



UTM
UNIVERSITI TEKNOLOGI MALAYSIA

PROCEEDINGS OF THE

6th IGCESH 2016

INTERNATIONAL GRADUATE CONFERENCE
ON ENGINEERING, SCIENCE AND HUMANITIES



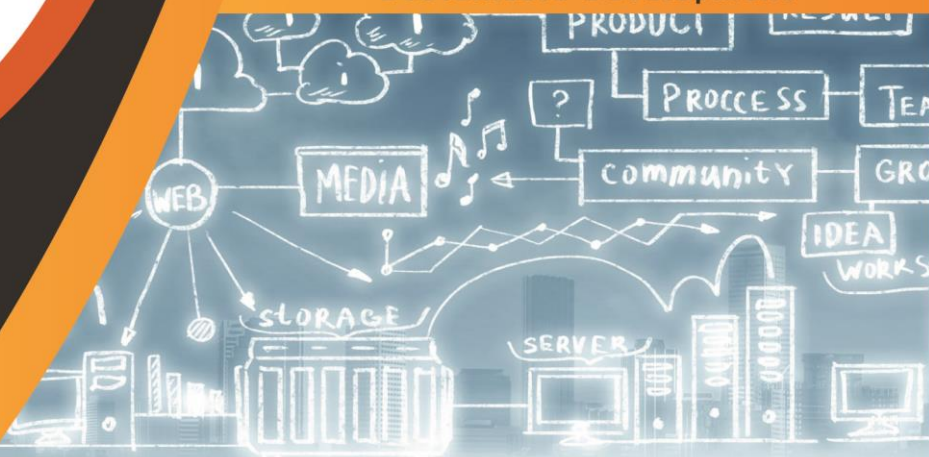
IGCESH 2016

**15-17
AUGUST 2016**

**BLOCK N24,
UNIVERSITI TEKNOLOGI
MALAYSIA,
UTM JOHOR BAHRU,
JOHOR, MALAYSIA**



**"Empowering Innovation and
Entrepreneurship for
Sustainable Development"**



innovative • entrepreneurial • global



6th International Graduate Conference on Engineering, Science
& Humanities
(IGCESH 2016)

CONFERENCE PROCEEDINGS

15th -17th August 2016

Organized by

UTM Postgraduate Student Society (PGSS-UTM)

In collaboration with

School of Graduate Studies,
Universiti Teknologi Malaysia

 Email: igcesh2016@utm.my

 Tel: [+607-5537903](tel:+607-5537903) (office)

 Fax: [+607-5537800](tel:+607-5537800)

 Website: sps.utm.my/igcesh2016

STRUCTURAL SUBCLASS OF PLACE-LABELLED PETRI NET CONTROLLED GRAMMARS: STATE MACHINE

N. Mohamad Jan*¹, W. H. Fong², N. H. Sarmin³ and S. Turaev⁴

^{1, 2, 3} Department of Mathematical Sciences, Faculty of Science, Universiti Teknologi Malaysia,
81310 UTM Johor Bahru, Johor, MALAYSIA.

(E-mail: nurhidayamj@gmail.com, fwh@utm.my, nhs@utm.my)

⁴ Department of Computer Science, Kulliyyah of Information and Communication Technology,
International Islamic University Malaysia, 53100 Kuala Lumpur, MALAYSIA.

(E-mail: sherzod@iiu.edu.my)

ABSTRACT

A place-labelled Petri net controlled grammar is, in general, a context-free grammar equipped with a Petri net and a function which maps places of the net to productions of the grammar. The languages of place-labelled Petri net controlled grammar consist of all terminal strings that can be obtained by parallel application of the rules of multisets which are the images of the sets of input places in a successful occurrence sequence of the Petri net. In this paper, we investigate the structural subclasses of place-labelled Petri net controlled grammar which focus on the state machine. We also establish the generative capacity of state machine of place-labelled Petri net controlled grammars.

Key words: Petri net, context-free, grammar, state machine

INTRODUCTION

In 1962, Carl Adam Petri first introduced the Petri net as a new model of information flow in systems [1]. This model provided an elegant and useful mathematical formalism for modeling concurrent systems and their behaviors. Petri net is a model with two sets of nodes called places and transitions based on the concepts of asynchronous and concurrent operation by parts of a system.

A Petri net controlled grammar is a context-free grammar equipped with a transition of Petri net and a function which maps transitions of the net to productions of the grammar [2]. Then, the language consists of all terminal strings that can be obtained by applying the sequence of productions which is the image of an occurrence sequence of the Petri net under the function. Several variants of Petri net controlled grammars have been introduced and investigated in [3-8].

For all variants of Petri net controlled grammars, the production rules of a grammar are associated only with transitions of a Petri net. Thus, it is also interesting to consider the place labelling strategies with Petri net controlled grammars. Theoretically, it

would complete the node labelling cases, i.e., we study the cases where the production rules are associated with places of a Petri net, not only with its transitions. Moreover, the place labelling makes possible the consideration of parallel application of production rules in Petri net controlled grammars, which allows formal language based models to be developed for synchronized/parallel discrete event systems.

Informally, a place-labelled Petri net controlled grammar is a context-free grammar with a Petri net and a function which maps places of the net to productions of the grammar [9]. The language consists of all terminal strings that can be obtained by parallel application of the rules of multisets which are the images of the sets of the input places of transitions in a successful occurrence sequence of the Petri net.

MAIN RESULTS

In this section, we establish the generative power of state machine structural subclass of place-labelled Petri net controlled grammars. Lemma 1 shows the inclusion properties of free, λ -free and arbitrary place-labelled Petri net controlled grammars.

Lemma 1

For $y \in \{r, t\}$, $pSM^{[\lambda]}(f, y) \subseteq pSM^{[\lambda]}(-\lambda, y) \subseteq pSM^{[\lambda]}(\lambda, y)$.

Further, we show that the state machine of Petri net is a subset of state machine of place-labelled Petri net controlled grammars.

Lemma 2

For $x \in \{f, \lambda, -\lambda\}$ and $y \in \{r, t\}$, $SM(x, y) \subseteq pSM(x, y)$.

CONCLUSION

In this research, we investigated the structural subclasses of place-labelled Petri net controlled grammar which focus on the state machine. The first lemma shows the inclusion properties of free, λ -free and arbitrary place-labelled Petri net controlled grammar. We also showed that state machine of Petri net is a subset of state machine of place-labelled Petri net controlled grammars, in order to increase the generative power of place-labelled Petri net controlled grammars.

Acknowledgment: The first and third authors would like to thank the Ministry of Higher Education (MOHE) and Research Management Centre (RMC), Universiti Teknologi Malaysia (UTM) for the financial funding through Fundamental Research Grant Scheme Vote No. 4F590. The second author would also like to thank UTM for the UTM Zamalah Scholarship. Also, the fourth author would like to thank MOHE and International Islamic University Malaysia (IIUM) for the financial funding through Endowment B Fund EDW B13-053-0983.

REFERENCES

1. Petri, C.A. Kommunikation mit Automaten. University of Bonn, Ph.D. Thesis, 1962.
2. Turaev, S. Petri net controlled grammars. Universitat Rovira I Virgili, Ph.D. Thesis, 2010.
3. Dassow, J. and Turaev, S. Arbitrary Petri net controlled grammars. In Proceedings of Linguistics and Formal Languages, Second International Workshop on Non-Classical Formal Languages in Linguistics (2008), 27-39.
4. Dassow, J. and Turaev, S. Petri net controlled grammars: The power of labeling and final markings. *Romanian Journal of Information Science and Technology* 12 (2009), 191-207.
5. Dassow, J. and Turaev, S. k -Petri net controlled grammars. In Proceedings of Language and Automata Theory and Applications, Springer-Verlag (2008), 209-220.
6. Dassow, J. and Turaev, S. Petri net controlled grammars with a bounded number of additional places. *Acta Cybernetica* 19 (2010), 609-634.
7. Stiebe, R. and Turaev, S. Capacity Bounded Grammars and Petri Nets. In Proceedings Eleventh International Workshop on Descriptive Complexity of Formal Systems, Otto-von-Guericke University of Magdeburg Publisher (2009), 193-203.
8. Stiebe, R. and Turaev, S. Capacity Bounded Grammars. *Journal of Automata, Languages and Combinatorics* 15 (2009), 175-194.
9. Mohamad Jan, N. and Turaev, S. and Fong, W. H. and Sarmin, N. H. A New Variant of Petri Net Controlled Grammars. In AIP Conference Proceedings of the 22th National Symposium on Mathematical Science, American Institute of Physics 1682 (2015), 040015 1-11.