

# On Homogeneous Spiking Neural P System Variants

Ren Tristan A. de la Cruz<sup>1</sup>, Francis George C. Cabarle<sup>1,2</sup>, Iva Cedric H. Macababayao<sup>1</sup>, Henry N. Adorna<sup>1</sup>, and Xiangxiang Zeng<sup>3</sup>

<sup>1</sup>Algorithms and Complexity Laboratory

Department of Computer Science, University of the Philippines - Diliman  
Diliman 1101, Quezon City, Philippines

<sup>2</sup>Shenzhen Research Institute of Xiamen University  
Xiamen University, Shenzhen 518000, Guangdong, China.

<sup>3</sup>School of Information Science and Engineering  
Hunan University 410082, Changsha, China  
radelacruz@up.edu.ph, fccabarle@up.edu.ph, ivan.cedric10@gmail.com,  
hnadorna@dcs.upd.edu.ph, zxxhust@gmail.com

**Abstract.** (ABSTRACT)

**Keywords:** Membrane Computing, Spiking Neural P Systems, Homogeneous Neurons, Structural Plasticity

## 1 Introduction

## 2 Spiking Neural P System and Some Variants

## 3 Homogenization of Spiking Neural P Systems

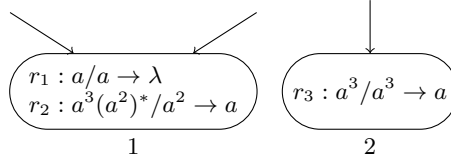
A *state transition diagram* will be used to represent the activities of a neuron. A *state* is a set of spike counts. For example, the state  $\{4, 5\}$  represents spike counts 4 and 5, the state  $\{0, 2, 4, 8, \dots\}$  represents even spike counts, and the state  $\{15, 20, 25, 30, 35, \dots\}$  represents spike counts that are multiples of 5 starting from 15.

If a neuron has  $n$  spikes, the neuron is said to be *in state*  $S$  if  $n \in S$ . For example, let  $n = 10$  be the number spikes in the neuron and  $S_a = \{1\}$ ,  $S_b = \{2, 4, 9, 10, \dots\}$ ,  $S_c = \{5, 10, 15, 20, \dots\}$  be states, the neuron is not in state  $S_a$  since  $n \notin S_a$  but it is in state  $S_b$  and  $S_c$  since  $n \in S_a$  and  $n \in S_b$ . States can intersect since they are sets which means a neuron can be in multiple states at the same time.

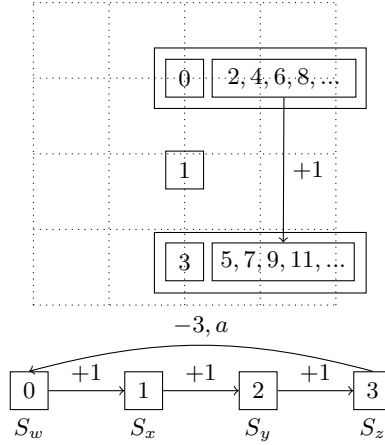
Most states that are associated with a given neuron represent the regular expressions of the rules in the neuron. For example, in Figure 1, neuron 1 have the rules  $r_1 : a/a \rightarrow \lambda$  and  $r_2 : a^3(a^2)^*/a^2 \rightarrow a$ . The state  $S_a = \{1\}$  represents the regular expression  $a$  of rule  $r_1$  while the state  $S_b = \{3, 5, 7, 9, 11, \dots\}$  represents the regular expression  $a^3(a^2)^*$  of rule  $r_2$ . The state  $S_c = \{0, 2, 4, 6, 8, \dots\}$ , the set

of even spike counts, is also associated with neuron 1 even though it does not represent a regular expression of any of the rules in neuron 1. State  $S_c$  is relevant to neuron 1 because neuron 1 can be in state  $S_c$ . For example, if neuron 1 starts with 0 spike and only receives even number of spikes, then neuron 1 will stay in state  $S_3$ .

For neuron 2 in Figure 1, it has the single rule  $r_3 : a^3/a^3 \rightarrow a$  which means  $S_z = \{3\}$  is associated with the neuron and it represents the regular expression  $a^3$  of rule  $r_3$ . Neuron 2 only has one incoming synapse so it can only receive one spike at a time assuming the use of non-extended/standard spiking rules. The only other relevant states for neuron 2 are  $S_w = \{0\}$ ,  $S_x = \{1\}$ ,  $S_y = \{2\}$ . If neuron 2 starts with 0 spike, it will be state  $S_w$ . Neuron 2 will be in state  $S_x$  after receiving a spike, in state  $S_y$  after receiving a total of 2 spikes, and in state  $S_z$  after receiving a total of 3 spikes. At state  $S_z$ , neuron 2 will use rule  $r_3$  consuming 3 spikes and returning to state  $S_w$ . Only states  $S_w, S_x, S_y, S_z$  are relevant to neuron 2 since it can only reach the spike counts in those states.



**Fig. 1.** Example Neurons



**Fig. 2.** Example Neurons

## References