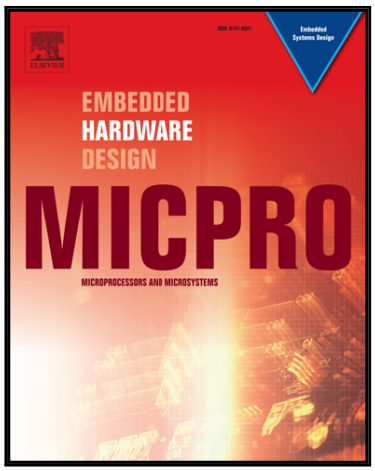

Minimizing the System Impact of Router Faults by Means of Reconfiguration and Adaptive Routing

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Minimizing the System Impact of Router Faults by Means of Reconfiguration and Adaptive Routing

Junshi Wang, Masoumeh Ebrahimi, Letian Huang, Qiang Li, Guangjun Li, Axel Jantsch

***Abstract*—To tolerate faults in Networks-on-Chip (NoC), routers are often disconnected from the NoC, which affects the system integrity. This is because cores connected to the disabled routers cannot be accessed from the network, resulting in loss of function and performance. We propose *E-Rescuer*, a technique offering a reconfigurable router architecture and a fault-tolerant routing algorithm. By taking advantage of bypassing channels, the reconfigurable router architecture maintains the connection between the cores and the network regardless of the router status. The routing algorithm allows the core to access the network when the local router is disabled.**

Our analysis and experiments show that the proposed technique provides 100% packet delivery in 100%, 92.56%, and 83.25% of patterns when 1, 2 and 3 routers are faulty, respectively. Moreover, the throughput increases up to 80%, 46% and 34% in comparison with FTLR, HiPFaR, and CoreRescuer, respectively.

***Index Terms*—Reconfigurable router architecture, Bypassing channels, Adaptive routing algorithm.**

I. Introduction

To detect and tolerate faults on the control paths of the routers, it is very common to isolate routers from the running NoC temporarily or permanently. However, it disturbs the integrity of the system and is not always necessary. Routers might be disabled for different reasons. In [1], the router under test (RUT) is disabled from the network for on-line testing, and thus packets have to be blocked in the neighboring routers until the testing procedure is completed. As another example, the router with faulty units (such as arbiters) may be abandoned if no other method has been applied to tolerate faults [2,3]. Every router has the probability to be faulty or abandoned, and all of them should be tested as well. RUTs and abandoned routers may block the communication between the core and the rest of the network. Moreover, the entire system may be stopped due to data dependency and coherency.

NoCs provide inherent path redundancy and a fault-tolerant infrastructure [4]. Fault-tolerant routing is an effective solution to tolerate disabled links and routers by reconfiguring paths. Different techniques are exploited to equip NoCs with fault tolerance [2]. Fault-tolerant routing algorithms including Dynamic Routing Protocol for NoCs (DR-NoC) [5], Fault-on-Neighbor (FoN) [6], Q-Learning based routing [7], Simple Flooding Algorithm, Directed Flooding Algorithm, and Redundant Random Walk Algorithm [8] can be executed in NoCs to bypass the disabled areas. The basic assumption behind these methods is that the core is disabled if the local router is disabled. However, this is not always necessary and may have a severe impact on the functionality of the entire system or its performance.

In our previous work [9], we introduced a routing algorithm, *CoreRescuer*, which keeps alive the core connected to a disabled router (either because of faults or testing the router). The disabled router is reconfigured to act as a bypassing router, maintaining the connectivity between the routers in the horizontal and vertical directions. The main features of the CoreRescuer algorithm are as follows:

1) Cores continue to be connected to the network when their local routers are disabled.
2) An adaptive fault-tolerant routing algorithm is utilized which supports the access of the cores through bypassing channels.
3) CoreRescuer can tolerate disabled routers. Also, the faulty units in routers can be bypassed. However, faults on links are not covered.

In this paper, we propose an enhanced mechanism for the mesh topology, called *E-Rescuer* advancing the features of CoreRescuer as follows:

1) The effect of the disabled router has been limited to a 3×3 area whereas a *fully* adaptive routing algorithm is applied to the rest of the network. Note that in this context *fully* means all available minimal paths. The proposed idea results in the performance improvement of up to 33% over CoreRescuer. This observation highlights the importance of adaptivity in maintaining the network performance when faults are presented. The paper includes a complete Pseudo-code, showing the simplicity of the algorithm.
2) Our analysis provides precise reliability values. The obtained values are compared with experimental results, leading us to an observation that the commonly used traffic pattern, uniform traffic, overestimates reliability values as it does not necessarily identify all possible deadlock scenarios.

Also, we employ a bypassing channel, introduced in [9], and demonstrate that it improves performance and reduces hop count because the disabled router offers shortcut channels.

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