1. Authors:

Ju Hui Li
Centre for Integrated Circuits & Systems, S2.1-B3-01, School of Electrical & Electronic Engineering,
Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798
Tel: +65-67906507, E-mail: pg01896341@ntu.edu.sg

Meng Hiot Lim
School of Electrical & Electronic Engineering, Block S1, Nanyang Technological University, Singapore 639798
Tel: +65-67905408, E-mail: emhlim@ntu.edu.sg

Qi Cao
Centre for Integrated Circuits & Systems, S2.1-B3-01, School of Electrical & Electronic Engineering,
Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798
Tel: +65-67906507, E-mail: pg04780942@ntu.edu.sg

2. "Evolvable Fuzzy Hardware for Real-Time Embedded Control for Packet-Switching", to appear on book series on Intelligent Systems Engineering published by Springer-Verlag.

Abstract: In this chapter, we describe a scheme to realize an *evolvable fuzzy hardware* (EFH) for real-time packet switching problem. The common challenges of *evolvable hardware* (EHW) implementation are issues pertaining to *online adaptation*, *scalability* and *termination of evolution*. The proposed EFH addresses these issues effectively. A very interesting advantage of the proposed EFH is that the system performance can be tuned intuitively through parametric adjustment of the fitness function. This advantage gives the EFH system a very special property that conventional scheduling methods cannot fulfill easily. For the hardware implementation of the EFH, real-time fuzzy inference with high-speed context switching capability is necessary. We address this aspect through implementation based on a context independent *reconfigurable fuzzy inference chip* (RFIC).

3. Statement

Our objective is to implement evolvable hardware system that is able to carry out online real-time evolution. We address this challenge through evolvable fuzzy hardware, a symbiotic marriage of real-time fuzzy systems and evolutionary algorithm. For the purpose of demonstration, we apply EFH on the control of ATM cell scheduling to achieve Quality of Service (QoS) balance between two input channels.

Dynamic cell scheduling is an important aspect of bandwidth management for communication network. FIFO (first-in first-out) is a very traditional scheme for addressing the scheduling problem. Due to its ease of implementation and good balance among the flows in terms of arrival time, it has been widely used. The disadvantage of FIFO is that it is a fixed scheme.

DWPS (dynamic weighted priority scheduling) on the other hand is an alternative that is a modification from static priority scheme. It can trace the flow patterns and adjust the priorities for different cell flows. Thus it delivers good flexibility and balance in terms of QoS (quality of service). Although QoS of DWPS can be tuned parametrically, the process of tuning to achieve the desired QoS is not explicit.

With our contribution in the form of EFH (evolvable fuzzy hardware), we provide a means of tuning the QoS in a flexible and intuitive manner.

The most significant advantage is that the QoS tuning process is very straightforward. It is also tunable to a very wide range. The flexibility of EFH is embedded in the fitness function of the evolutionary engine. The extent of flexibility is such that the performance of the system can even be adjusted to approach that of the different traditional schemes. Through our work here, we have shown an effective way of combining real-time fuzzy system and evolutionary algorithm. Furthermore, it addresses some of the pertinent implementation issues of real-time online evolvable hardware.

Referring to the eight criteria for establishing that an automatically created result is competitive with a human-produced result, the creation of the EFH system satisfies the following three of the eight criteria:

(E) The result is equal to or better than the most recent human-created solution to a long-standing problem for which there has been a succession of increasingly better human-created solutions.

(F) The result is equal to or better than a result that was considered an achievement in its field at the time it was first discovered.

(G) The result solves a problem of indisputable difficulty in its field.