Chapter 39
Fuzzy Labeled Transition Refinement Tree:
Application to Stepwise Designing Multi Agent Systems

Sofia Kouah
University of Constantine 2, Algeria & University of Oum El Bouaghi, Algeria

Djamel-Eddine Saidouni
University of Constantine 2, Algeria

ABSTRACT

This paper aims to provide a formal framework that supports an incremental development of dynamic systems such as multi agents systems (MAS). We propose a fuzzy labeled transition system model (FLTS for short). FLTS allows a concise action refinement representation and deals with incomplete information through its fuzziness representation. Afterward, based on FLTS model, we propose a refinement model called fuzzy labeled transition refinement tree (FLTRT for short). The FLTRT structure serves as a tree of potential concurrent design trajectories of the system. Also, we introduce bisimulation relations for both models in order to identify equivalent design trajectories, which could be assessed with respect to relevant design parameters.

INTRODUCTION

Nowadays, Multi Agent Systems (MAS for short) are omnipresent in computer science applications. This paradigm is used to resolve complex problems where reactivity, mobility, dynamicity and adaptation of the system to uncertain or unpredictable factors should be considered (Kouah, Saïdouni & Ilié, 2013). Then, the discipline of MAS engineering (i.e. specification, development, management and deployment … etc.) is becoming very important. It is concerned with models, methods and tools which are needed to develop MAS.

In the literature, several labors have been made-up to describe MAS, among others (Brazier, Dunin-Keplicz, Jennings & Treur, 1997; Caire et al., 2002; DeLoach, Wood & Sparkman, 2001; Demazeau, 1995; Ferber & Gutknecht, 1998; Jennings & Wooldridge, 1998; Fisher, 1994; Lind, 2001; Luck, Griffiths & d'Inverno, 1997; Marik, Müller & Pechoucek, 2003).However, they lack of an efficient methodology enabling designers to precisely built MAS with respect to its specification and dealing with almost MAS functionalities.

In fact, designing MAS needs both a specification model and an associated design methodology (Kouah et al., 2013). Concerning MAS specification models, several powerful formalisms have been proposed, such as Z-language (Regayeg, Kacem & Jmaiel, 2005), Petri nets (Celaya, Desrochers & Graves, 2007), colored Petri nets(ElFallah-Seghrouchni, Haddad & Mazouzi, 1999;Mazouzi, ElFallah-Seghrouchni & Haddad, 2002; Xu & Xie, 2011), recursive Petri nets (RPN for short) (Seghrouchni & Haddad, 1996), Maude (Mokhati, Boudiaf, Badri & Badri, 2007), Logic (Lomuscio & Sergot, 2003). As it has been clarified in (Kouah et al., 2013), these modeling approaches cannot deal with at least one of the following characteristics: abstraction and refinement, asynchronous aspects, synchronization between several processes. Accordingly, RPN has been extended to Synchronized Petri Nets model (SyPN for short). SyPN covers several functionalities of MAS such as: modeling abstraction and refinement, dynamicity, concurrency, preemption, recursion …etc.; enabling dynamic interactions between several Petri nets, preserving agents' proprieties specially autonomy and enabling modeling of both internal and collective behaviors of MAS (Kouah et al.,2013).

Regarding design methodology, the formal refinement paradigm is an effective way to safeguard several design properties. In fact, abstracting something away is needed to deal with system constraints and designer limitations in gathering MAS requirements. Thus, refinement is needed to develop MAS in an incremental manner where details are added gradually.

At each abstraction level, a collection of abstraction (i.e. agents, interactions, processes …etc.) may be arbitrarily detailed and unambiguous but at the same time still contains abstractions that enable designer comprehension. So, MAS behaviors are not necessary well known at some abstraction level. Consequently, we introduce an unknown or undefined behavior which will be noted ↻ .

Our aim is to provide a top-down refinement-based approach of MAS where SyPN formalism is adopted as MAS specification model. Before giving an overview about how this approach looks like, we point out that in this paper; the focus is on refinement process. We intend to define stepwise formal refinement model that support MAS design requirement that is an approximate and gradual behavior definition (i. e. uncertainty and refinement).

In top-down refinement-based approach, development starts from an initial specification of requirements (functional and nonfunctional), environmental constraints and potential architectures of the whole system or its parts. This abstract specification is written by means of SyPN model. After that, it is refined through several steps to reach a concrete description of MAS which can be translated to execution code. In this approach, verification of MAS is based on reachability graph generation from SyPN model. Such generation can be easily built by generating all possible firing sequences using SyPN operational semantics. In this graph, nodes represent MAS states, and edges represent transitions taking the MAS from one state to another. It can be seen as a labeled transition system (LTS for short) (Aceto & Hennessy, 1991).

Since LTS model is based on interleaving semantics in which actions are atomic. Atomicity property should be preserved after action refinement (the associated process is also atomic). The consideration of actions refinement under an interleaving semantics assumes that the semantics preserves the atomicity of transitions. To clarify these ideas let us consider the example of Figure 1:

Related Content

Optimizing Student Engagement in Online Learning Environments: Intuitionistic Fuzzy Logic in Student Modeling
Mukta Goyaland Rajalakshmi Krishnamurthy (2018). *Intelligent Systems: Concepts, Methodologies, Tools, and Applications (pp. 671-702).*
www.irma-international.org/chapter/optimizing-student-engagement-in-online-learning-environments/205803

An Enhanced Facial Expression Recognition Model Using Local Feature Fusion of Gabor Wavelets and Local Directionality Patterns
Sivaiah Bellamkondaand Gopalan N.P (2020). *International Journal of Ambient Computing and Intelligence (pp. 48-70).*
www.irma-international.org/article/an-enhanced-facial-expression-recognition-model-using-local-feature-fusion-of-gabor-wavelets-and-local-directionality-patterns/243447

Ranking Functions
Franz Huber (2009). *Encyclopedia of Artificial Intelligence (pp. 1351-1355).*
www.irma-international.org/chapter/ranking-functions/10415

Bayesian Networks for Image Understanding
Andreas Savaki, Jiebo Luoand Michael Kane (2007). *Bayesian Network Technologies: Applications and Graphical Models (pp. 128-150).*
www.irma-international.org/chapter/bayesian-networks-image-understanding/5499

Supporting Text Retrieval by Typographical Term Weighting
Lars Wernerand Stefan Böttcher (2007). *International Journal of Intelligent Information Technologies (pp. 1-16).*
www.irma-international.org/article/supporting-text-retrieval-typographical-term/2415