



APPLICATION FORM

Applicant Name	Guilherme Oliveira Chagas
Title of the Proposal	A hybrid heuristic for the overlapping p -median problem
Period Abroad	Start Date: 06/2019 End Date: 12/2019
Foreign Institution	Name: Laval University City / Country: Québec/Canada Is the Country in the PII-INPE subproject list? Yes.
INPE's Supervisor	Name: Luiz Antonio Nogueira Lorena E-mail: luizlorena54@gmail.com Graduation Program: Applied Computing
Foreign Supervisor	Name: Leandro Callegari Coelho E-mail: leandro.callegari-coelho@fsa.ulaval.ca Dept: Operations and Decision Systems Department
PII-INPE Subproject	Title: Research and Development in Modeling and Analysis of Earth and Space Data Coordinator: Karine Reis Ferreira
Proposal Objectives (20 lines max)	<p>From the technical perspective, the main objective of our project is to propose and develop a method for a variation of the p-median problem. The p-median problem is a well-known combinatorial optimization location problem where the goal is to determine the placement of p facilities in order to minimize the sum of the distances from each client to its closest facility. However, the literature concerning variations of the p-median problem where each client can be assigned to one or more facilities is scarce. In this context, we intend to introduce an overlapping relaxation of the p-median problem in order to allow facilities share clients. Furthermore, we want to propose a hybrid heuristic, coupling one or more metaheuristics with a mixed-integer linear program, to address this problem. Then, with the acquired knowledge from our research in this subject, we hope to publish it in a form of one or more co-authored articles in a relevant journal.</p> <p>In addition, attending to one of the objectives of INPE's Institutional Plan for Internationalization, we hope to take, perhaps, the first step towards the creation of a possible future cooperation network between researchers from Laval University and CAP/INPE. Another objective is, within the six month period, to experience an international academic environment in a world-renowned University gaining and</p>



	exchanging knowledge with experienced researchers, as Dr. Leandro C. Coelho. Then, we expect to give our small contribution in order to help to consolidate INPE as an internationally recognized institute.
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Justification & Relevance for PII-INPE (30 lines max)	<p>The p-median is a classical operations research problem that has been studied since the sixties. This problem has many real world applications such as planning the location of schools, ambulances, fire stations, police stations, satellites and meteorological instruments. Indeed, some of these applications are in the CAP and INPE's research interest. In the past, solutions and tools were developed at CAP/INPE related to some p-median problem variations. For example, the “<i>Análise de Redes com Sistemas de Informações Geográficas 1 e 2</i>” (ARSIG 1 and ARSIG 2) projects were developed by CAP's researches aiming the integration of locations problems algorithms and heuristics to geographic information systems (GIS). In addition, another example is a <i>TerraView</i> plugin called <i>TerraNetwork</i>. The <i>TerraNetwork</i> project objective was to use optimization techniques to solve complex decision-making related to p-median problems variations in a GIS environment. Considering such examples of applications, it is important, for CAP and INPE, to improve and to expand the knowledge related to p-median problem. In particular, the variation of the p-median characterized by overlapping demand, i.e., clients should be attended by more than one facility, is an under-explored problem. This issue has many practical applications and is a promising subject for study.</p> <p>Although there were projects at CAP in the optimization/operations research context as previously mentioned, there is a lack of research in this area at CAP nowadays. The operations research is an interdisciplinary discipline that, as CAP, was also created to meet the demands and solve problems in many areas of science. Indeed, optimization techniques and algorithms are a useful and a fundamental tool for problem solving that can be applied to data modeling and analysis of earth and space as well as almost all INPE's fields of study.</p> <p>With an international experience in the Operations and Decision Systems Department of Laval University, which has a remarkable tradition in the operations research area, we hope to bring back some attention to CAP in the operations research context. In this way, helping to reestablish this field of study in CAP by producing a relevant work.</p>
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Relationship with the Foreign Institution & Co- supervisor (30 lines max)	<p>Created in 1852, the Laval University is a traditional institution recognized worldwide for its academic excellence. This university is currently in the sixth position of the best research universities in Canada, with over \$377 million in research funds and counting with 1,625 professors.</p> <p>The Faculty of Administration Sciences (FSA) at Laval University is a relevant canadian administration school. The FSA has a world-class environment and infrastructures to support its researchers. In addition to others FSA's research departments, there is the Operations and Decision Systems Department. This interdisciplinary department has research and studies focusing, among others research areas, on logistics and transportation, counting with many experienced researchers. The Operations and Decision Systems Department has a solid academic production and expertise in combinatorial optimization problems in the logistic context.</p> <p>Professor Leandro Callegari Coelho is a research chair in Integrated Logistics, working at the Operations and Decision Systems Department since 2016. He has remarkable experience in operations research, mainly, using mixed and integer linear programming, metaheuristics and hybrid heuristics to solve location and transportation problems. For example, almost all his recent works published in important journals, from 2016 to present date, were related to solve routing and location problems.</p> <p>In addition, Professor Leandro Callegari Coelho and Professor Luiz Antonio Nogueira Lorena already collaborate with each other in a p-median-related problem. Specifically, they introduced a hybrid heuristic for the <i>Probabilistic Maximal Covering Location–Allocation Problem</i> (PMCLAP) [1]. The proposed hybrid heuristic was composed by coupling the Adaptive Large Neighborhood Search (ALNS) metaheuristic, which solves the location problem, to a integer linear program, which solves the allocation problem.</p> <p>[1] Pereira, M. A.; Coelho, L. C. ; Lorena, L. A. N.; Souza, L. C. A hybrid method for the Probabilistic Maximal Covering Location–Allocation Problem. Computers & Operations Research, v. 57, pp. 51-59, 2015.</p>
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**Activities &
Timetable
Schedule**
(40 lines max)

1 - Literature review.

In the first month, a literature review will be conducted aiming articles of p -median problem variations where clients can be assigned to more than one facility. We hope, with this review, identify approaches and techniques that can serve as guidelines for our hybrid heuristic development. In addition, we also expect to select datasets and methods to compare the hybrid heuristic's results with.

2 - Hybrid heuristic development.

In this phase, we hope to apply the knowledge obtained from the literature review to develop our hybrid heuristic. The goal is to use some existing techniques from related p -median variations and adapt them to our context.

3 - Hybrid heuristic implementation.

We will implement the hybrid heuristic following the development carried out in the previous phase. We intent to combine the Adaptive Large Neighborhood Search (ALNS) metaheuristic (and, possibly, other methods) to a mixed-integer linear programming.

4 - Hybrid heuristic tests.

In this step, computational tests will be performed to evaluate the hybrid heuristic. We hope to compare its results with other methods from literature and also use our method in real world instances.

5 - Article writing.

We expect to transform all obtained knowledge and results in a form of at least one article. We will start writing the article as soon as we finish the literature review.

6 - Article submission.

We hope submit the final version of the article in a relevant journal.

Table 1 shows the expected activities schedule of a six month period. This period starts in June 2019 and ends in December 2019.

Activities	2019					
	June	July	August	September	October	November
Literature review	x					
HH development	x	x				
HH implementation		x	x			
HH tests				x	x	
Article writing		x	x	x	x	x
Article submission						x

Table 1: Activities timetable schedule.



Expected Results & Acquired Knowledge (30 lines max)	<p>We hope to give our small scientific contribution by proposing a new variation of the p-median problem in which allows clients to be attended by more than one facility. In order to achieve this, an overlapping relaxation of the original p-median problem will be introduced. This issue is an under-explored problem which is a promising subject for study that has many practical applications.</p> <p>With the new variation of the p-median problem, we hope to highlight the overlapping feature. In this way, helping bringing more attention and future new approaches and methods proposals, since it is an important problem that has real world demands.</p> <p>A hybrid-heuristic for the overlapping p-median problem will also be proposed. We intent to combine the Adaptive Large Neighborhood Search metaheuristic (and, possibly, other metaheuristics) to a mixed-integer linear programming. Based on this, we expect to propose an effective and efficient method to solve the overlapping p-median. Then, with the acquired knowledge from our research in this subject, we hope to publish it in a form of one or more co-authored articles in a relevant journal.</p> <p>I also hope to experience an international academic environment in a world-renowned University. In this way, gaining and exchanging knowledge with experienced researchers in the Operations and Decision Systems Department, which has a remarkable tradition in the operations research area. Furthermore, I expect to improve my thesis quality by taking advantage of Dr. Leandro's expertise.</p>
Contributions to the INPE's Graduation Program (20 lines max)	<p>I hope tso use the knowledge and the experience acquired to improve my thesis quality. I also expect to be able to publish the developed work in an important journal collaborating to maintain the CAP tradition of producing relevant works. Moreover, I hope to bring a little of the international experience to share with the other CAP's students.</p> <p>As previously mentioned, the operations research is an interdisciplinary disciple that, as CAP, was also created to meet the demands and solve problems in many areas of science. Indeed, optimization techniques and algorithms are an useful and a fundamental tool for problem solving that can be applied to almost all INPE's fields of study. Therefore, we hope to bring back some attention to CAP in the operations research context. In this way, helping to reestablish this field of study in CAP by producing a relevant work.</p> <p>In addition, we expect, perhaps, to help build a future network collaboration between Laval University and CAP/INPE researchers. Then, we expect to give our small contribution in order to help to consolidate INPE as an internationally recognized institute.</p>