stochastic Networks (ECHOS) (2014-2015). Principal Investigators: Matthieu Jonckheere, Paola Bermolen and Balakrishna Prabhu. Project funded by the SticAmSud Programme.
- Random graphs and fluid limits for modeling wireless networks (2013-2014). Principal Investigators: Paola Bermolen and Federico Larroca. Project funded by the 'Fondo Profesor Clemente Estable' (ANII).

8 - Publications

8.1 – Highlight the most important publications related to the project theme

- Decentralized robust spectrum allocation for cognitive radio wireless mesh networks, Germán Capdehourat, Federico Larroca, Pablo Belzarena. Ad Hoc Networks, 2016
- A stochastic geometry analysis of multichannel cognitive radio networks, Claudina Rattaro, Paola Bermolen, Federico Larroca, Pablo Belzarena. LANC 16 Proceedings of the 9th Latin America Networking Conference, 2016
- Robust spectrum allocation for cognitive radio networks, Germán Capdehourat, Federico Larroca, Pablo Belzarena. 2014 11th International Symposium on Wireless Communications Systems (ISWCS), 2014
- An Overview of WLAN Performance, Some Important Case-Scenarios and Their Associated Models. Federico Larroca, Fernanda Rodríguez, Wireless Personal Communications, 2014
- Optimal multipath forwarding in planned wireless mesh networks. Germán Capdehourat, Federico Larroca, Pablo Belzarena. Computer Communications, 2014
- Minimum Queue Length Load-Balancing in Planned Wireless Mesh Networks, Germán Capdehourat, Federico Larroca, Pablo Belzarena. International Symposium on Wireless Communication Systems, 9th. ISWCS 2012.

8.2 – Publications in cooperation with the project partners

- Estimating the transmission probability in wireless networks with configuration models, Paola Bermolen, Matthieu Jonckheere, Federico Larroca, Pascal Moyal, ACM Transactions on Modeling and Performance Evaluation of Computing Systems, 2016

9/ Theses oriented and post-doctoral fellows supervised

9.1 – Finished/defended in the last 5 years

PhD Thesis:

- Germán Capdehourat, Analysis & Design of Cognitive Wireless Multihop Networks. Began in 2011 and defended in June 2015.

Master thesis (please note that in Uruguay the Master involves two years of courses, plus a thesis, after the five years bachelor degree):

- Pablo Flores, On the implementation of a ISDB-T software-defined radio receiver. Began in 2013. Defended in December 2016.
- Fernanda Rodríguez, Performance evaluation of WLAN networks. Began in 2013. Defended in October 2015.

9.2 – Ongoing

Master thesis:

- Pablo Menoni, Spying on unintentional radioelectric emanations. Began in 2016.
- Juan Martín Vanerio, Experts' based online predictions for secondary markets in Cognitive Radio. Began in 2013. Expected to defend in Q2 2017.

Matthieu Jonckheere, Conicet, UBA, Buenos Aires,

Birth date: 30 april 1979, Phone: +541130623812 Email: matthieu.jonckheere@gmail.com Webpages: <http://matthieujonckheere.blogspot.com>

Cursus

2010- ... CONICET, University of Buenos Aires, Researcher (investigador adjunto). Probability group, mathematics department.

Professor at the University of Buenos Aires (applied mathematics department)

2015 Co-founder of Aristas, start-up in web technologies, machine learning and stochastic analysis
<http://www.aristas.com.ar/>

2008-2010: Eindhoven University of Technology, Assistant Professor Mathematics and computer science department.

2005-2007 CWI – Amsterdam Post doc fellow in PNA2 Advance Communications Network group

2002-2005 France Telecom Research and Development (FTR&D), Ecole Polytechnique PhD with T. Bonald (FTR&D) & F. Baccelli (ENS): Insensitive load balancing and bandwidth allocation in telecommunication networks.

Scientific events organization:

Member of the organizing committee of Big Data and Environment, Buenos Aires, 2015.
<http://www.cima.fcen.uba.ar/UMI/bde/>

Member of the organizing committee of Stochastic Processes and applications, Buenos Aires, 2014.
<http://mate.dm.uba.ar/~probab/spa2014/>

Coordinator of CIMPA school, Mar del Plata 2012, (Stochastic dynamics of particles and networks),
Member of the organizing committee of Erpem 2011, PASI 2012.

Co organiser of the workshop YEQT (young european queuing theorists) Eindhoven, dec 2008.

Grants obtained:

PICT (2013-2015) (Probability group) 300K pesos

PICT (2013-2014) (Young researcher) 50K pesos

POST DOCS

Ioannis Papageorgiou - Existence of quasi-stationary measures

Santiago Saglietti - Dynamics on random graphs and branching processes.

Clara Fittipaldi - Branching processes and processor sharing queues.

PHD STUDENTS

Emmanuel Ferreyra: Load balancing and stochastic games

Maximiliano Altamirano : Some probabilistic models of neuronal connexions

Manuel Saenz Parking processes on random structures 2015-...

Sergio Lopez (co-supervised with P. Ferrari), Dynamics of particles systems and networks, graduated in 2013.

Program committee

Sigmatrics 2012, 2015, 2016. Netcoop 2009, Valuetools 2009, ITC 22, Performance 2010, EuroNGI 2010, Valuetools 2011, Erpem 2011, CIMPA 2012, ITC 2012.

PUBLICATIONS (selected):

The jamming constant of uniform random graphs

with P. Bermolen and P. Moyal. Accepted in Stochastic Processes and Applications 2016

Asymptotics of insensitive load balancing and phases of blocking,

With B. Prabhu,

ACM Performance evaluation review 2016 and Sigmetrics/performance evaluation conference proceedings 2016.

Sub-poissonian statistics of jamming limits in ultra-cold Rydberg gases

with J. Sanders, S. Kokkelmans, accepted in Physical review letters 2015

Companion paper: Scaling limits for exploration processes, with P. Bermolen and J. Sanders.

CSMA with RTS/CTS and the Jamming Constant for the Associated Parking Process

with P. Bermolen, F. Larroca, P. Moyal, submitted in ACM Transactions on Modeling and Performance Evaluation of Computing Systems (TomPECS)

Fleming-Viot selects the minimal quasi-stationary distribution: the Galton-Watson case.

with A. Asselah, P. Groisman, P. Ferrari,

to appear in Ann. Inst. H. Poincaré 2015

Bandwidth sharing networks with multi-scale traffic

With M. Feuillet, B. Prabhu,

Stochastic Systems, vol 4, 449-478 2014.

Stability of multi-dimensional birth-and-death processes with state-dependent 0-homogeneous jumps.

with S. Shneer

Advances in Applied Probabilities, vol. 46-1 [2014](#)

Large deviations of the proportional fairness allocation

with S. Lopez-Ortega,

Mathematics of Operation Research, vol 39-2, pp. 418-43, 2013

Approximation for quasi-stationary distributions on countable spaces

with P. Groisman, Markov Processes and Related Fields, vol. 19-3, pp. 521-542, 2013

Scheduling in random environment: stability and asymptotic stability.

with U. Ayesta, M. Erausquin, M. Verloop.

IEEE/ACM Transactions on Networking, vol.21, no.1, pp.258,271, 2013.

Towards an Erlang formula for multiclass networks,

with J. Mairesse,

Queueing systems : Theory and applications, 66 (1), 53 -78, 2010.

Urtzi Ayesta INP-CNRS (IRIT)

Web site: <http://www.irit.fr/~Urtzi.Ayesta>

Date of birth: 1st December 1976, St. Sebastian, Basque Country, Spain

Research area

My goal is to build mathematical models that explain fundamental phenomena in computing systems with the objective of evaluating and optimizing the performance. Given the complexity of the models, exact analysis is often out of reach, and I resort to asymptotic regimes and approximations (such as heavy-traffic limits, fluid limits, and approximate stochastic control). I made both methodological contributions to the theory of stochastic modeling, as well as succeeded in applying into practice the solutions of the theoretical models to improve the design of real protocols.

Education:

- HDR - Habilitation, Univ. Toulouse – Paul Sabatier, France, [May 2014].
- PhD degree, Université de Nice-Sophia Antipolis, France, [Mars. 2005]. Research carried out at INRIA and France Telecom R&D. Advisor: Konstantin Avrachenkov.
- Master of Science in Electrical Engineering, Columbia University, New York City, US, [June 2001].
- BS/MS in Telecommunication Engineering, Universidad Pública de Navarra, Iruñea-Pamplona, Spain, [June 2000].

Current positions:

- [10/2016] CNRS Director of Research at Institut de Recherche en Informatique de Toulouse - □ IRIT.
- Adjunct lecturer. Univ. of Basque Country, Spain. Department of Computer Science. Part-time appointment funded by Ikerbasque (Research agency in Basque Country, Spain) [2012®].

Former positions:

- CNRS Researcher at SARA team at the Laboratory for Analysis and Architecture of Systems (LAAS), Toulouse, France. [Joined LAAS (as CR2) in April 2006, and promoted (as CR1) in April 2010.]
- Postdoc within Probability and Stochastic Networks Group. Centrum voor Wiskunde en Informatica (CWI, Center for Mathematics and Informatics, □ www.cwi.nl), Amsterdam, the Netherlands, [January 2005 – March 2006].

Awards and Honors:

- 2013: Elected member □ IFIP Working Group 7.3, “Computer Performance Modelling and Analysis”. (Invitation based working group, gathering experts in the domain)
- 2011: Applied Probability Trust Award as co-author of paper (see below [P9]) in Operations Research.
- 2005-2006: □ ERCIM “Postdoc Fellowship” to join CWI (awarded to excellent PhDs worldwide).
- 2006: Telecom-Valley Award for the best PhD thesis defended in Sophia-Antipolis during 2004-2005.
- 2001-2004: PhD Grant from France Telecom R&D.

Research Grants [only those as PI]:

- 2015-2019, French national research agency (ANR) young researcher award (JCJC): “RACON: Efficient resource allocation in congested networks”, Acceptance rate 7%, assignment 260Keuro including funding for a PhD

and a postdoc, <https://www.laas.fr/projects/racon/>. PI.

- 2012-2015: EADS-Airbus Group Research Foundation Grant. Acceptance rate 8%, 150keuro, including funding for PhD of M. Larranaga. Co-PI.
- 2012-2014: PhD grant from French Ministry of Science and Education for PhD of A. Izagirre. Co-PI.
- 2010-2014: PhD grant Spanish Ministry of Science and Education for PhD of M. Erausquin. Co-PI.

Supervision: (In brackets the percentage in the supervision responsibility)

- PhD students: Santi Duran (50%), Univ. Paul Sabatier, (starting 10/2016); Halldora Thorsdottir (33%), Univ. of Amsterdam (NL), 2012-2016, defense 13 May 2016; Maialen Larranaga (50%), INP Toulouse (FR), 2012-2015. Recipient of Prix Léopold Escande 2015 as one of the best theses of the year from INP Toulouse. Now postdoc at Huwaei-Supelec; Ane Izagirre (50%), INSA Toulouse (FR), 2012-2015, now postdoc at Biodonostia Health Research Institute; Martin Erausquin (75%), UPV/EHU, 2010-2014, now researcher at BuntPlanet; Josu Doncel (33%), INSA, 2012-2015, now postdoc at INRIA Grenoble; Ianire Taboada (33%), UPV/EHU, 2009-2013, now lecturer at UPV/EHU.
- Postdocs: Tejas Bodas (from 10/2016 on), Christopher Thraves (2014), Jonata Anselmi (2010-2011, now at INRIA), Peter Jacko (2009-2011, now Lancaster Univ.), Maaïke Verloop (2009-2010, now CNRS).

Editorial Duties

- Member of Editorial Board of journals: Performance Evaluation (since 2008), IEEE/ACM Transactions on Networking (since 2012).

(IEEE/ACM ToN is the main journal on networking in terms of impact and reputation, and Performance Evaluation journal is the reference journal on performance of computing systems).

- TPC member of leading conferences (responsible of reviewing multiple papers and composing the program): ACM SIGMETRICS 2012, 2013, 2017, Inform's Applied Probability 2013, ITC 2013, 2017, IFIP Performance 2010, 2014, 2015, IEEE ICNP 2014, 2017.

(ACM Sigmetrics, is the leading conference on the performance modeling of systems with 10% acceptance rate)

- Guest Editor (together with B. Prabhu) of Performance Evaluation. Special Issue on “European Conference on Queueing Theory 2016”.

Organisation of scientific meetings

- Conference co-chair (together with B.J. Prabhu), of “European Conference on Queueing Theory 2016” Toulouse, France (July 18-20, 2016), <http://ecqt2016.sciencesconf.org/>. 3 parallel sessions and around 120 participants.
- Conference co-chair (together with Y. Nazarathy and A. Wierman) of the workshop “Young European Queueing Theorists III, Scheduling and Resource Sharing in Queueing Networks”, Eindhoven, The Netherlands (Nov 19-21, 2009). <http://www.eurandom.nl/events/workshops/2009/YEQTIII/index.htm> 50+ participants, 3 keynote speakers.

Scientific production

I have co-authored in total 3 Patents, 1 RFC (see Section 4.1), 2 chapters in books, 32 journals and 31 conference papers. For a complete list of publications please see my website or Google Scholar profile

- [Quality of conferences] I have 8 IEEE Infocom, 2 ACM Sigmetrics, and 5 IFIP Performance papers. These three conferences have acceptance rates lower than or comparable to leading networking journals (10%-20%). According to the □ CORE Conference ranking, INFOCOM and SIGMETRICS are A* (flagship conference, leading venue), and IFIP PERFORMANCE is A (excellent conference, and highly respected). [Journals] I have published 2 papers in IEEE/ACM Transactions in Networking (Impact Factor (IF) 1.811, ranked 16/102 in “Computer Science, theory and methods”), which is the best networking journal, and one paper in Operations Research, one of the most reputed journals in Operations Research (IF 1.454, ranked 22/81 in “Operations

Research”).

Main publications in the period 2013-2017

Journals

P1: J. Doncel, S. Aalto and U. Ayesta, Economies of scale in parallel-server systems, accepted to IEEE Infocom 2017

P2: M. Larrañaga, U. Ayesta, I.M. Verloop, Dynamic control of birth-and-death restless bandits: application to resource-allocation problems, IEEE/ACM Transactions on Networking 24(6), 3812--3825, 2016

P3: M. Larrañaga, U. Ayesta, I.M. Verloop, Asymptotically optimal index policies for an abandonment queue with convex holding cost, Queueing Systems, 81(2):99-169, 2015.

P4: M. Larrañaga, U. Ayesta, I.M. Verloop, Stochastic and fluid index policies for resource allocation problems, Proceedings of IEEE INFOCOM 2015: 1230–1238.

P5: U. Ayesta, A. Izagirre, I.M. Verloop, Heavy-Traffic analysis of multi-class queue with relative priorities, Probability in the Engineering and Informational Sciences, 29(02), 153–180, 2015. 2015.

P6: M. Larrañaga, U. Ayesta, I.M. Verloop. Index Policies for a multi-class queue with convex holding cost and abandonments. Proceedings of ACM SIGMETRICS 2014:125–137.

P7: J. Doncel, U. Ayesta, B.J. Prabhu, O. Brun, Is Price of Anarchy the right measure for Load-Balancing Games?, ACM Transactions on Internet Technology, 14(2–3), 1–18, 2014.

P8: A. Izagirre, U. Ayesta, I.M. Verloop, Sojourn time approximations in a multi-class time-sharing server. Proceedings of IEEE INFOCOM 2014: 2786–2794.

P9: U. Ayesta, M. Erausquin, M. Jonckheere, and I.M Verloop, Scheduling in a random environment: stability and asymptotic optimality, IEEE Transactions on Networking, 21(1), 258-271, 2013

Balakrishna Prabhu, LAAS-CNRS, Toulouse

Date of Birth : 19.04.1978

Professional address (with telephone and e-mail): LAAS-CNRS, 7 Avenue du Colonel Roche, 31077 Toulouse Cedex 4, France. Balakrishna.Prabhu@laas.fr. <http://homepages.laas.fr/bala>

Current job title and size of the research group: Chargé de Recherche (CR1) CNRS, currently co-supervising three PhD students with Olivier Brun. He is a member of SARA research group of LAAS-CNRS which has about 25 full-time researchers (including U. Ayesta) and 40 Phd students

Employment history

03/2012– Chargé de Recherche 1 (CR1) CNRS at LAAS, Toulouse

03/2008–03/2012 Chargé de Recherche 2 (CR2) CNRS au Laboratoire d’Analyse et d’Architecture des Systèmes (LAAS), Toulouse, France.

05/2007–02/2008 Post-doctoral fellow with CWI, EURANDOM, and the Technical University of Eindhoven, The Netherlands.

08/2006–04/2007 ERCIM post-doctoral fellow with Centrum voor Wiskunde en Informatica (CWI), Amsterdam, The Netherlands.

11/2005-07/2006 ERCIM post-doctoral fellow with VTT, Espoo, Finland.

Education

- Ph.D., Computer Science, 10/2005. Université de Nice Sophia Antipolis. Research was carried out with Project MAESTRO, INRIA Sophia-Antipolis, France. Title : Markov chains and decision processes for congestion avoidance and power control. Advisers : Dr. Eitan Altman and Dr. Konstantin Avrachenkov

- M.Sc., Electrical Communication Engineering, 01/2002. Indian Institute of Science, Bangalore, India. Title : Energy Efficient Algorithms for Wireless Networks. Adviser : Dr. A. Chockalingam
- B.E., Electronics and Communication Engineering, 07/1999. Manipal Institute of Technology, Manipal, India.

Ongoing funded research projects with dates, titles, sources of funding

Participant in a STIC-AmSud project title PROVE with Telecom Bretagne, UdelaR (Uruguay) and University of Concepcion (Chile). The project ends in 2017. The theme of the PROVE project is learning algorithms for intelligent routing. This is very much different from the themes of the GENE proposal.

Participant in a CEFIPRA project on Network Economics between France and India. The teams are from University of Avignon, CNRS, and IIT Bombay (India). 2017-2020

Participant in a research contract between LAAS and the automotive solutions company Continental. The project is on algorithms for smart vehicles. 2016-2019.

Projects approved during the past 5 years

Local coordinator of a STIC-AmSud project titled ECHOS between CNRS, University of Compiègne, UdelaR (Uruguay), UBA (Argentina). Duration 2014 and 2015.

Participant in ANR project titled SOP, November 2012-November 2015, Funded by ANR (French National research funding agency)

Participant in FUI project titled Network Engineering and Control (NEC), August 2012-July 2015, Funded by FUI (French Inter-ministerial funding)

Co-PI of PHC Tournesol with University of Ghent, Belgium, titled Stochastic modelling of dissemination and epidemic process on complex networks, January 2013-December 2013, French Ministry of External Affairs

Participant in PAI Volubilis with Morocco, titled DTNs for communication in vast and critical environments

Participant in ANR ECOSCELLS, October 2009 -- December 2012. Funded by ANR (French National research funding agency)

Publications

- K. De Turck, D. Fiems, and B. J. Prabhu. Analytic approximations of queues with lightly- and heavily-correlated autoregressive service times. *Annals of Operations Research : Selected papers from MCQT'10*, 202(1):103–119, January 2013
- A. Al-Sheikh, O. Brun, P.-E. Hladik, and B.J. Prabhu. A Best response algorithm for multi-processor periodic scheduling. *Real-Time Systems*, 48(4):359–386, 2012.
- B.J. Prabhu, A.E. Tugui, and I.M. Verloop. Steady-state approximations for Dynamic Speed Scaling in Data Centers. In *Proc. of 6th International Conference on Network Games, Control and Optimization (NeTGCooP12)*, Avignon, France, November 2012.
- U. Ayesta, O. Brun, and B. J. Prabhu. Price of anarchy in non-cooperative load balancing. *Performance Evaluation*, 68(12):1312–1332, December 2011.
- E. Altman, U. Ayesta, and B. J. Prabhu. Load Balancing in Processor Sharing Systems. *Telecommunication Systems: Special Issue on Selected Papers from GameComm'08.*, 47(1-2):35–48, 2011.
- M. Jonckheere, R. Nunez-Queija, and B.J. Prabhu. Performance Analysis of Traffic Surges in Multi-Class Communication Networks. In *Proc. of International Teletraffic Congress (ITC)-22*, Amsterdam, The Netherlands, September 2010.
- E. Altman, K. Avrachenkov, I. Menasche, G. Miller, B. J. Prabhu, and A. Shwartz. Dynamic Discrete Power Control in Cellular Networks. *IEEE Transactions in Automatic Control*,

- 54(10):2328–2340, October 2009.
- O.J. Boxma, O. Kella, D.Perry, and B.J. Prabhu. Analysis of an M/G/1 queue with customer impatience and an adaptive arrival process. In Proc. of IWAP'08, Compiègne, France, July 2008.
 - R. Nunez-Queija and B.J. Prabhu. Scaling laws for file dissemination in P2P networks with random contacts. In Proc. of IWQoS'08, Enschede, The Netherlands, June 2008.
 - I. Norros, B.J. Prabhu, and H. Reittu. On uncoordinated file distribution with non-altruistic downloaders. In Proc. of ITC-20, Ottawa, Canada, June 2007.
 - I. Norros, B.J. Prabhu, and H. Reittu. Flash Crowd in a file sharing system based on random encounters. In Proc. of Inter-Perf '06, Pisa, Italy, October 2006.
 - E. Altman, K. Avrachenkov, C. Barakat, A. A. Kherani, and B. J. Prabhu. Analysis of MIMD Congestion Control Algorithm for High Speed Networks. Computer Networks., 48(6):972–989, August 2005.
 - E. Altman, K. Avrachenkov, and B. J. Prabhu. Fairness in MIMD Congestion Control Algorithms. Telecommunication Systems:Special Issue on High Speed Transport Protocols., 30(4):321–350, December 2005.
 - A. A. Kherani, B. J. Prabhu, K. Avrachenkov, and E. Altman. Comparative Study of Different Adaptive Window Protocols. Telecommunication Systems:Special Issue on High Speed Transport Protocols., 30(4):387–415, December 2005.

PhD students

2 ongoing thesis co-supervised with Dr. Olivier BRUN (CRI, CNRS)

Bruno Gaujal

• Name: Bruno Gaujal

• Birth date: 27/04/1966

• Professional address: Bureau 437,

Imag 700 Av. Centrale, Université Grenoble Alpes 38000 St Martin d'Hères, France.

tel: (33) 4 57 42 14 99

Email: bruno.gaujal@inria.fr

• Current job: Inria Research Director, member of the INRIA-CNRS-Univ-Grenoble team, Polaris (25 members)

2 Highest obtained degree

• Thèse de doctorat (1997) from the University of Nice (Equiv. PhD).

• Habilitation à diriger des recherches (2001) from the University of Nancy (Equiv. Tenure).

3 Professional activity in the last 5 years

• Research Director at Inria

• Leader of the large-scale computing team in Grenoble (2005-2016)

4 Other duties/ positions

- Scientific advisor of a start-up company (RTaW).
- Member of the scientific committee of Inria Grenoble-Rhone-Alpes.
- Member of the scientific bureau of the LIG (Computer Science Laboratory of Grenoble)

5 Awards, fellowships and external recognition

6 Ongoing funded research projects with dates, titles, sources of funding

- ULTRON, Industrial contract With Huawei (wireless network optimization) (2017-2018)

Budget for our group: 200 KE

- ANR MARMOTE, ANR project (French Research Agency) (2013-2017) Partners: 6 Partners, Budget for our group : 180 KE
- QUANTICOL, FP7 project (Fet-proactive) funded by the European Union from 2013 to 2017. Total budget : 2.5M euros (five partners).
- CASERM, ANR-Labex Persyval Project (French Research Agency and Univ. Grenoble-Alpes) , 3 Partners, (2016-2018), Budget for our group : 100 KE.

7 Projects approved in the least 5 years (not including the previous ones)

- MARMOTE, ANR project (French Research Agency) (2013-2017) Partners: 6 Partners,

Budget for our group : 180 KE

- CHECKBOUND, ANR Project (2011-2014), 4 Partners, Budget for our group: 100 KE.
- LICIA, (2013-2016) CNRS, Inria, the Universities of Grenoble, Grenoble INP, and Universidade Federal do Rio Grande do Sul have created the LICIA (Laboratoire International de Calcul intensif et d'Informatique Ambiante). Budget for our group : 120 KE.
- GATHERING, PEPS Project (2013-2015) (local grant from Univ. of Grenoble-Alpes), 10KE.
- SELFNET, Contract with Alcatel Lucent-Bell (now Nokia) (2010-2014) . A common laboratory between Inria and the Alcatel Lucent-Bell Labs was created in early 2008 (terminated in 2014). Budget: 120 KE.

8 Publications

An up to date list of publications is available online:

<https://team.inria.fr/polaris/members/bruno-gaujal/>

8.1 Highlight the most important publications related to the project theme

1. Nicolas Gast and Bruno Gaujal. Computing absorbing times via fluid approximations, Journal of Applied Probability, 2017 (to appear).
2. Bruno Gaujal, Panayotis Mertikopoulos. A stochastic approximation algorithm for stochastic semidefinite programming. Probability in the Engineering and Informational Sciences, Cambridge University Press (CUP), 2016, 30 (3), pp.431-454.
3. Josu Doncel, Nicolas Gast, Bruno Gaujal. Are mean-field games the limits of finite stochastic games?

The 18th Workshop on MATHematical performance Modeling and Analysis, June 2016, Nice, France. Performance evaluation review (PER), 2016.

4. Pierre Coucheney, Bruno Gaujal, Panayotis Mertikopoulos. Penalty-Regulated Dynamics and Robust Learning Procedures in Games. *Mathematics of Operations Research*, INFORMS, 2015, 40 (3), pp.611-633.

5. Nicolas Gast, Bruno Gaujal. Markov chains with discontinuous drifts have differential inclusion limits. *Performance Evaluation*, Elsevier, 2012, 69 (12), pp.623-642.

9 Theses oriented and post-doctoral fellows supervised

- Stephane Durand (Phd student), Network Games, started in Sept. 2015.
- Stephan Plassart (Phd student), Optimization in Real-Time Systems, started in Sept. 2016.
- Baptiste Jonglez (Phd student), Path Diversity in Communication Networks, started in Sept. 2016.
- Carmen Higuera Vanishing Population Dynamics, Post-doc, co-supervised with N. Gast (2016-2017)
- Josu Doncel Mean field Games, Post-doc, co-supervised with N. Gast (2014-2016).

B7. Additional information

List all the complementary fundings expected or already obtained.

LAAS-CNRS

Group of Probability of Buenos Aires :

2017-2019 PICT/PIP grant 300 Kpesos (appr 40 Keuros)

ARTES Group in Uruguay:

- Fluid limits, diffusion approximations and large deviations in large communication Systems (2017-2018). Principal Investigator: Paola Bermolen. Project funded by the ‘Comisión Sectorial de Investigación’ (CSIC) through its Investigación y Desarrollo programme. Grant: 1 Mpesos (approximately 30 Keuros).
- Research Group: ARTES (2014-2018). Principal Investigator: Pablo Belzarena. Project funded by the ‘Comisión Sectorial de Investigación’ (CSIC, Universidad de la República) through its ‘Grupos de Investigación’ programme. Grant: 2Mpesos (approximately 60 Keuros).

Experience of the coordinators in similar projects.

Federico ‘Larroca’ La Rocca has been part of several national and international projects in Europe (EuroNGI, EuroNF, Celtic, ECOS, Stic-Amsud) and Uruguay (Fondo Clemente Estable, CSIC-I+D, FSTV). Moreover in the last years he has been responsible of some of them, for instance “Medium Control Access Algorithm in Wireless Networks” (finished national project 2010-2012); “Implementation of an open ISDB-T receiver for Software Defined Radio” (finished national project 2014-2015). He has also been responsible for the Master and PhD programmes of Electrical Engineering from 2011 to 2016 at UdelaR.

Matthieu Jonckheere has been part of several international projects in Europe (EuroNGI, EuroNF, Bricks) and in South-america. He was part of two Math-Amsud projects until 2016. He has organized several

international workshops and summer school: the YEQT workshop on queueing theory in Eindhoven in 2008, the ERPEM (south-american probability and statistics meeting) in 2011, and the CIMPA school entitled “stochastic dynamics of particles and queues” in Mar del Plata (Argentina) in 2012. He was also part of the organizing committee of SPA (Stochastic Processes and Applications) which took place in Buenos Aires in 2014. He was the international coordinator of a STIC-AMSUD project in 2014-2015.

B. Prabhu has been Co-PI of a Partenariat Hubert Curien PHC-Tournesol (exchange of researcher’s between France and Belgium) on the topic of stochastic modelling of information dissemination on wired and directed networks. He co-organized with Urtzi Ayesta and Maaïke Verloop the European Conference on Queueing Theory (ECQT 2016) in 2016.

Present main activities and their relationship with the project’s main goal.

Matthieu Jonckheere is a CONICET researcher and a professor, in the probability group of Buenos Aires, (Mathematics department, University of Buenos Aires). His main center of interest focuses on the analysis of stochastic networks, performance evaluation of communication networks and more recently in more theoretical probability theory (particles systems and their link with quasi-stationary measure). He has 3 PhD students working in performance evaluation and probability theory. He has on-going collaborations with Urtzi Ayesta (gave a mini course in 2015 at LAAS on Markov processes for performance evaluation), Bala Prabhu, Maaïke Verloop at LAAS, Paola Bermolen (several visits, mini courses to the UDELAR), Pablo Groisman in the UBA.

Federico Larroca and Paola Bermolen are both professor at the Faculty of Engineering of UdelaR. Their main research interest is the stochastic modelling of telecommunications networks. In particular, they worked in the past on the use of machine learning techniques for traffic prediction and classification and currently on the stochastic geometry modelling of wireless networks as well as the fluid limit approximation in several contexts. They collaborated with F.Baccelli and S. Vaton in France and have on-going works with M. Jonckheere of UBA. They dictate regularly courses on mathematical modelling of telecommunication networks and gives a seminar on stochastic geometry. All these activities matches perfectly our scope; in particular previous projects gives a deep understanding on CSMA modelling that can be very useful for challenge 3

Andres Ferragut joined the MATE Research Group in February 2007, and he currently is Assistant Professor on Telecommunication Networks at the School of Engineering of Universidad ORT Uruguay and Level I Researcher in the National Research System. He specializes in communication networks modelling, particularly by using probability theory, stochastic processes, queueing theory and control theory. His work in collaboration with F. Paganini has the originality to mix techniques from (continuous) control theory to probability theory, leading to new solutions for problems with a strong stochastic component. That might of great interests for all the challenges presented here.

B. Prabhu’s main activities centre around performance evaluation, control and design of distributed communication networks. His research focuses on the application of Stochastic modelling, Optimization, and Game theoretic techniques for the design and performance evaluation of protocols and algorithms in networks. These techniques have been applied to congestion control (TCP), power control in wireless networks, load balancing in server farms, energy efficient speed-scaling in data centers, and information diffusion in P2P networks. He is currently participating in a Partenariat Hubert Curien (PHC) Tournesol with the University of Ghent, Belgium and INRIA Sophia Antipolis, France on the theme of information diffusion in complex networks, and in particular on wired networks. The PHC Tournesol funds bilateral visits for researchers. The Challenge 3 in the present project proposal is a major step further than the Tournesol proposal as we propose to investigate in decentralized wireless networks which are more challenging due to interference between nodes constraints.

Bruno Gaujal is the author of more than 100 scientific publications in journals and international conferences. He is a founding partner and a scientific advisor of a start-up company, RTaW, since 2007.

His main interests are in performance evaluation, optimization and control of large discrete event dynamic systems with applications to telecommunications networks and large computing infrastructures. Together with Nicolas Gast, his expertise on stochastic games and his interest for performance evaluation are central for the current project.

Perspectives of continuing collaboration after project financing is over.

One of the envisioned outcomes of this project is to create of a network of French and South American researchers working on themes related to probability, stochastic modelling, and their applications to communication networks. As has been pointed out earlier, there are strong existing ties between several participants in this project which have resulted in several joint publications between, for example, M. Jonckheere, U. Ayesta, and M. Verloop, or M. Jonckheere and B. Prabhu. This project will help in consolidating this collaboration on the one hand, and widening its scope by bringing in specialists in stochastic games (B. Gaujal and N. Gast) and specialists in applications of these theories to network optimization and control (A. Ferragut, F. Larroca, P. Bermolen from Uruguay). We expect that the collaboration initiated in this project will lead to other joint projects and regular exchange of researchers (senior and junior).

Finally, we would like to highlight the fact that in South America there are very few research groups in telecommunications and therefore this project would fill an important gap in education and research in this geographical area.

B8. International referees

Suggest names of at least 3 international referees to evaluate the project. These researchers should not be connected to people in the project.

- 1- Sem Borst
- 2- Neil Walton
- 3- Marc Lelarge

Names of referees who should not review this project in your opinion (optional)

- 1-
- 2-

B9. Public and private support obtained related to the project:

Previous project STIC AMSUD / MATH AMSUD?
YES

If YES, indicate the code, the year and the name of the project:
14_STIC_03, year 2014-2015 project: ECHOS

Other public support in the past (ECOS, COFECUB, CNRS, European Union, etc.):

Other private support in the past:

Prospects for public or private support in the future:

C. Project Budget

Project title:

Participating institutions:

The STIC-AmSud program **funds travel expenses** (air tickets and *per diem*) to researchers in research missions and workshops.

C1. First year (2018)

Planned missions – Year 1

Researcher	Status (student, junior, senior)	Institution	Origin	Destination	Planned date	Duration (max . 30 days)	Estimated cost of the trip (€)	Estimate of total <i>per diem</i> (€)	Trip and Mission funding institution ¹	
Federico Larroca	senior	Udelar	Montevideo	Buenos Aires	March	10	300	800	ANII-MINCYT	...
Bruno Gaujal	senior	INRIA	Grenoble	Montevideo/Buenos Aires	March	15	1400	1500	INRIA-ANII	
Emmanuel Ferreyra	junior	UBA	Buenos Aires	Grenoble	May	30	1200	1500	Myncit INRIA	
Bala Prabhu	senior	LAAS	Toulouse	Montevideo	September	10	1200	1000	CNRS-ANII	
Andres Ferragut	senior	ORT	Montevideo	Toulouse	November	20	1200	2000	ANII-MAE	

1

Each institution will pay for the trip and per diem of its own researchers.

CONSOLIDATED BUDGET: Year 1

Funding requested to the STIC-AmSud Program Estimated costs (€)

	A. Travel costs (air tickets)	B- Maintenance costs (<i>per diem</i>)	TOTAL
MAEDI France		2000	2000
CNRS France	1200	1000	2200
INRIA France	1200	1500	2700
Institut Mines-Télécom France			
MINCYT Argentina	1200	1800	3000
CAPES Brazil			
CONICYT Chile			
CONACYT Paraguay			
CONCYTEC Peru			
ANII Uruguay	1500	2500	4000
MPPEUCT Venezuela			
SENESCYT Ecuador			
COLCIENCIAS Colombia			
Total requested funding to STIC-AmSud	5100	8800	13900
Other funding²	1000	2000	3000
TOTAL	6100	10800	16900

Do you have additional funding sources for this project³? (if so please specify the amount and source (s)).

2

Specify in additional page.

³ Reserved for CNRS researchers

Funding via ANII and PICT projects in Uruguay and Argentina and ANR in France.

C2. Second year (2019)

Second year funding depends on approval of intermediate progress report.

Planned missions – Year 2

Researcher	Status (student, junior, senior)	Institution	Origin	Destination	Planned date	Duration (max. 30 days)	Estimated cost of the trip (€)	Estimate of total <i>per diem</i> (€)	Trip and Mission funding institution ⁴
Santiago Duran	junior	LAAS	Toulouse	Buenos Aires	March	30	1200	1200	CNRS-Mincyt
Pablo Groisman	senior	UBA	Buenos Aires	Toulouse/Grenoble	June	15	1200	1200	Myncit-IRIA
Manuel Saenz	junior	UBA	Buenos Aires	Grenoble	September	15	1200	1200	Myncit-IRIA
Claudina Rattaro Eugi	junior	Udelar	Montevideo	Toulouse	September	15	1200	1200	ANII-INP
Urtzi Ayesta	senior	INP-IRIT	Toulouse	Montevideo	October	10	1200	1000	INP-ANII

CONSOLIDATED BUDGET: Year 2

Funding requested to the STIC-AmSud Program Estimated costs (€)

	A. Travel costs (air tickets)	B- Maintenance costs (<i>per diem</i>)	TOTAL
MAEDI France	1200	1200	2400
CNRS France	1200	1200	2400
INRIA France		2400	2400
Institut Mines-Télécom France			
MINCYT Argentina	2400	1200	3600
CAPES Brazil			
CONICYT Chile			
CONACYT Paraguay			
CONCYTEC Peru			
ANII Uruguay	1200	1000	2200
MPPEUCT Venezuela			
SENESCYT Ecuador			
COLCIENCIAS Colombia			
Total requested funding to STIC-AmSud	6000	7000	13000
<u>Other funding</u>⁵	1000	1000	2000
TOTAL	7000	8000	15000

Do you have additional funding sources for this project⁶? (if so please specify the amount and source (s)).

⁵ Specify in additional page.

⁶ Reserved for CNRS researchers

C3. BUDGET TOTALS

	Year 1	Year 2	Total
Funding requested to MAEDI (France)	2000	2400	4400
Funding requested to INRIA (France)	2200	2400	4600
Funding requested to CNRS (France)	2700	2400	5100
Funding requested to Institut Mines-Telecom (France)			
Funding requested to MINCYT (Argentina)	3000	3600	6600
Funding requested to CAPES (Brazil)			
Funding requested to CONICYT (Chile)			
Funding requested to CONACYT (Paraguay)			
Funding requested to CONCYTEC (Peru)			
Funding requested to ANII (Uruguay)	4000	2200	6200
Funding requested to SENESCYT (Ecuador)			
Funding requested to MPPEUCT (Venezuela)			
Funding requested to COLCIENCIAS (Colombia)			
Matching funds from the partners	13900	13000	26900
Other sources	3000	2000	5000
TOTAL	16900	15000	31 900

ANNEX

Model CV (maximum 2 pages)

1/ Personal data

Name:

Birth date:

Professional address (with telephone and e-mail):

Current job title and size of the research group:

2/ Highest obtained degree (with indication of place and date)

3/ Professional activity in the last 5 years

4/ Other duties/ positions

5/ Awards, fellowships and external recognition

6/ Ongoing funded research projects with dates, titles, sources of funding

7/ Projects approved in the last 5 years

8/ Publications

8.1 – Highlight the most important publications related to the project theme

8.2 – Publications in cooperation with the project partners

9/ Theses oriented and post-doctoral fellows supervised

9.1 – Finished/defended in the last 5 years

9.2 – Ongoing