Exploit parallel computing on SMT solving

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22 December 2015

The Satisfiability Modulo Theories (SMT) problem is the decision problem of determining whether a logical formula is satisfiable, given that some of the variables have an interpretation with respect to combinations of first-order background theories. The expressiveness of SMT makes it suitable for a vast range of application domains, including software verification, and for that reason it has recently attained significant interest from both industry and academia.

The computational cost of SMT can be very high given that just the problem of determining the propositional satisfiability, the Boolean Satisfiability Problem (SAT), is proven to be NP-complete, and the introduction of the background theories can only make the problem harder. Nevertheless relatively little research exists on how parallel computing can be used to speed up SMT solving.

The goal of this UROP project is to exploit parallel computing on SMT solving by iteratively partitioning the search-space and solving each partition independently. The work, including implementation and experimentation, will be carried out as an extension of the novel parallel version of OpenSMT, an SMT solver developed by the Verification Group at USI.

We are looking for a motivated student who wants to improve his/her knowledge on software verification and cloud-based parallel computing. This project will give the student an excellent overview of a quickly developing field while being sufficiently approachable. Prior knowledge of C++ language is required. The knowledge of POSIX threads API of C language is highly recommended before beginning. Prior knowledge in SMT modelling is not required, though is a plus.

The project is from Prof. Natasha Sharygina and it will be assisted by Matteo Marescotti. The aim of this project is to extend the novel parallel version of OpenSMT. The student will be coached while:

1. Getting familiar with the current research and implementation state.

2. Implementing and debugging the core functionalities in a cloud computing environment.

3. Designing and running a set of experiments.
Analysis and Optimization of Task Granularity in Concurrent Applications

Task granularity, i.e., the amount of work to be performed by computing tasks, is a key performance attribute of parallel and distributed applications. On the one hand, fine-grained tasks (i.e., short-running tasks carrying on small computations) may introduce considerable parallelization overheads, due to the high number of tasks required by the application and the scheduling costs. On the other hand, coarse-grained tasks (i.e., long-running tasks performing substantial computations) may result in missed parallelization opportunities, as tasks might be further split to speed up computations. To optimize performance and scalability of concurrent applications, developers need to find the best tradeoff between fine and coarse task granularity. Despite being a key feature of concurrent applications, related work has paid little attention to parallel task granularity. As a result, detailed analysis on this topic as well as tools that aid developers in finding the optimal granularity tradeoff are, to the best of our knowledge, missing to date.

This project aims at filling this gap by providing a thorough analysis of task granularity in real-world concurrent applications. The student will be involved in a number of activities:

1. Identification of quantitative metrics suitable for task granularity characterization;
2. Development of profilers for the measurement of those metrics in concurrent applications;
3. Empirical evaluation of the profilers on real-world concurrent applications and identification of scalability bottlenecks;
4. Program optimizations targeting at the removal of the identified bottlenecks.

The project is a unique opportunity for the student to deepen his or her knowledge in the domains of concurrent programming, dynamic program analysis, and empirical evaluation, all being important skills for a software engineer. The student will work side-by-side with the members of the Dynamic Analysis Group at USI, and will receive support in learning about advanced topics that will strengthen his or her abilities as a computer scientist. Applicants interested in this project should have a good knowledge of Java, good programming skills, and deep interest in the field of concurrent programming.

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Using DiSL for Bytecode Instrumentation as a Service

DiSL is a bytecode instrumentation framework utilizing a domain-specific language for instrumentation hosted in Java. DiSL reconciles the conciseness of the pointcut/advice model known from aspect-oriented programming and the expressiveness and performance that can be achieved using low-level bytecode manipulation libraries. One of the important features of DiSL is that it retains Java as the language for both the inserted code as well as code that controls the instrumentation process. To avoid perturbation to the observed program due to the use of Java during instrumentation, DiSL performs instrumentation in an isolated process, the DiSL server.

While the primary role of the DiSL server was to isolate instrumentation from the base program execution, the secondary role envisioned for the server was to provide a true instrumentation service that could be deployed on a dedicated machine. Currently, the server needs to be configured to handle a specific instrumentation task, and started before the observed base program to handle instrumentation requests during the base program execution. It terminates automatically after the base program stops executing. This prevents efficient deployment of dynamic analyses in scenarios that would benefit from the ability to run the server continuously as a proper service on a dedicated machine (e.g., reduced start-up overhead, or more opportunities for caching).

The goal of the project is to design a proper instrumentation service with support for instrumentation sessions. This will allow a client to supply the instrumentation server with all the information necessary to fulfill its instrumentation requests (as opposed to configuring a server for a specific task) for the duration of an instrumentation session.

In this project, the student will be involved in the following activities:

1. Design of a DiSL-based instrumentation service (involves requirement analysis and the design of a communication protocol between the client and the server);
2. Partial refactoring of the DiSL instrumentation framework (involves identification and removal of architectural constraints that hinder the exposure of the DiSL framework as a service);
3. Integration and testing of the DiSL instrumentation service with research tools for automated synthesis of benchmarking workloads based on user-specified criteria (ongoing research).

The project is a unique opportunity for the student to deepen his or her knowledge in the domains of software design, concurrent programming, and dynamic program analysis, all being important skills for a software engineer. The student will work side-by-side with and receive support from the members of the Dynamic Analysis Group at USI. Applicants interested in this project should have a good knowledge of Java, and be interested in learning more about software design and concurrent programming.

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User Studies in Human Memory Augmentation

Technology always had a direct impact on what humans remember. In the era of smartphones and wearable devices, people easily capture information such as pictures and videos on a daily basis which can help them evoke memories for reminiscing or simply to help one remember a past event. The ubiquity and increasing use of such devices and technologies produce a sheer volume of pictures and videos that, in combination with additional contextual information, could significantly improve one’s ability to recall a past experience or future event.

In this UROP project, the selected candidate should help a team of USI researchers prepare, conduct, and analyse a set of user studies in human memory augmentation over the summer. Specifically, we are seeking to trial two prototypes that are currently under development: The "PulseCam" and the "DashCam". The PulseCam uses a wristband to measure a user's physiological parameters, such as heart rate or stress level, and records this information together with periodically captured first-person photographs (captured every 30s using a small wearable camera). The study will investigate if physiological parameters can allow us to predict which pictures help a user the most in recalling past events. The DashCam is a messenger-style interface to the aforementioned wearable camera, allowing a user to browse through a day's set of pictures that have been augmented by other contextual events, e.g., people that were detected in the vicinity, or places entered/left, etc. Again, the study will seek to understand how such a messenger-style presentation can aid human memory.

As part of the project, the student may help fine-tune and improve an existing set of software (alternatively develop novel modules as needed), combine them with state-of-the-art hardware (E4 wristband, Narrative Clip2, smartphone) into a fully functional prototype, and trial the entire system in a week-long study (which includes participant recruitment, participant briefing and de-briefing, data collection, and data analysis). The student will be part of an international research project and will gain invaluable experience in running scientific studies with real participants in real settings.

prof. Marc Langheinrich

Evangelos Niforatos
**PROMO - PROtotypes and MOck-ups for Anch’ ioLAC**

Project PROMO is a two month contribution to larger project Anch’ioLAC, currently run in collaboration with FIPPD, “Fondazione Informatica per la Promozione della Persona Disabile”, a charity providing ICT solutions for the well being and growth of people with disability. The aim of Anch’ioLAC is to design, prototype, test, develop and evaluate tools to make visiting a museum a more engaging and rewarding experience for people with a range of disabilities, mostly, but not exclusively, of cognitive nature.

We are currently running an extensive Contextual Enquiry in order to get to know better our users, a particularly complex task as each person comes with a very different profile. Direct communication with users is not always an option and often we need to refer to intermediaries such as caregivers and experts in special need education. We are collecting relevant literature, running observations of special need visitors in situ and conducting interviews with different stakeholders: museum curators and tour guides, educators and when possible special need visitors. This is in preparation of a co-design phase to take place from end of February to beginning of May. We are currently recruiting a small group of volunteers, all affected by minor cognitive disorders, to act as co-designers. They will help us design tools to make visiting a museum a better experience for friends and people they know have more serious disabilities than theirs. The idea is to benefit from their direct experience of the implications of disabilities on a museum visit. By engaging our volunteers in a series of activities we will aim at triggering their creativity. Thus, we will get valuable insights to help draw relevant personae for our design to address. Co-design is spread over five meetings: two will be visits to the LAC museum and three will focus on design activities, such as sketching and crafting, to take place at USI. In particular, we will explore the concept of esouvenir as a means for visitors to take home with them a memory of their visit to keep and share in many ways.

By the end of May the co-design phase will come to its end, personae will be ready for us to use and we will have enough information to start designing solutions to test with our users by following a formative evaluation approach.

The student chosen to work in PROMO will get involved in the ideation, design and early testing of mock-ups and prototypes based on the user requirements extracted in the phase described above. She will start from the analysis of data gathered and engage with the design discussions to determine the type of mock-ups and/or prototype to be used for this study. We will also debate functionalities to be tested and interface features to be relevant to our personae.

Then, we will run a quick pilot study with small sample of users and/or experts in order to gather early usability feedback.

As we have established a good working collaboration with few local organisations caring for special need users and given LAC is involved directly as partner in the project, we feel the suitable candidate will be able to experience for real how to work with partners from a different background.

At the moment we have one Master student working on project Anch’ioLAC and he has been extremely effective in running the Contextual Enquiry stage. His contract will come to an end in June, and even if we hope he will decide to stay with us for longer, it is possible we will need to get a new person appointed to take the project to the next step: prototyping. We feel that having a chance to involve an extra person over this transitional time could be very beneficial by providing us with a different point of view and making the shift from understanding our users to making solutions for them smoother. Besides, s/he could prove to be the best candidate to go on and continue working on Anch’ioLAC.

PROMO will offer a student the chance to engage with the complexities of working with real users without having to go through the ordeal of running a user study from scratch. The chosen student will also enjoy working in a truly multidisciplinary team.

It would be an ideal experience for any of the students who attended our HCI Design Master class to practice what they have learned in the last semester.

Dr. Monica Landoni
ASQ

ASQ (http://asq.inf.usi.ch) is a Web platform for delivering interactive lectures in traditional brick and mortar classrooms. It allows presenters to pose questions inside HTML slides and receive answers from the audience. ASQ has grown from an ambitious student project with support for multi-choice and text question types to a platform that scales to hundreds of students, featuring its own plugin system, support for two HTML5 presentation frameworks (reveal and impress) and a revamped presenter control view for live statistics.

ASQ has been successfully used both at USI and other universities from which we have gathered a lot of valuable feedback. We are looking for motivated students that will help us make ASQ an indispensable tool for Professors, teachers and presenters in general. There are a lot of different areas to work on from data analysis and visualization to live programming and Web presentation development tools.

prof. Cesare Pautasso
Background and significance
Predicting the thermodynamic and kinetic properties of the binding interaction of a drug to its target is of primary relevance to shed light on its mechanism of action and develop new medications [1,2,3]. This information can be obtained from advanced calculations such as funnel-metadynamics, FM [4]. Using a funnel-restraint potential, this method enhances the exploration of the ligand bound poses and its solvated states leading to an accurate description of the protein-ligand binding free energy surface (Fig. 1). This approach allows investigating further important aspects of the binding process, such as the presence of alternative binding modes and the role of the solvent. Albeit very recent, FM has proven successful in studying complex ligand/protein, ligand/DNA and peptide/membrane binding interactions [5,6].

Aim of the project
To date, the implementation of FM is not completely automated and this can discourage people to use this powerful technique. The aim of the present project is to develop a graphical interface to set up in an interactive way the parameters necessary to run FM simulations. This module will be implemented in the widely used molecular visualisation program Visual Molecular Dynamics (VMD). This work will extend the functionality and the use of FM with impact in drug design. Knowledge in C/C++ or python programming is required.

References
Evaluating a Personal Memory Sharing System

Using smartphones and wearable devices, people now can fully log their life in pictures, audio or even video recordings. Such data - "life-logs" - can help evoke past memories. Within the RECALL research project, we are exploring how reviewing segments of life-logs can significantly augment human memory to better remember past experiences.

One interesting ability in highly networked environments is the ability to share parts of one's life-logs with others in order to benefit from each other's recordings (e.g., by having access to a third person view of oneself in a meeting). In order to avoid any privacy violations, it makes sense to share life-logs with co-located people or people that were part of the same event and that appear in the life-log. For example, consider a work meeting scenario where participants are equipped with wearable devices that automatically capture pictures and short audio snippets in order to better remember the meeting. The aim of this project is to evaluate an Android app - called "Personal Memory Sharing System" – that allows participants to share their recordings securely with other meeting participants.

We are looking for a highly motivated student that will help with evaluating the usability of the Secure Personal Memory Sharing system. The work includes deployment of the system in the wild and conduction of usability experiments with real participants. In addition the student will gain insights and knowledge of how audio-visual recordings can be used to improve human memory.

Prof. Marc Langheinrich
Agon Bexheti
Roaming Objects - Object-Encoded Digital Experiences

In the era of Internet of Things, traditionally “disconnected” objects such as household items, domestic electronics, and even vehicles will have their own unique identity and can be addressed through the Web anywhere, anytime. With the advent of “sharing economy”-services, those objects may be easily shared among users (e.g., book sharing, household item sharing via pumpipumpe.ch). Once shared, the object creates a unique experience with a borrower, which often could be described with a story.

Within the SHARING21 research project, we are looking into new ways of supporting sharing both digital information and physical objects. In this UROP summer project, we would like to explore sharing practices in the context of a "sports rental shop“ – in our case the sports equipment rented out by USI Sports. Using a "checkout card" metaphor (similar to checkout cards in library books) we would like to embed a digital tag (using a QR code, an NFC tag, or using an augmented reality markerless tracking technique) on a rented sports equipment such as a ski or a snowboard. The tags will be read using a smartphone (e.g., its NFC reader or its camera).

Specifically, the student should co-design, develop, and prototypically evaluate an ecosystem to support “experience-enabled” roaming objects, which consist of

- a smartphone app that allows one to “connect” to a rental equipment in order to add and retrieve digital information encoded "into" the gear. The types of information that can be encoded could be textual information (e.g., comments, ratings), personal media (photos and videos) taken during the rental period of the object, or location details (GPS path where the gear was used). System-generated information can be added automatically (how many times object was lent, how long it was used, etc), while user-generated information should be added manually using the smartphone app.

- a web-service to handle storage and retrieval of the object’s encoded information on a server.

- an optional web-interface that allows a rental shop administrator (or external users) to retrieve a status, a list a currently encoded experience of the rented gear, and send a notification to the current user.

- good iOS and Web programming skills required. All hardware will be provided.

prof. Marc Langheinrich

Anton Fedosov
FPGA to VGA: controlling graphic displays with reconfigurable hardware.

Field Programmable Gate Arrays (FPGAs) are a class of circuits whose functionality can be defined by a designer after manufacturing. This flexibility allows FPGAs to perform a plethora of different functions, while retaining the benefits of highly-efficient hardware execution. In fact, modern FPGAs present performances close to the ones of fixed-function ASICs.

FPGAs are configured by a bit-stream derived from the synthesis of a design, described in a Hardware Description Language (HDL) such as VHDL. To allow an early debug and assessment of the implemented functionality, cycle accurate simulations of the HDL code is usually performed before deployment.

In this context, the goal of the project is to devise, simulate and test on a FPGA development board a hardware module interfacing with a VGA monitor. The module will be able to properly drive control and data signals according to the VGA protocol specifications, so that still images and/or animated patterns can be correctly displayed.

During the project, the student will get acquainted with FPGA programming and the complete tool-chain required to develop a digital design on reconfigurable hardware. In particular, the student will acquire proficiency with the VHDL language, the Xilinx ISE development environment and the Modelsim simulator.

Requirements:
- Interest in computer architectures and digital design
- Experience in low-level programming (e.g.: C) is a plus

Mentors:
- Laura Pozzi
- Giovanni Ansaloni