Editorial by Gilles Caporossi

2013 is the International Year of Mathematics of Planet Earth, an initiative to recall the connection between mathematics and our planet. GERAD being associated with this initiative, we decided to mark the occasion by devoting this newsletter. The subject is vast and most of the work done at GERAD is directly or indirectly associated with the topic.

Without claiming to be exhaustive, we have chosen to only present here some applications of mathematics to problems in ecology, energy and sustainable development.

From game theory to stochastic programming, various facets of research at GERAD are applied to the issue of energy management, climate change or environmental protection.

Thus, Olivier Bahn and Camille Fertel wonder about climate change and raise the question of what to do, whether it is better to adapt or try to reduce them. The issue of the environmental protection is central to the article of Michèle Breton and Georges Zaccour interested in the use of game theory in international agreements. In a context where the issue of greenhouse gas emissions is a concern, Brigitte Jaumard outlines approaches to minimize the consumption of goods trains, making them more attractive than the more polluting trucks. With similar motivations, but in the field of energy production, Stéphane Krau presents challenges of a good management of water resources in Quebec. Finally, in a world where computing and telecommunications become predominant, Brunilde Sansò shows how to improve the energy performance of telecommunications networks and make them greener.

Summary

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Addressing climate change: mitigation or to adaptation?

Olivier Bahn and Camille Fertel

Climate change is one of the greatest challenges facing our planet in the foreseeable future. It is expected, according to the Intergovernmental Panel on Climate Change (IPCC), to impact ecosystems and the environmental services they provide (in terms of biodiversity, for example), but also human societies (affecting human health, for instance). In Canada specifically, the National Round Table on the Environment and the Economy (NRTEE) evaluates total damages at approximately $5 billion per year by 2020, which could reach up to $43 billion per year by 2050.

To cope with these threats, the strategy traditionally used is the so-called mitigation approach, which aims to reduce anthropogenic greenhouse gas (GHG) emissions. In Canada, for example, the federal government seeks to regulate emissions in specific sectors, such as the electricity sector where a new regulation imposes more stringent emission standards for new coal power plants. In 1992, the United Nations Framework Convention on Climate Change has indeed called to "stabilize (...) GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". In this perspective, the Kyoto Protocol (1997) has set emission reduction targets for the developed countries. More recently, the Copenhagen Accord (2009) has recognized the importance of drastically reducing GHG emissions to limit global temperature rise to 2°C, but without setting binding emission reduction targets. Yet despite all these measures, global GHG emissions continue to increase, as well as atmospheric GHG concentrations.

In this context, and since future climate changes appear now unavoidable to some extent, adaptation measures have recently gained a new political momentum as an important component of climate polices. Contrary to mitigation options, adaptation measures do not reduce emission levels, but provide strategies to deal effectively with climate change effects by reducing their negative impacts. Adaptation strategies cover a large array of sectors and options, for instance the introduction of new agricultural crops better adapted to new climatic conditions or the construction of sea dikes to protect coastal cities of expected sea level rises. In Canada, the NRTEE distinguishes adaptation strategies for timber supply, coastal areas, human health and ecosystems. More specifically, two types of adaptation strategy can be considered. Reactive strategies correspond to measures implemented in reaction to existing impacts, for instance the selection of drought-resistant seeds to deal with recurrent water shortages. Whereas proactive strategies correspond to preventive measures that can be taken before the onset of impacts, for example vaccination campaigns that can be made mandatory as a precaution without any materialized threat.

Integrated assessment models (IAMs) are tools that combine key elements of the economic and biophysical systems, elements that underlie the anthropogenic global climate change phenomenon. IAMs are used to elaborate and evaluate climate policies. They allow in particular assessing the optimal proportions and temporal dynamics of adaptation and mitigation measures. In a recent study[1] done in collaboration with Prof. Marc Chesney and Jonathan Gheyssens (University of Zurich, Switzerland), we have shown, using an IAM of intermediate complexity designed at GERAD, that the more effective adaptation strategies are at reducing negative impacts of climate change, the more justified it is to use them from an economic rationality standpoint, but this at the detriment of GHG emission abatement. Thus, a greater reliance on adaptation measures would yield an increase in GHG emissions in the short and medium term. Additional work is underway within the Energy and Environment Team (E2G) at GERAD to assess adaptation strategies using more complex IAMs (with a better representation of economic and climate dynamics), to get more specific results about the optimal levels of adaptation and mitigation measures.

It remains that the use of adaptation strategies can be risky. Indeed, if it is possible to efficiently adapt to gradual climate changes, it is not likely to be the case for 'abrupt' climate changes. These correspond to rapid and potentially irreversible changes in climate regimes. Such changes could occur with a temperature rise of 2°C, a threshold considered as dangerous by the Copenhagen Accord in 2009. Climate policies should therefore implement local measures to adapt to the inevitable impacts of climate changes, but without neglecting global efforts to reduce GHG emissions to avoid suffering in the future from drastic climate changes.■

[1] Bahn, O., Chesney, M., Gheyssens, J. (2012). "The effect of proactive adaptation on green investment", Environmental Science and Policy, Vol. 18, pp. 9-24.

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International Environmental Agreements: A Game Theoretic Perspective

Michèle Breton and Georges Zaccour

Transboundary environmental problems, e.g., global warming, acid rain, exploitation of the fishing grounds and rainforests, have been running high on the agenda of decision makers and of scientists of many disciplines during the last decades. Because of their international scope, the established consensus by now is that dealing seriously and efficiently with these problems requires a concerted effort by all countries, through the use of international environmental agreements (IEAs). Numerous IEAs have been signed and ratified by many countries during the last 60 years (see for instance statistics collected by the IEA Database project at http://iea.uoregon.edu/). Many reasons are mentioned to justify the need for such agreements, the most compelling ones being technical and economic efficiency of concerted actions, and the common property feature of environmental resources.

Notwithstanding the simplicity of these arguments, the design and implementation of IEAs is still a difficult task. To illustrate why in a highly synthetic way, let us suppose that two countries are presently suffering from pollution and considering the possibility of abatement. Assume that the abatement cost is 3 and the pollution cost, borne by all, is 2 per polluting country. If both countries abate, each bears a cost of 3, if both decide not to abate, each bears a cost of 4, and if only one country abates, the abating country's cost is 5 (3 + 2) while the polluting country's cost is 2 (see the following table, where the first number in each cell is the cost of Country 1, and the second the cost of Country 2).

		Country 2	
Country 1		*Abate*	*Pollute*
	Abate	3,3	5,2
	Pollute	2,5	4,4

It is easy to see that Pollute is a dominant strategy for both countries, that is, a strategy that gives this country a lower cost whatever the other decides to do. The conclusion is that the unique solution (called Nash equilibrium in the game theory jargon) is the strategy pair (Pollute, Pollute). This game, known as Prisoner's Dilemma, is one of the most celebrated example in game theory because of its simplicity in illustrating how rational decisions by selfish players lead to a higher cost (4) than what could be attained by a joint decision (3 if both choose to abate). The question that kept game theorists busy for years is: How could players implement the efficient outcome (3, 3) without having an authority imposing it?

The design of an international environmental agreement shares many of the features in the Prisoner's Dilemma game. First, the welfare of one country depends not only on its own policies, but also on those of other countries. Moreover, each country stands to gain from letting others join IEAs and bear the costs of compliance, while enjoying the global environmental benefits (free-riding). Further, as there is no supranational jurisdiction that can impose a collectively suitable strategy, adhesion to an IEA must then be on a voluntary basis. In addition, the design of an IEA involves other complexities, such as uncertainties (e.g. climate sensitivity, mitigation costs, long-term consequences, technological innovations), asymmetries (conflicting objectives, diversity of environmental vulnerability), and responsibilities (e.g. who is responsible for the current state of the environment, and who should bear the cost).

A significant game-theoretic literature has developed during the last two decades, attempting to provide some hints into how to design and implement environmental agreements. This literature can be divided into two streams. The first one adopts cooperative game theory as the methodological framework, implicitly assuming that cooperation and coordination will indeed take place, and that players' commitments are binding. In that case, the problem is approached in two steps. First, the collectively desirable solution is computed; this amounts to finding strategies (emissions or extraction levels, abatement or regeneration efforts, investments in clean technologies, etc.) optimizing a joint objective function. In a second step, the players' shares of the total payoff (welfare or cost) are determined using one of the available solutions of a cooperative game (a sharing mechanism typically based on a series of desirable properties), and these shares are implemented via a system of side payments.

The second game-theoretic line of research adopts the non-cooperative point of view, which assumes that players cannot make binding agreements (or that there is no transnational institution able to impose compliance to an IEA) and that they act in their own best interest. In that case, IEAs are signed by coalitions of countries that voluntarily follow a common environmental policy. The stability concept used in this literature was originally proposed in the context of the cartel problem in industrial organization: An IEA is defined to be stable if no member of the coalition has an incentive to leave it (internal stability), while no non-member has an incentive to join it (external stability).

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Minimizing the energy consumption of freight trains

Brigitte Jaumard

In the October 2012 issue of the Scientific American, Chris Nelder wrote: "The Rail built America in the 19th century and now it may be poised for a massive resurgence in the 21st century as high fuel prices make it competitive again". While it is difficult to predict fuel prices, the costs are rising, and transportation costs increase as a result of rising gas prices. For North American companies of railway freight, fuel costs are their biggest expense, and come before the labor cost. It is therefore of utter importance to optimize the energy consumption of trains: this is the objective of one of the research projects of Dr. B. Jaumard. Train industry executives are currently discussing the potential of using natural gas to power the trains, rather than diesel. Dr. B. Jaumard was recently awarded a Transport Canada grant on the minimization of the energy consumption of long-haul locomotives under two different energy-powered locomotive scenarios (fuel-diesel, natural gas).

There are different directions to explore in order to minimize energy consumption. Indeed, the rising price of diesel, which is almost four times higher today than they were in 1999, forces shippers to seek the most economical mode of transport in terms of fuel. According to a 2009 study by the Federal Railroad Administration, rail fuel efficiency varies from 66 to 218 ton-kilometers per liter, whereas truck fuel efficiency ranges from 29 to 57 ton-kilometers per liter. Moreover, the fuel efficiency of rail has been ramping up at a far faster rate than trucks. Between 1990 and 2006, rail efficiency improved by about 20% (1.1% annually).

Much of the gain is due to technological improvements: Railroads have adopted electronic controllers in locomotives, including advanced sensors and fault diagnostics; improved diesel fuel mixture and combustion as well as cooling systems that maintain an optimized engine temperature; replaced binary switch DC motors with AC traction motors that respond to load with variable voltage/frequency output, and better control/communication systems.

Another direction, which is currently studied by Dr. Jaumard, is the design and development of tools that will help minimizing the locomotive energy consumption throughout the optimization of cruise scheduling, train scheduling and locomotive idle times (which is acknowledged to be the time of maximum carbon accumulation, i.e., an estimated 6.5% of the rail freight energy).

During her on-going three-year collaboration with CP, B. Jaumard co-supervised, with Dr. A. Agkunduz, a master student, T.H. Le, on the design of a very comprehensive model and algorithm for train scheduling. T.H. Le developed both simulation and optimization tools, which encompass several constraints which were never considered so far in literature papers: selection of the trains which take the sidings, isolated double tracks, capacity (i.e., number of alternate tracks) of the stations and of the sidings, offset on the expected train departure times and its impact on the average travel times of the trains, as well as the variation of the speed of the trains taking into account the different speed limits and the slow down or full stop at sidings. Both simulation and optimization tools have been extensively tested on data and have suggested different ways of improving train management, in order to reduce the average end to end travel of the trains for CP.

After the completion of his master thesis, T.H. Le now works on improving his first tools with respect to cruising optimization, taking into account the load of the trains, the characteristics of the braking systems in order to minimize the fuel consumption. His research project is coordinated with another PhD research project, also under the joint supervision of Drs. Jaumard and Akgunduz on optimizing the assignment of locomotives to trains in order to reduce the operational costs, including the fuel cost, as it is the major cost component. Maintenance constraints are also taken into account, whether they are conditions driving by the number of locomotive operation days, or the mileage of the locomotives.

Another objective of the research project is to estimate the air emission of natural gas vs. diesel fuel for the railway systems. In spite of the contradictory claims on the health and environment impacts of natural gas over traditional diesel fuel, due to economic considerations, i.e., rising diesel prices, natural gas appears as an energy source that is a smart move in the battle against global climate change and a good transition step on the road toward low-carbon energy, e.g., hydrogen power.

Optimization tools that are used include a combination of large scale optimization techniques, heuristics and meta-heuristics in order to tackle the complex mathematical models associated with train scheduling and locomotive assignment under minimum energy consumption. The corresponding mathematical models may contain few millions of variables, and few hundred of thousands of constraints. While train scheduling and locomotive assignment have already been studied for several years, they remain highly challenging optimization problems to be solved for large locomotive and train fleet such as the one of CPR, where trains operates under different time zones, and with a large variety of geographical topologies.

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Management of water systems: an operations research challenge

Stéphane Krau

The Canada has more lakes than any other country; about 2 million lakes cover 7.6% of the territory. With rivers, these lakes form water systems, the majority of which are not controlled; the water flows naturally. For controlled water systems, operators decide the flow at the exit of the controllable structures (dams, dikes) by policies managements which vary according to the role of each water system. For the Great Lakes, for example, water management aims at facilitating navigation. For large hydroelectric complexes managed by Hydro-Quebec (Manic, La Grande, Churchill Falls), one needs to optimally accumulate water in huge reservoirs to ensure energy reliability of Quebec for several years. When water systems are close to inhabited areas, two conflicting objectives are to be considered: minimizing the risk of flooding and maintaining high levels of water for recreational activities during the summer.

Management issues would not have the same importance if they were not subject to multiple sources of uncertainty. The hazard of natural inflows is the one that most affects the management of water systems. Operators of water systems continuously adapt to this hazard by "refreshing" ongoing decisions. To that end, they use decision support tools based upon scenarios of projected forthcoming inflows.

Two classes of decision support tools are used. Simulation models and optimization models.

Simulation models have the advantage of being fast to run and to integrate accurately the characteristics of a water system. Based upon decision rules, they simulate the water management system from multiple realizations of hazards (natural inputs, energy demand, broken equipment). The simulation tool faces its limits when the operator faces situations of great uncertainty as it is the case, for example, during the spring flood in Quebec. When the range of possible withdrawals is large and the events of inputs are complex, it is difficult to provide the system good decision rules. Operators then have no choice but to use the optimization models.

The optimization models calculate management decisions based on a simplified mathematical representation. The more the mathematical representation is realistic, the better the management rules gets but also more computation time is needed. In an operational context, the choice of the optimization model is a compromise between the quality of the solution and the computation time. In this sense two types of optimization models may be considered. Deterministic models sacrifice the consideration of the hazard for a quick response while stochastic models, explicitly take randomness into account. This later case requires much more computation time.

Deterministic models are based upon the hypothesis that the future is known. Decisions are therefore calculated from a single realization of the hazard. Operators of water systems therefore need to constrain these models in order to avoid solutions that are too optimistic. For example, they introduce limits on the discharge system to be sure that whatever the inputs scenario used, the security criteria of the reservoirs are respected. The optimization model is then solved several times by sampling the hazards space (scenarios). They get a decision strategy for each chosen scenario. Decisions are made after analyzing the various strategies and their respective scenario.

The stochastic optimization models are based upon a more or less accurate statistical representation of the natural input, depending on the type of mathematical approach used. For water systems with more than two tanks, an acceptable characterization of the spatial and temporal variability of the contributions already generates models of considerable size. The spatio-temporal variability of inputs, usually represented by a multidimensional scenario tree, has a size grows exponentially with the number periods. If we consider the case of a weekly management (decisions are refreshed every week) over a period of 1 year, with 10 values of likely intakes per week on a single tank system, the scenario tree would yield 10^{52} scenarios.

Solving the problem for the management of a water system with more than two tanks under uncertainty is therefore an important challenge. To handle this problem, three approaches are proposed in the literature.

- To decompose the problem in time. This is the case of stochastic dynamic programming and its variants that solve a sequence of optimization problems over a single period each time. The combinatorics remains important even for smaller water systems; it then uses dynamic programming to push approached the problem of dimensionality. The latter is viewed in other areas of optimization and that of artificial intelligence.
- The second approach is to spatially resolve the problem. The idea is to aggregate tanks together to solve the problem of management composed of 1 or 2 tanks and then to deduce aggregated systems using heuristics adapted to the water system, the decision rules with all the containers.
- The third approach directly addresses the decision tree resulting from the tree of input scenarios using scenario based decomposition methods.

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Green networking optimization

Brunilde Sansò

The pervasive influence of the Internet is having an environmental impact due to its telecommunication systems and data centre energy consumption. In 2007, it was estimated that the environmental impact of Internet and Communication Technologies (ITC) was 2% of the planet's greenhouse gas emissions. That was probably a conservative estimate, since it predates the introduction of intelligent phones that, in just one year, multiplied wireless traffic by 30. This augmentation has been accompanied by the omnipresence of social media, which has had a profound effect on traffic that is more and more prone to be information-centric. This has increased the proliferation of large data centres that are huge power hogs. According to some estimates, a mid-sized data center can consume the equivalent of 25,000 households, and its CO_2 emissions are expected to have doubled by 2020. Even after discarding these stations' impact, the consumption of Internet Service Providers remains important. For instance, a 2009 study showed that a single large service provider's consumption could reach 10 TWh per year.

To deal with this increasingly important issue, the group LORLAB at the GERAD, directed by Brunilde Sansò, has explored optimization solutions to make telecommunication networks greener and it has found more energy-efficient ways to plan and manage networks and data centres.

For IP core networks, the natural approach is to put system elements to sleep when they are not in use. The difficulty of this type of approach is that the network must still function correctly and must still guarantee the QoS at all times. For this, we have created some optimization methods for planning and management that allow us to reduce the daily consumption by at least 30%, while guaranteeing network performance. Both off-line and on-line approaches have been developed.

For mobile networks, it is estimated that 80% of the energy consumption comes from the access equipment that is essentially composed of base stations. Our objective in this problem has been to produce new ways to plan and operate the networks in order to reduce the CAPEX and OPEX related to energy. The idea is to plan the network while taking into account the energy management of base stations by combining the location choice, the base station type, and the optimal energy management of the installed system. The approach guarantees the QoS while producing reductions of 30 to 50% in energy consumption.

In relation to data centres energy consumption, we underline that it is due not only to equipment like servers and routers, but also to the basic infrastructure such as air conditioning and transformation as well as distribution of electricity. Thus, the location of data centres has a double impact on energy consumption, since the ones located in cold places can reduce the use of air conditioning. Moreover, the centres located in places powered by green energy can significantly reduce the CO_2 emissions that result from their operation. In fact, wind and hydroelectric energy can each produce 10g of CO_2 per kWh, geothermal produces 38g per kWh, while diesel and coal produce 778g and 960g, respectively. Besides the consumption and the type of energy, data centre position impacts the application's QoS, since the centres that are closer to the users experience less propagation delay. In that context, we have created a multi-objective optimization software, called Cloptimus, which is based on Cloud Computing, that optimally maps users' applications into a distributed data centre system, and considers all the previously mentioned aspects to find the optimal solution. The planner can use such a system to evaluate the trade-offs between cost, delay, energy consumption and CO_2 emissions. The system then optimizes the management at the data centre level so that the consumption and ecological impact of each data centre is minimized.■

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Michèle Breton and Georges Zaccour just received a SSHRC grant ($375,000 over 5 years) to address the sustainable use of renewable natural resources (forests, fisheries, and environment) in a context where the decisions of several independent agents influence the evolution of the stock of these resources. The objective of this research program is to reconcile two fundamental concepts: on one hand, individual rationality, according to which agents seek to maximize their economic and social preferences, and on the other hand, sustainability, so that the survival and well-being of future generations should not be jeopardized.

Specifically, the researchers aim to determine the conditions leading to sustainable equilibria (in the sense of sustainable development) realized through negotiated agreements that are acceptable to all parties involved and stable over time. Indeed, although the importance of sustainable development is recognized, it is very difficult to reach agreements such no party sees an advantage in leaving the responsibility and costs of sustainable management to the others, especially when the state of the system (stock of resources, economic development) evolves over time. The problem of negotiating an acceptable agreement is even more difficult when the parties have conflicting immediate interests, which is the case for example for countries that are at different stages of their economic development.

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International Environmental Agreements: A Game Theoretic Perspective

During the years, we have contributed with our Ph.D. students and post doctoral trainees, along with colleagues from different universities, more than twenty papers on the design and implementation of IEAs under a game-theoretical perspective. In the cooperative game stream, our contribution consisted in proposing dynamic side payments (monetary transfers) mechanisms and incentive strategies in the form of "I behave as a gentleperson as long as you do the same," as well as other mechanisms to support cooperation over time, such as joint implementation in investment projects in developing countries, credible threats to deter defection from the agreement, etc. Under the non-cooperative approach, we investigated stability issues and IEA membership time-evolution under various perspectives, namely the impact of punishment mechanisms, farsightedness and other rational conjectures, players' asymmetry and uncertainty.■

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Minimizing the energy consumption of freight trains

The trend toward freight rail is destined to continue. It is estimated that market share of rail could double by 2035 as more trains will be "double-stacked" with shipping containers and as fuel prices are likely to continue to rise. The benefit is obvious: One double-stacked train can replace 300 trucks and save 285,000 liters of fuel on a about 3,200-kilometer journey between Vancouver and Toronto. The migration from trucks to rail is particularly advantageous for shipping distances longer than 800 kilometers. The longer the haul, the more of a fuel efficiency advantage rail has over trucking. However, sizes of the railway systems are too big, and cannot be optimized using manual tools, optimization techniques are required. Preliminary results are very encouraging as CP is now planning to incorporate some of our tools in their own train and locomotive management tools.■

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Management of water systems: an operations research challenge

Until recently, the gap between methods developed in the academic field and those used in by operators was important. Even if it still exists, this gap tends to shrink. The considerable increase in the computational power of computers has played a major role in the reduction of this gap. Operators of water systems are more and more involved in the design of optimization models that they aim to use, given the importance of security and economic issues in their management decisions.■

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A Great Fish War Model with Asymmetric Players
Revision: January 2013

G-2012-13 **Fertel, C., Bahn, O., Vaillancourt, K., Waaub, J.-Ph.**
Canadian Energy and Climate Policies: A SWOT Analysis in Search for Federal/Provincial Coherence
Revision: February 2013

G-2012-62 **Laporte, G.**
Scheduling Issues in Vehicle Routing
Revision: February 2013

G-2012-26 **Aouchiche, M., Hansen, P.**
Two Laplacians for the Distance Matrix of a Graph
Revision: February 2013

Awards, honours and contributions

- **Luc-Alain Giraldeau**, professor at the Biological Sciences Department of UQAM, was Sophie-Andrée Blondin's guest, this past January 14, at the "Bien dans son assiette" show. He spoke of the biology of our appetites.
- **Jean-Bertrand Gauthier**, supervised by Jacques Desrosiers, is the winner of the HEC Montréal 2011-2012 MSc Best Paper Award.
- **Hichem Garbouj**, supervised by Olivier Bahn and Jean-Philippe Waaub, has been listed at the Honour Roll of the MSc in Administration program management of HEC Montréal for the fall 2012 term.

Thesis defences

- **Yossiri Adulyasak**, cosupervised by Jean-François Cordeau and Raf Jans
  Doctoral Thesis: Formulations and Solution Algorithms for Production Routing Problems
- **Hélène-Sarah Bécotte-Boutin**, cosupervised by Gilles Caporossi and Sylvain Perron
  Master Thesis: Homards, Araignées, Chenilles et autres arbres : Une dendrologie théorique des graphes
- **Mélisende Brazeau,** cosupervised by Alain Hertz and Charles Audet
  Master Thesis: Affectation des infirmières aux salles de l'unité d'endoscopie digestive du Centre hospitalier universitaire de Sherbrooke
- **Yessirath-Lai Damala**, cosupervised by Michel Gamache and Diane Riopel
  Master Thesis: Conception d'un outil d'aide à la décision pour l'entrepôt montréalais d'Air Canada Cargo à partir d'un modèle de simulation
- **Charles Gauvin**, cosupervised by Guy Desaulniers and Michel Gendreau
  Master Thesis: Un algorithme de génération de colonnes pour le problème de tournées de véhicule avec demandes stochastiques
- **Marc Gendron**, supervised by Alain Hertz
  Master Thesis: Détermination de la taille des effectifs et affectation des séquences de repos dans les horaires d'employés de compagnies de transport public
- **Anthony Guillou**, cosupervised by Pierre Hansen and Sylvain Perron
  Doctoral Thesis: Problèmes quadratiques non convexes sous contraintes quadratiques non convexes : méthode numérique d'optimisation globale, extensions et applications
- **Shahrouz Mirzaalizadeh**, cosupervised by Gilles Savard and Patrice Marcotte
  Doctoral Thesis: Stochastic Bilevel Pricing Problems over a Transportation Network
- **Nour Mustapha**, cosupervised by Jean-Marc Frayret and Michel Gamache
  Master Thesis: Gestion des vols en retard chez Air Canada
- **Pierre-Olivier Poliquin**, cosupervised by Mario Jolicoeur and Mathieu Cloutier
  Master Thesis: Modélisation métabolique pour l'étude des voies de régulation énergétiques enjeu dans la maladie de Parkinson

Visitors

September 2012 | August 2013
Xiao-Wen Chang (McGill University, Canada)

December 2012 | February 2013
Bastien Talgorn (France)

January | February 2013
Mohammed Saddoune (Université Hassan II de Casablanca, Morocco)
Manuel Vieira (Universidade Nova de Lisboa, Portugal)

January | April 2013
Sourour Elloumi (ENSIIE, France)

February 2013
Kelly Chloe de Bruin (Umeå University, Sweden)

March | May 2013
Pablo Andres-Domenech (LEF, AgroParisTech, France)

April 2013
Elena Parilina (St. Petersburg State University, Russia)
Isabel Christina da Silva Martins Robeiro (FEUP, Portugal)

April | May 2013
Jesús Marin-Solano (Universitat de Barcelona, Spain)
Michael Grothe (University of Bielefeld, Germany)

Trainees

February 2012 | February 2013
Puduru Viswanadha Reddy (GERAD, Canada)
Luca Gianoli (Politecnico Di Milano, Italy)

April 2012 | August 2013
Jean Buvry (INP Toulouse, ENSEEHIT, France)

June 2012 | March 2013
Nabila Remli (Université Laval, Canada)

June 2012 | June 2013
Nabila Azi (GERAD, Canada)

September 2012 | August 2013
Rafael Ponti Martinelli (Brazil)

October 2012 | October 2013
The Amouh (Université de Namur, Belgium)

February | June 2013
Ali Ayedi et **Med Béchir Radhi Ben Hassine**
(École Polytechnique de Tunisie, Tunisia)

February | August 2013
Nidhal Gharsellaoui (Essai, Tunisia)

March | July 2013
Ely Cheikh N'Diaye (École Polytechnique de Tunisie, Tunisia)

April | June 2013
Heiko Breier (Karlsruhe Institute of Technology, Germany)

April | August 2013
Adil Tahir
(Faculté des Sciences et Techniques de Mohamadia, Morocco)

April | September 2013
Driss Chakour (École Polytechnique ParisTech, France)
Dounia Lakhmiri (INP Toulouse, ENSEEHIT, France)

April | October 2013
Bastien Talgorn (France)

Activities

Workshops | Schools | Congresses

May 1-3, 2013
10th International Conference on Computational Management Science

May 6-8, 2013
Optimization Days/OPDE 2013

July 2-6, 2013
2nd Montreal workshop on Idempotent and Tropical Mathematics

GERAD Seminars

April 30, 2013
Michael Kokkolaras (McGill University, Canada)
Utilizing Numerical Optimization in Computational Engineering Design

December 17, 2012
Roussos Dimitrakopoulos (McGill University, Canada)
Mine Planning Optimization with Uncertainty: A Review of Concepts and Applications from Single Mines to Mining Complexes

December 13, 2012
Omar Cherkaoui (UQAM, Canada)
Software Defined Network Research Challenges

Séminaires « Un chercheur du GERAD vous parle ! »

March 06, 2013
Lê Nguyên Hoang (Polytechnique Montréal, Canada)
A Trek Through 20th Century Mathematics

Activities

GERAD/CRC-ONDI Optimization Seminars

April 30, 2013
David Titley-Peloquin (IRIT-ENSEEIHT Toulouse, France)
Stochastic Error Analysis Tools for Data Assimilation

April 4, 2013
Sourour Elloumi, (ENSIIE Évry, France)
Quadratic Convex Reformulation for Discrete Quadratic

March 20, 2013
Christoph Helmberg
(Chemnitz University of Technology, Germany)
A View on Graph Laplacians from the Perspective of Semi-definite Optimization

February 28, 2013
Steven Gabriel (University of Maryland, USA)
An SOS1-Based Approach for Solving MPECs with an Application in Energy

February 21, 2013
Chen Greif (University of British Columbia, Canada)
Numerical solution of Saddle-Point Linear Systems

January 31, 2013
Antoine Deza (McMaster University, Canada)
Combinatorial, Computational, and Geometric Approaches to the Colourful Simplicial Depth

January 17, 2013
Christodoulos A. Floudas (Princeton University, USA)
Advances in Deterministic Global Optimization for Mixed-Integer Quadratically Constrained Quadratic Programs (MIQCQP) and Mixed-Integer Signomial Optimization (MISO)

POLYTECHNIQUE MONTRÉAL

Canada Research Chair in Discrete Nonlinear Optimization in Engineering

"Meet a GERAD researcher!" Seminars

April 11, 2013
Minh Bui (Concordia University, Canada)
Anycast End-to-End Resilience for Cloud Services over Virtual Optical Networks

April 4, 2013
Brigitte Jaumard (Concordia University, Canada)
Design of a Survivable VPN Topology over a Service Provider Network

March 21, 2013
Sadegh Bolouki (Polytechnique Montréal, Canada)
Linear Consensus Algorithms and the Infinite Jet-Flow Property of Markov Chains

March 14, 2013
Roland Malhamé (Polytechnique Montréal, Canada)
Mean Field Games: A Paradigm for Individual-Mass Interactions

January 24, 2013
Dominique Cartier (Polytechnique Montréal, Canada)
Application de la recherche opérationnelle à l'optimisation de modèles hydrologiques

January 17, 2013
Sébastien Le Digabel (Polytechnique Montréal, Canada)
Optimisation de boîtes noires avec l'algorithme MADS et le logiciel NOMAD

GERAD Seminars cofunded by Fondation HEC Montréal and the Chair in Game Theory and Management

April 19, 2013
Elena Parilina (Saint-Petersburg State University, Russia)
Strategic Support of Cooperative Agreements in Stochastic Games

February 21, 2013
Kelly Chloe De Bruin (Umeå University, Sweden)
The Role of Proactive Adaptation in International Climate Change Mitigation Agreements

February 20, 2013
Stéphanie Monjon (Université Paris Dauphine, France)
A Border Adjustment for the EU ETS: Reconciling WTO Rules and Capacity to Tackle Carbon Leakage

Fondation HEC MONTRÉAL

HEC MONTRÉAL
CHAIR IN GAME THEORY AND MANAGEMENT

Activities

CRM/ISM/GERAD Statistics Colloquium

April 12, 2013
Arup Bose (Indian Statistical Institute, India)
Consistency of Large Dimensional Sample Covariance Matrix under Weak Dependence

March 22, 2013
Hélène Massam (York University, Canada)
The Hyper Dirichlet Revisited: A Characterization

January 18, 2013
Victor Chernozhukov (MIT, USA)
Inference on Treatment Effects After Selection Amongst High-Dimensional Controls

December 14, 2012
Raymond J. Carroll (Texas A&M University, USA)
What Percentage of Children in the U.S. Are Eating a Healthy Diet? A Statistical Approach

GERAD Newsletter

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