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Mitacs Accelerate Proposal Application

INSTRUCTIONS

- Please make sure you are using the latest version of this form posted on **www.mitacs.ca/en/programs/accelerate/apply-now**
- Please **do not modify, remove** text or instructions in each section/subsection **or reformat** this form in any way. A modified form will result in a delay in the internship evaluation process.
- Detailed information on how to write your proposal can be found in the *Accelerate Guide: Writing your proposal document*.
- Send your draft proposal to your Mitacs Business Development Representative **prior** to obtaining all signatures and submitting.
- The proposal should be written and submitted **at least eight (8) weeks prior to the planned start date of the internship.**
- The start date of the internship has to be **after** research approval and the **receipt** of the partner funds at Mitacs.
- Partner funds can be sent directly to Mitacs prior to approval to expedite the process.
- If applicable, proposals with a not-for-profit partner must seek partner and project eligibility approval before proceeding. Please contact a Mitacs Business Development Representative to discuss the eligibility of an NFP organization **BEFORE** submitting your application (see section 2.7).
- If applicable, conflict of interest declarations must be received by Mitacs **before** submitting your application (see section 4.1/4.3).
- If you cannot see the items listed in the drop downs, please refer to the Appendix B: Options and type the corresponding answer on the space provided.

Please note:

If required, your **Mitacs Business Development Representative** can assist you with:

- Identifying your Office of Research Services (ORS) representative.
- Assessing the eligibility and completeness of the proposed research.

APPLICATION CHECKLIST

A complete internship application package must include the following :

- ☐ The proposal application **completed and signed** by all parties. *The Mitacs Accelerate Memorandum* (see Section 7) with signatures must be submitted as a scanned PDF file.
- ☐ List of six external expert, arms-length reviewers and their contact information.
- ☐ Intern(s) CV (a CV template is available on the Mitacs website).
- ☐ Lead Academic Supervisor's CV **only** for projects with **6 IUs and up** (CCV as per Tri-Council or other CV format).
- ☐ Excel budget spreadsheet: *Accelerate Resource Plan and Invoicing*.
- ☐ Any supplementary documents (as applicable).
- ☐ Appendix A - Accelerate Intern Consent Form signed.

*** An incomplete application or a modified form will result in a delay in the internship evaluation process.**

For more information, contact a **Mitacs Business Development representative.**

1. Research Proposal Summary

1.1.	**Title of project:**	An Efficient Data Analysis Pipeline		
1.2.	**Type of project:** Please indicate (x)	(x_) Standard		
		(_) Cluster (minimum of 6 internships and 3 interns)		
1.3.	**Number of Internship units:**	1		
1.4.	**Keywords to identify reviewers:** (3-10 specific keywords; 50% technically related, 50% discipline-related)	Embedded software, prognostics, anomaly detection, machine learning		
1.5.	**Academic discipline:**	Engineering		
1.6.	**Project priority sectors:**	Information & Communications Technology	Automotive	3rd Priority Sector
	Please **rank up to three** top priority sector(s) of your project:	1	2	3

1.7. List of participants:

Supervisor(s)	Department	University
Mark Crowley	Department of Electrical and Computer Engineering	University of Waterloo

Partner organization(s)	Contact name at partner organization	Province of organization	Partner Legal Status
Acerta Analytics Solutions, Inc.	Gonen Hollander	Ontario	For Profit Canadian Private Corporation
			Select Legal Status
			Select Legal Status

1.8. Proposed work plan for internship unit(s) (IU):

Please summarize the work plan for the project by showing which intern will work when. This table provides a high level overview of the proposed research project and information about intern(s) to the reviewers. Please refer to the **Accelerate Guide: Writing your proposal** to assist you.

			Year 1						Year 2						Year 3					
Years																				
Months			1-4			5-8			9-12			1-4			5-8			9-12		
Intern Name	**Degree Program**	**IU**																		
Anderson Oliveira Sousa	MASc	1	x																	

Total Internship Units			1																	
Total Project Funding	**$16,000**																			

2. Description of Proposed Research

2.1. **Project title:** An Efficient Data Analysis Pipeline

2.2. **Research Abstract** (Approx. 200 words):

Safety-critical systems are pervasive throughout our society with everyday objects such as airplanes, cars, trains, or medical devices. The requested functionality and expectations from these systems is growing rapidly and consequently they become more complex. The challenge is that while the developers want to provide all features that consumers want, developers must still make sure that the systems are working properly and are safe to use.

One approach for handling the complexity is to develop advanced tools that rely on data analytics to help the developers. Such tools require novel system architectures as they process millions of entries and thus have substantial data storing and processing requirements.

This project will apply results in performance evaluation to design improvements to the data analytics pipeline in place for the products sold by Acerta.

2.3. **Background** and review of relevant prior work (minimum 500 words):

Empirical systems research relies on effective and correct performance evaluation, but it is facing a dilemma: Getting accurate performance measurements is difficult and time consuming, and consequently mediocre experimental methodology is common place in many areas of computer science [DFJ + 12, VK11, KJ11, MDHS09, GBE07, Den05, Tic98, Lis92]. Getting accurate performance measurements is both difficult and time consuming. Minor aspects of the experiment can have a significant impact on the measurements and potentially invalidate conclusions drawn; especially for results with a speedup of a few percent as common in many areas. Examples of such influences, often called hidden factors, include binary link order (up to 15% error [MDHS09]), process environment size (up to 15% error [MDHS09]), trivial symbol renaming (up to 2.7% error [GVG04]), group scheduler assignments (up to 50% less standard deviation [OFD + 12]), and various interpreter details (up to 9.5% error [GVG06]). The growth in complexity and size of modern systems will further exacerbate this dilemma, especially with the given time pressure of producing results. So how can one trust any reported empirical analysis of a new idea or concept in computer science?

Measurements are currently inadequately tested for accuracy. To illustrate this we conducted a survey of recent publications at top software, systems, and embedded conferences. Table 1 shows the results with the columns, in order, showing (1) the total number of papers, (2) the fraction that contains empirical performance analysis, (3) the fraction that describes their hardware targets and (4) software versions, (5) the fraction that performs the experiment under different conditions as a sanity check of the measurements, (6) the fraction that contains a dispersion metric for the measurements, (7) the fraction that published the software being evaluated, (8) the fraction that uses a publicly available workload (established benchmarks, input files, etc.), and, finally, (9) the fraction that published their resulting data. Only a fraction of the papers report dispersion on the measurements (e.g., variance, standard deviation), although everyone should [Tic98, DFJ + 12]. Only a tiny fraction performs sanity checks on the measurements, although everyone should [Jai91, Lil05]. Few papers publish the software, the hardware, and the workload, so other researchers could validate the results. Hence how should an inexperienced reader decide whether the innovation is worth implementing in a product?

Conference	No. of Papers	Perf. Eval	HW Desc.	SW. Desc.	Sanity Check	Disp. Metric	Public SW	Public Load	Public Data
SOSP'11	27	93%	92%	60%	24%	44%	4%	68%	0%
ASPLOS'11	36	61%	100%	55%	5%	31%	4%	82%	4%
OSDI'10	30	93%	71%	61%	0%	32%	7%	39%	0%
ATC'12	40	95%	87%	58%	3%	32%	8%	26%	0%
EuroSys'11	22	86%	95%	74%	42%	47%	21%	58%	0%
PLDI'12	45	64%	90%	79%	37%	10%	24%	72%	0%
RTAS'12	29	38%	90%	64%	64%	18%	0%	45%	0%
EMSOFT'11	36	22%	62%	38%	0%	12%	37%	50%	0%
LCTES'12	15	47%	100%	28%	0%	100%	0%	42%	0%

Table 1: Illustration of experimental rigor in recent scientific publications (parts from [OPRF12])

In related work, various researchers [Tic98, PP07, Den80, CGM+89, Den05] argue for more (statistical) rigor in computer science. Vitek and Kalibera [VK11], Desprez et al. [DFJ + 12], and Kalibera and Jones [KJ11] contain survey data demonstrating the lack of rigor and availability of experiments in computer science. This directly confirms the general need for our proposed research. A number of works demonstrate hidden factors that can affect measurement accuracy: binary link order [MDHS09], process environment size [MDHS09], symbol renaming [GVG04]), group scheduler assignments [OFD + 12], and various interpreter details [GVG06].

In related work special experimentation infrastructures have been built [CGH + 09, WLS + 02, PBFM06, JBK07] to get precise measurements. Most of them aim at large-scale computing [DFJ + 12] with homogeneous infrastructure. DataMill [OPRF12] differs as it aims for heterogeneity and the intern has contributed to the development of this infrastructure.

2.4. **General objective** of the research project broken down into sub-objectives, activities, themes, or subprojects, as applicable:

The intern will concentrate on methods to improve empirical research by devising efficient and effective ways to accurately measure performance of computer software. This knowledge is critical, since Acerta's main product relies on a cloud-enabled data analysis software pipeline.
Sub-objective 1: properly characterize the performance of the different stages and identify bottlenecks.
Sub-objective 2: suggest and realize improvement in each stage.

2.5. **Details of internships or subprojects:**

For <u>each</u> intern or subproject, provide the following mandatory information:

a. **Name of intern.** Anderson Oliveira Sousa

b. **Specific objectives of the internship or subproject**. Clearly state your [sub-] objectives so reviewers can assess if they are achievable.

Figure 1 provides an overview of a generic data analysis pipeline. The top portion is the customer. The ingestion stage received data from the customer. The preparation and plausibility checks stages clean the customer data and prepare it for algorithmic processing. The feature extraction stage parses the clean data and generates from it the features used in the different machine learning algorithms. The analytics stage runs the actual classification and prediction algorithms. Finally the reporting stage prepares the results for the customer.

Each stage bears opportunity for optimization. Since the stages are executed in sequence, it is important for each stage to not be the bottleneck. Note that the algorithms inside each stage can still leverage parallelism.

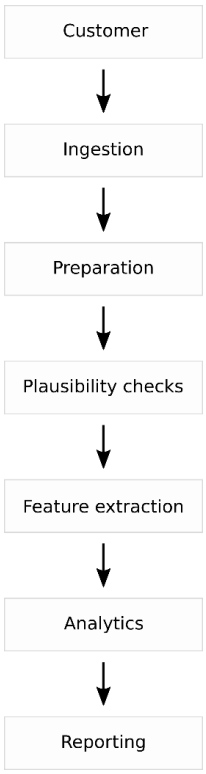

Figure 1: Data analysis pipeline overview

Sub-objective 1: properly characterize the performance of the different stages and identify bottlenecks.
Sub-objective 2: suggest and realize improvement in each stage.

c. **Methodologies**. Provide enough detail so reviewers can determine if the proposed methodology is appropriate and sufficient to achieve the [sub-] objectives.

Objective 1: To achieve this objective, the intern will proceed as follows: First, he will measure the performance of each stage in isolation. This will require some adaptation of the stages and the development of a benchmarking test harness for loading data, extracting features, performaing analysis and saving results for reporting. The workload for the performance evaluation will be customer data readily available at Acerta. In the benchmarking and feature extraction, the intern will leverage the knowledge gained in his masters' research at the university. This includes the use of feature extraction algorithms such as PCA, ICA, Autoencoders and selection heuristics to isolate common factors such as background load, network communication, memory pressure and more. These will be used to ensure that the performance measurements of the stages are accurate. To collect the performance data, the intern will use tools such as perf and gprof for C programs and similar tools. After the initial characterization, the intern will rank the stages based on their execution time and start investigating the top three stages which take the most time in the system. In each of these, the intern will use performance data collected to identify the most expensive routines and summarize them in a performance evaluation report.

Objective 2: Based on the results from Objective 1, the intern will improve the performance of the data analysis pipeline by iterating over the list of the most expensive routines and suggesting improvements. The intern is not limited to what suggestions should be put in place and consequently can suggest any of the following or other methods: revised algorithms with shorter runtime, code refactoring, or switching algorithms to a faster programming language. The result should be a significantly improved performance of the data analysis pipeline. To check whether the performance actually has been improved, the intern will re-run the performance testing developed in the first objective. Finally, depending on the time remaining in the internship, the intern will continue working on different functions and improve their performance.

d. **Timeline**. We suggest using a Gantt chart to provide a timeline showing which task will be done when to achieve each objective.

Objective	Activity	M1	M2	M3	M4
O1	Develop performance testing harness	XX			
	Run performance tests	XX	XX		
	Analyse performance data		XX		
	Report part 1		XX		
O2	Select 3 top expensive functions			XX	XX
	Revise functions to improve performance			XX	XX
	Re-test to check performance improvement			XX	XX
	Report part 2				XX
	Final report				XX

e. **Expected deliverables.** Each project requires the submission of a completed Mitacs Final Report and Mitacs survey at the end of the project**.** Please describe the additional expected deliverables of the project

i.e. expected outcomes, results, documents (intern's thesis, peer-reviewed journal, conference presentation).

- Source code, documentation, and regression tests for the performance test harness
- Source code and documentation for the performance workload
- Updated functions in the different stages
- A final report summarizing the findings and results
- Mitacs Final report
- Mitacs Survey

f. Benefit to the intern.

The field of study of the intern is performance evaluation. In his research, he is investigating effective and efficient methods for performance evaluation of computer software. The internship provide the opportunity to get hands-on experience with a real application and deepen his understanding of performance evaluation.

g. **Interaction**. Indicate the percentage (%) of time during the project that the intern will spend on-site at the partner's location and at the university. Research should be carried out equally (50%) in the premises of the partner and the university, if different, please include a **justification**. NOTE: The minimum interaction at either site is 25% with a maximum of 75%.

% of partner interaction: __**75**__ % + % of academic interaction: _**25**__ % = 100%

h. **Justification** for an interaction other than 50/50 : to maximize productivity the intern will spend most of their time at the industry partner site in order to have access to secure client data and direct communication with the experts at the industry partner. Regular meetings will still be held on campus with the academic supervisor to track progress and develop the research.

i. Partner Interaction.

(1) Provide a detailed description of the activities that will be performed on-site at the partner organization and the expected interaction with and supervision by employees of the partner organization.

(2) Indicate the resources the partner organization will be providing to support the intern's work at their premises. Include information about space, resources and expertise that will be provided by the organization to the intern.

The industry partner will provide:

- A full workplace
- Supervision through a senior DevOps person
- Full integration into the DevOps team
- Training on using a cloud infrastructure (e.g., S3)

2.6. **Relevance** to the partner organization and to Canada:

Describe the partner's proposed role in the project, how the partner will benefit from participating, and how the Canadian community will benefit from this research.

Acerta Systems Analytics is providing a framework for estimating the quality of a product at the end of line in the factory. The framework uses advanced data analytics to predict the likelihood of the product being defective. Acerta is investing heavily into research and development to try new algorithms to keep and improve their edge over competitors. A fast data analysis pipeline is essential for being able to analyze in time the data volumes received from customers.

2.7. Project economic orientation (for submissions with a NFP organization ONLY):

Describe the economic or productivity orientation of the project. NOTE: if any partner listed in this proposal is a not-for profit (NFP) organization, please contact a Mitacs Business Development representative to discuss its eligibility before proceeding with your proposal submission.

2.8. Relationship (if any) to past/other Mitacs Accelerate internships, Mitacs Elevate fellowships, or current applications in submission to any Mitacs program:

Describe whether or not the current project is related AND provide specifics about the relationship (e.g. not related because it refers to a different research area OR if related: provide information about what has been achieved in past projects and how the current application complements other submissions)

Acerta has applied for a second Mitacs Accelerate internship. However, there is no conceptual or budgetary overlap to this internship.

2.9. References:

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3. [CGH + 09] Roy Campbell, Indranil Gupta, Michael Heath, Steven Y. Ko, Michael Kozuch, Marcel Kunze, Thomas Kwan, Kevin Lai, Hing Yan Lee, Martha Lyons, Dejan Milojicic, David O'Hallaron, and Yeng Chai Soh. Open CirrusTMcloud Computing Testbed: Federated Data Centers for Open Source Systems and Services Research. In Proceedings of The 2009 Conference on Hot Topics in Cloud Computing, HotCloud'09, Berkeley, CA, USA, 2009.
4. [CGM + 89] D. E. Comer, David Gries, Michael C. Mulder, Allen Tucker, A. Joe Turner, and Paul R. Young. Computing as a Discipline. ACM Communications, 32(1):9-23, January 1989.
5. [Den80] Peter J. Denning. ACM President's Letter: What is Experimental Computer Science? ACM Communications, 23(10):543-544, October 1980.
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7. [DFJ 12] F. Desprez, G. Fox, E. Jeannot, K. Keahey, M. Kozuch, D. Margery, P. Neyron, L. Nussbaum, C. Perez, O. Richard, W. Smith, G. von Laszewski, and J. Voeckler. Supporting Experimental Computer Science. Technical report, Argonne National Laboratory, 2012.
8. [FB10] Sebastian Fischmeister and Yanmeng Ba. Sampling-based Program Execution Monitoring. In Proc. of the ACM SIGPLAN/SIGBED Conference on Languages, Compilers, and Tools for Embedded Systems (LCTES), pages 133-142, Stockholm, Sweden, April 2010.
9. [FL10] Sebastian Fischmeister and Patrick Lam. Time-Aware Instrumentation of Embedded Software. IEEE Transactions on Industrial Informatics, 6:652-663, August 2010.
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12. [GF12] Giovani Gracioli and Sebastian Fischmeister. Tracing and Recording Interrupts in Embedded Software. Journal of Systems Architecture, pages 1383-7621, 2012.
13. [GOL12] Shay Gal-On and Markus Levy. Creating Portable, Repeatable, Realistic Benchmarks for Embedded Systems and the Challenges Thereof. In Proceedings of the 13th ACM SIGPLAN/SIGBED International Conference on Languages, Compilers, Tools and Theory for Embedded Systems, LCTES '12, pages 149-152, New York, NY, USA, 2012. ACM.
14. [GVG04] Dayong Gu, Clark Verbrugge, and Etienne Gagnon. Code Layout as a Source of Noise in JVM Performance. In Proc. of the Component And Middleware Performance Workshop, 2004.
15. [GVG06] Dayong Gu, Clark Verbrugge, and Etienne M. Gagnon. Relative factors in performance analysis of java virtual machines. In Proceedings of the 2nd International Conference on Virtual Execution Environments, VEE '06, pages 111-121, New York, NY, USA, 2006. ACM.

16. [Jai91] Raj Jain. The Art of Computer Systems Performance Analysis. Wiley Professional Computing. Wiley, 1991.
17. [JBK07] Elliot Jaffe, Danny Bickson, and Scott Kirkpatrick. Everlab: A Production Platformfor Research in Network Experimentation and Computation. In Proceedings of the 21thLarge Installation System Administration Conference, pages 203-213, 2007.
18. [KF12] Hany Kashif and Sebastian Fischmeister. Program Transformation for Time-aware Instrumentation. In Proc. of the 17th IEEE International Conference on Emerging Technologies & Factory Automation (ETFA), Krakow, Poland, 2012.
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21. [Lil05] D.J. Lilja. Measuring Computer Performance: A Practitioner's Guide. Cambridge University Press, 2005.
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23. [MDHS09] Todd Mytkowicz, Amer Diwan, Matthias Hauswirth, and Peter F. Sweeney. ProducingWrong Data Without Doing Anything Obviously Wrong! SIGPLAN Notes, 44(3):265-276, March 2009.
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26. [NBF12] Samaneh Navabpour, Borzoo Bonakdarpour, and Sebastian Fischmeister. Path-awareTime-triggered Runtime Verification. In Third International Conference on Runtime Verification (RV), Istanbul, Turkey, September 2012.
27. [OFD+ 12] Augusto Oliveira, Sebastian Fischmeister, Amer Diwan, Matthias Hauswirth, and PeterSweeney. Why You Should Care About Quantile Regression. Submitted to the International Conference on Architectural Support for Programming Languages and OperatingSystems (ASPLOS), Jul. 2012.
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30. [PBFM06] Larry Peterson, Andy Bavier, Marc E. Fiuczynski, and Steve Muir. Experiences BuildingPlanetLab. In Proceedings of The 7th Symposium on Operating Systems Design andImplementation, OSDI '06, pages 351-366, Berkeley, CA, USA, 2006.
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32. [Tic98] Walter F. Tichy. Should Computer Scientists Experiment More? IEEE Computer,31(5):32-40, 1998.
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34. [WLS 02] Brian White, Jay Lepreau, Leigh Stoller, Robert Ricci, Shashi Guruprasad, Mac Newbold, Mike Hibler, Chad Barb, and Abhijeet Joglekar. An Integrated Experimental Environment for Distributed Systems and Networks. In Proc. of the Fifth Symposium on Operating Systems Design and Implementation, pages 255-270, Boston, MA, December 2002. USENIX Association.

3. Declarations

3.1. Will the proposed research be taking place outside of the lab or normal business environment?

Yes___ No_x__

If yes, please complete the following section to indicate what (if any) impact there may be on the environment.

a. Main characteristics of the location (i.e. physical description & coordinates).

b. Principal activity(ies): for each activity, list the environmental elements affected.

c. Are authorizations, permits, or licenses required to undertake any activity during the internship?
Yes___ No___

If yes, please list and include copies with your application.

3.2. Does the proposed research involve living human subjects (including conducting interviews) or human remains, cadavers, tissues, biological fluids, embryos, or fetuses?

Yes___ No_x__

If yes, the proposal must be approved by the participating University Research Ethics Board*, and a valid Ethics approval is required for the duration of the research project. Access to funding may be denied for projects that do not have ethical approval.

Please note: Mitacs may request a copy of the report to ensure compliance.

3.3. Does the proposed research involve animal subjects?

Yes___ No_x__

If yes, the proposal must be approved by the participating University Animal Care Committee*, and a valid approval from the committee is required for the duration of the research project.

Please note: Mitacs may request a copy of the report to ensure compliance.

3.4. Is a biohazards review required?

Yes___ No_x__

If yes, the necessary review/report must be conducted in accordance with your university's policies*, and a valid biohazards approval is required for the duration of the research project.

Please note: Mitacs may request a copy of the report to ensure compliance.

3.5. Have any participants declared a Conflict of Interest (COI)* as part of this application?

Yes___ No_x__

If yes, please attach the signed conflict resolution letter.

** if you have any questions about the requirement for Research Ethics/Animal Care/Biohazards review or University/Conflict of Interest Policies at your institution, please contact your corresponding institution's research office.*

Mitacs-Accelerate

Intern CV Template

Date 18 September 2017	
Family Name Oliveira Sousa	Given Name Anderson
Permanent address in Canada: 204 504 Glenelm Crescent, Waterloo, ON	
Permanent phone number or cellphone in Canada: 1 226 792 7914	

ACADEMIC BACKGROUND

Degree	Name of Discipline	Institution	Country	Date
Bachelor degree in Computer Engineering		Federal University of Goias	Brazil	December 2014

ACADEMIC, RESEARCH & INDUSTRIAL EXPERIENCE

Position held	Organization	Department	Period (yyyy/mm to yyyy/mm)
Teaching Assistant	University of Waterloo	Electrical and Computer Engineering	2017/01 to 2017/08
Independent Contractor	Embrapa	Research and Development	2015/01 to 2016/01
Intern	Merck Sharpe & Dohme	Global secutity and anti counterfeiting Dpt.	2013/05 to 2013/08

DESCRIPTION OF ACTIVITIES AT ACADEMIC INSTITUTIONS

Provide details of published papers, title of dissertation and name of supervisor and other relevant activities.

University of Waterloo: MASc student, my research area is performance evaluation and benchmarking. As a TA, I worked on the design of a preemptive real-time operating system and provided advice and assistance to students. Dr. Sebastian Fishmeister is my supervisor at this institution. No papers were published yet.

Federal University of Goias: Undergraduate student with focus on embedded system. There was no supervisor in this institution.

AREAS OF EXPERTISE

Provide a maximum of 10 words that describe your area(s) of expertise.

Performance evaluation, benchmarking and embedded systems.