A study of a tool platform for developing formal specification

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1 Overview

Since computer systems are pervasive and have a major impact on society, such systems must be built safely and reliably. One of the existing approaches to this issue is to formally model (the designs of) such systems and formally verify that they have desired properties. Computer systems are often modeled as transition systems. If a computer system can be modeled as a finite transition system, model checking techniques may be the most useful. Otherwise, theorem proving techniques should be used.

In our approach, a computer system is modeled as an OTS (Observational Transition System), a kind of transition system, which is described in CafeOBJ. It is then verified that the systems have desired properties by writing proof scores in CafeOBJ and having the CafeOBJ system execute (or rewrite) the proof scores. We have demonstrated the efficiency of our approach by performing several case studies. However, proof scores have been entirely written by hand, which means that human errors might have occurred. To minimize human errors, writing proof scores should be mechanically supported.

We think that the difficulty to develop tools treating CafeOBJ specifications causes lack of such tools around CafeOBJ. Since CafeOBJ’s users can specify that their own syntax of terms such as _+_ or if_then_else_fi (An underscore _ indicates the place where an argument is put), we cannot parse specifications with parser generators such as Yacc. To solve this problem, we propose an XML scheme called CafeOBJ/XML as a tool platform and present a tool called Buffet which converts the original specification to the XML version of it. The main advantage of this idea is that we can use common XML parsers to parse specifications, and most programming languages have such parser. This advantage makes easy to develop such tools.

In this paper, we also presents three applications to demonstrate that the proposed scheme is a suitable for such platform. One of these applications can generate proof scores automatically, it is guaranteed that generated proof scores cover all cases, excluding human errors.
2 System developments

We have completed implementing and testing the following software in this fiscal year.

2.1 CafeOBJ/XML

CafeOBJ/XML is a scheme to describe specifications and proof scores of CafeOBJ. This scheme is given by means of DTD (Document Type Definition). XML documents according to CafeOBJ/XML are produced by Buffet and Gateau. We have demonstrated that CafeOBJ/XML is a useful tool platform with developing below tools.

2.2 Buffet

Buffet is a toolkit for converting specifications written in CafeOBJ to CafeOBJ/XML and reducing terms with CafeOBJ's rewriting engine. Buffet is implemented as an HTTP server which can be used by multiple clients.

2.3 Gateau

Gateau is a proof assistant for verifying whether a state machine have invariant properties or not. Given predicates used to split cases and lemmas, Gateau automatically generates proof scores and checks the proof scores with Buffet. Although the success of a proof depends on given predicates for case analysis and lemmas, it is guaranteed that generated proof scores cover all cases, excluding human errors.

We have done three case studies that Gateau can been applied to a simple mutual exclusion protocol, NSLPK and Otway-Rees authentication protocol.

2.4 Proof Score Presenter

Proof Score Presenter (PSP) is a pretty printer for proof scores written in CafeOBJ/XML. Given an XML document of a proof score and the results of reducing the proof passages in the proof score, PSP generates an HTML document like Figure 1. When an HTML document generated by PSP is first displayed on a web browser, proof passages for which results are not true and their results are shown, and other proof passages (namely those for which the proof has succeeded) are hidden. Proof passages are hierarchically shown according to the predicates used to split cases and each proof passage is clickable, allowing the proof passage to appear and disappear.

2.5 Executable code generator

We have implemented a code generator which takes a specification of a state machine and generates an executable code for JAVA. CafeOBJ/XML allows this tool to parse information of state transitions easily. A rule set for generating executable code is verified with CafeOBJ.
3 Future direction

Now, we plan the following research:

- Maude is a similar language to CafeOBJ and it has a good model checking tool. Although complex problem cannot be solved by model checking, it is useful to find counter examples. Therefore, developing a translator which translates a state machine written in CafeOBJ/XML to Maude is a good application of CafeOBJ/XML.

- We have learned from developing Gateau, generating proof scores can be manage more systematically. We plan that managing proof scores is implemented as an additional service of Buffet. This service makes easy developing proof assistants such as Gateau.

- All tools presented in this paper have character based interfaces. We plan to implement these tools on Eclipse which has a good GUI. Since Eclipse is very popular IDE (Integrated Development Environment), this plan makes a good opportunity to introduce our method to industrial society.
4 Publications

Refereed journal paper


Refereed Conference/Symposium/Workshop papers


Unrefereed Conference/Symposium/Workshop paper