Research proposal: Temporal logics on strings

Location : Laboratoire Spécification et Vérification (LSV)
Ecole Normale Suprieure Paris-Saclay

Advisor : Stéphane Demri (LSV, CNRS, ENS Paris-Saclay)
demri@lsv.fr

String theories in a temporal setting. Reasoning about strings is increasingly required in program verification and recently much effort has been dedicated toward designing solvers that handle string theories, see e.g. [AAC$^+$14, HL14]. The decidability status of expressive string theories is not always known, see e.g. [LRT$^+$14, Section 2.1] or [AAC$^+$14], but fortunately, decidability of word equations is known to be decidable thanks to Makanin's result [Mak77] and a PSPACE algorithm has been designed by Plandowski in [Pla04]. Many works have been dedicated to reasoning about temporal logics on concrete domains, see e.g. [BGL12, DHV14], so that temporal reasoning is done about the evolution of typed variables (for instance interpreted by integers or by strings to cite a few examples). Even when decidability is preserved, the complexity can be relatively high. For instance, LTL over the concrete domain $(\mathbb{N}, \leq)$ is PSPACE-complete [DD07, DG08]. In this internship, we are interested in temporal logics (see e.g. [DGL16]) when the concrete domain contains finite strings.

Temporal logics on strings with the prefix relation. A remarkable breakthrough has been made recently in [CKL13] by showing that CTL* over the domain $(\mathbb{N}, \leq)$ is decidable by using the decidability of Boolean combinations of formulae from MSO and from WMSO+U [BT12] where U is the unbounding second-order quantifier (see also the follow-up work [CKL14] involving ECTL*). Unfortunately, none of the known techniques has been able to handle LTL over concrete domain of the form $(\Sigma^*, \preceq)$ where $\preceq$ is not a total ordering on Σ^* such as the prefix relation $\preceq_p$ or the subword relation $\sqsubseteq$. In the paper [DD16], the main result establishes that the satisfiability problem for LTL over $(\Sigma^*, \preceq)$ is decidable and PSPACE-complete, which is done by an approach that consists in translating prefix constraints into numerical constraints.

The main objectives of the thesis are to design new decidability borders for temporal logics designed for reasoning about strings.

References

[AAC$^+$14] P.A. Abdulla, M.F. Atig, Y.-F. Chen, L. Holík, A. Rezine, Ph. Rümmer, and J. Stenman. String constraints for verification. In *CAV'14*, volume 8559 of *Lecture Notes in Computer Science*, pages 150–166. Springer, 2014.

[BGL12] F. Baader, S. Ghilardi, and C. Lutz. LTL over description logic axioms. *ACM Transactions on Computational Logic*, 13(3):21, 2012.

[BT12] M. Bojańczyk and S. Torunczyk. Weak MSO+U over infinite trees. In *STACS'12*, LIPIcs, pages 648–660, 2012.

[CKL13] C. Carapelle, A. Kartzow, and M. Lohrey. Satisfiability of CTL* with constraints. In *CONCUR'13*, Lecture Notes in Computer Science, pages 455–463. Springer, 2013.

[CKL14] C. Carapelle, A. Kartzow, and M. Lohrey. Satisfiability of ECTL* with constraints, October 2014. Under submission. Retrieved from `http://www.informatik.uni-leipzig.de/~kartzow/Paper/ECTL-With-Constraints.pdf`.

[DD07] S. Demri and D. D'Souza. An automata-theoretic approach to constraint LTL. *Information and Computation*, 205(3):380–415, 2007.

[DD16] S. Demri and M. Deters. Temporal logics on strings with prefix relation. *Journal of Logic and Computation*, 26(3):989–1017, 2016.

[DG08] S. Demri and R. Gascon. Verification of qualitative Z constraints. *Theoretical Computer Science*, 409(1):24–40, 2008.

[DGL16] S. Demri, V. Goranko, and M. Lange. *Temporal Logics in Computer Science*. Cambridge University Press, 2016. To appear.

[DHV14] A. Deutsch, R. Hull, and V. Vianu. Automatic verification of database-centric systems. *SIGMOD Record*, 43(3):5–17, 2014.

[HL14] M. Hutagalung and M. Lange. Model checking for string problems. In *CSR'14*, volume 8476 of *Lecture Notes in Computer Science*, pages 190–203. Springer, 2014.

[LRT+14] T. Liang, A. Reynolds, C. Tinelli, C. Barrett, and M. Deters. A DPLL(T) theory solver for a theory of strings and regular expressions. In *CAV'14*, volume 8559 of *Lecture Notes in Computer Science*, pages 646–662, 2014.

[Mak77] G.S. Makanin. The problem of solvability of equations in a free semigroup (english translation). *Mathematics of USSR-Sorbnik*, 32:147–236, 1977.

[Pla04] W. Plandowski. Satisfiability of word equations with constants is in PSPACE. *Journal of the Association for Computing Machinery*, 51(3):483–496, 2004.