A Centralized Token-based Medium Access Control Mechanism for Wireless Network-on-Chip

Ayodeji Ireti Fasiku
School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia
Johor, Malaysia
fasiku@graduate.utm.my

Olagoke Oladokun
Chemical Engineering Department
Faculty of Engineering
Covenant University
Ota, Nigeria
gokeoladokun@gmail.com

Shahrizal Rusli, M. N. Marsono
School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia
Johor, Malaysia
(shahrizalr, mnadzir)@utm.my

2021 International Conference on Artificial Intelligence and Computer Science Technology (ICAICST) | 978-1-6654-2404-2/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICAICST53116.2021.9497802

***Abstract*—In wireless network-on-chip (WiNoC), the average network latency and the energy consumption increase partly due to congestion experienced in the wireless medium. Hence, a suitable, dynamic, and efficient medium access control (MAC) mechanism is required to enhance wireless channel utilization. This study proposes a Centralized-MAC (C-MAC) mechanism that allocates tokens to wireless medium based on radio-hub (RHs) with most packets in each cycle. The proposed method enhances network throughput, reduces latency and energy consumption of the WiNoC compared with existing methods. The simulation experiments show that C-MAC performs better than the conventional method and radio access control mechanism (RACM) in average latency, throughput, and energy. C-MAC shows up to 37% and 11% improvement in throughput on the synthetic traffic patterns over conventional method and RACM.**

Keywords — C-MAC, Token-passing, Network-on-Chip, Wireless interconnect

I. Introduction

The emerging WiNoC integrates wireless backbone placed on top of the traditional wired-based NoC to provide high scalability [1]. Combining NoC with on-chip miniature wireless antennas that operate in the mm-wave bands [2], enhances the communication with faraway cores by replacing the long-distance multi-hop communication with single-hop wireless links [3]. The WiNoC architecture improves system bandwidth, enhances a high throughput, reduces latency in data communications, and low power consumption [4].

The medium access control (MAC) in WiNoC coordinates radio-hub communication to effectively utilize the wireless medium resources [5]. Most of the WiNoC architectures employ simple token-passing MAC mechanism techniques [6]. Tokens are passed on radio hubs (RHs) which are organized in a virtual ring (round-robin arbiter), and packets are transferred within a fixed duration of time [2], [7]. The RH with a token can use the wireless channel to transfer packets to any RH in one hop [8]. The limitation of the conventional method MAC mechanism is that the token can be allocated to RH that has no packets to transmit, resulting in low latency and energy wasting. To ensure better utilization of wireless medium, efficient transmission based on most packets in a cycle can improve the overall WiNoC performance [9].

This paper proposes a Centralized MAC (C-MAC) for WiNoC architectures that would improve communication efficiency, enhances network throughput, and reduce latency and energy consumptions in the system. The main contributions of this paper are as follow:

1) We propose a new arbitration technique that can maintain good fairness among the radio hubs.
2) The C-MAC mechanism prioritizes RH with the most packets to transmit.
3) The performance evaluations of the proposed method using various synthetics traffic patterns and application traces (SPLASH-2 and PARSEC). Our simulation results show that the proposed technique improves network performance.

The rest of this paper is structured as follows. Section II reviews the related works. Section III presents the proposed Centralized-MAC mechanism. Section IV is the results and discussion. The conclusion of the paper is in Section V with recommendations for future works.

II. Related Work

An effective MAC is required to guarantee quick access to the on-chip wireless communication channel in WiNoC. The design of an efficient, low-overhead and fair MAC mechanism is considered one of the critical challenges for WiNoC performance [10]. Hence, the MAC mechanism is responsible for ensuring efficient wireless bandwidth utilization by managing wireless channels among the radio hubs.

MAC techniques are unique to the multiprocessor interconnection, and it is responsible for scalable, fast, and efficient data flow control and multiplexing for the transmission medium [11]. Carrier Sense Multiple Access (CSMA) [7], [12] is a MAC mechanism based on sensing the medium before transmitting. Its limitation is the delay experienced when sensing whether or not the shared transmission channel is busy and defers communications until the channel becomes accessible. The Code Division Multiple Access (CDMA) [13] is based on the MAC protocol, allowing RHs to communicate in parallel, though its performance degrades as the number of cores increases in the system. The CDMA-based MAC mechanism requires overhead for maintaining synchronization and maintains orthogonality between code channels, hence these MAC mechanism makes transceiver design extremely difficult.

Many WiNoC architectures use a simple token-passing MAC mechanism [2], [7]. The token mechanism in WiNoC circulated in all the RHs regardless of whether the wireless medium needs it. The token-based MAC is better because it is only a core that holds the token, can access the wireless medium for a specific period of time. The token moves in the network in a daisy chain ring. [14]. The daisy chain is problematic because it has to follow a pre-defined order. Hence an effective MAC would be required to enhance the token-based MAC performance by adjusting the order of RHs in WiNoC.

The round-robin (RR) algorithm is a well-known arbitration mechanism that can guarantee fair scheduling and sharing of tokens in the RH [15]–[17]. The RR arbiter functions well under uniform traffic loads. It is not flexible enough for customized applications and distributed traffic loads, especially when packets generated vary. The maximum hold cycle (MHC) is the pre-defined time for each RH to hold the token. In a wireless medium, MHC is statically determined and remains the same, regardless of the traffic conditions; either the i-th radio hub has packets to transmit or not. The diagram in Fig.1 shows the conventional RR 64-cores (8x8) WiMesh architecture embodied with 8-RHs.

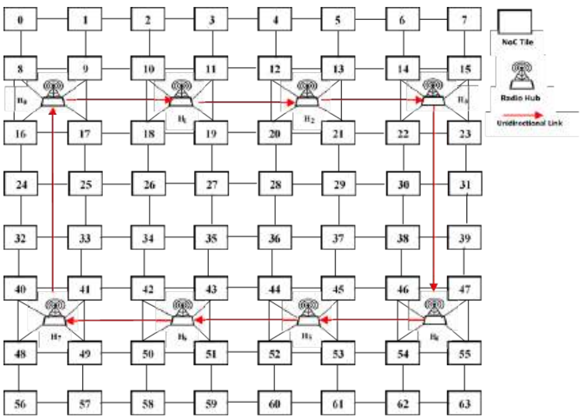


Figure 1: Conventional RR WiMesh Architecture

Some recent works [3], [7], [18], [19] proposed dynamic token MAC techniques that can dynamically and efficiently adjust the transmission or time slots of each token depends on a demand prediction estimated by the RH (that are usually considered in daisy-chained ring topology). Mansoor *et al.* [15] proposed a dynamic MAC mechanism that allocates time slots based on the predicted bandwidth requirement of the RH. Also, based on the predicted bandwidth demand, the token time can be adjusted. Palesi *et al.* [20] also proposed a dynamic Radio Access Control Mechanism (RACM). The RACM redistribute the unused clock cycles among the RHs that had fully used the radio channel in the previous count cycle. Mansoor *et al.* [3] improved the work in [15] by developing a low complexity and reliable traffic control mechanism that predicts a RH traffic demand. They proposed a dynamic MAC mechanism that can adjust the slot durations based on the predicted RH traffic demand.

Wang *et al.* [21] proposed a lottery-based dynamic priority arbiter. In every clock cycle, the arbiter detects a high number of input ports, then adjusts the priority of each input port dynamically, and authorizes one input port to transmit data using the lottery method. Also, Ouyang *et al.* [16] proposed Priority-based MAC mechanisms with the Central Control Unit (CCU) that ensure efficient utilization of WiNoCs based on the length of the transmitted packets of data. The CCU determines the priority of each RH before distributing the privilege to use the wireless medium. Rad *et al.* [22] proposed a crossbar switch arbitration mechanism that can accurately assign port priorities based on recent load demand and wireless channel bandwidth. This work adjusts the dynamic priority for each input of the RH based on the current network status and the data packet length. These works are based on first in, first out (FIFO) and did not put into consideration the RH that needs the token most in each cycle.

Therefore, to improve wireless channel access in WiNoC, a C-MAC mechanism is required to allocate tokens based on RH with the most packet in each round. The proposed C-MAC mechanism was designed to adjust the token in the RHs based on RH with the most packets rather than following the round-robin technique.

III. The proposed Centralized MAC (C-MAC) mechanism

The wireless channel is integrated into the NoC to serve as a shortcut for a long-haul transmission in WiNoC. Thus, a suitable MAC approach is required to ensure that wireless resources are effectively exploited in WiNoC to improve network performance. The existing RR mechanism is a daisy chain format, in which tokens were moved in a ring from one RH to another, and each RH uses the token for a specific MHC. The demerit of RR is that each RH in the cycle holds the token for the same period of time, including RHs that has no packet to transmit in that cycle. Hence, limit the system efficiency and take a longer time to complete the cycle. To ensure better utilization of wireless medium in WiNoC, we propose C-MAC, which allocates tokens to RHs based on RH with the most packets in each cycle to improve the overall WiNoC performance.

The C-MAC was designed to eliminate the time-wasting in the conventional methods that involve token passing from one RH to another; either it has packets to transmit, or it did not have any packet for transmission. The proposed method would select the RH with the most packets in the cycle and dynamically authorizes the wireless medium's user rights to use the token for a specific MHC, hence improves the system performance. The MHC is assigned to the generic i-th RH for using the wireless medium when it owns the token and remains the same, irrespective of the RH state.

The pseudocode designed for implementing the proposed C-MAC is summarized in Algorithm 1. Fig. 2 sketches 64-

cores (8*8) WiMesh architecture embodies with an 8-radio hub (2*4), though 64-cores with 16-radio hubs (4*4) was used for the design. The interface of the proposed C-MAC module implementation is shown in Fig. 3. It is connected to the RH signal, namely request, grant, and hold. The RH's input request signal is asserted when it wants to access the wireless medium and wait for a grant. The hold input signal is asserted as soon as it gets the grant output, hence initiated packets transmission in the allocated RH, and the grant output is kept high. The maximum number of a cycle does not exceed the MHC. When the input hold is reset, the MHC elapsed, then the C-MAC assigns a token to the next RH with the most packets in the cycle.

Algorithm 1: Proposed C-MAC Mechanism

```
Input: RH_T, RH_i, RH_R, packet, is_token_RH
Output: Token
CMAC = {}
While (is_ token_RH)
    for ∀ RHi ∈ RH_T
        RH_R = RH_T - CMAC
        for ∀ RHi ∈ RH_R
            Choose RH_i with most packet
            Assign Token to RH_i
        end for
        Add RH_i to CMAC
        if RH_R = 1
            CMAC = {}
        end if
    end for
end while
```

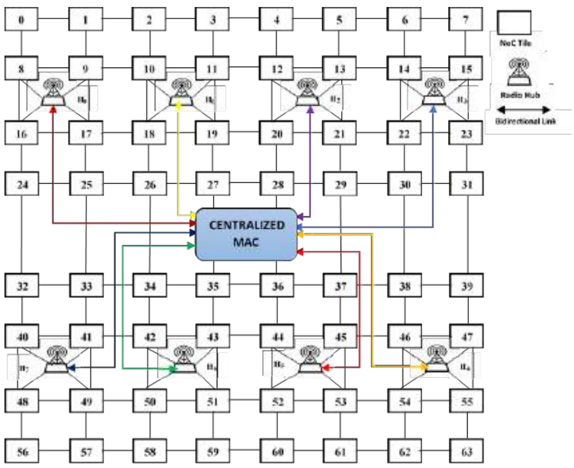


Figure 2: C-MAC WiMesh Architecture

In Algorithm 1, the RH_i is the counter for RH in the cycle, and RH_T is the total radio-hubs set in the cycle. The remaining RHs in each cycle to receive the token are stored in RH_R, and is_token_RH initiates a C-MAC mechanism for wireless medium communication. The C-MAC scheme in Fig. 4 shows the C-MAC block structure, which contains a Hubs-Cycle module, and how RH communicates with the C-MAC. This

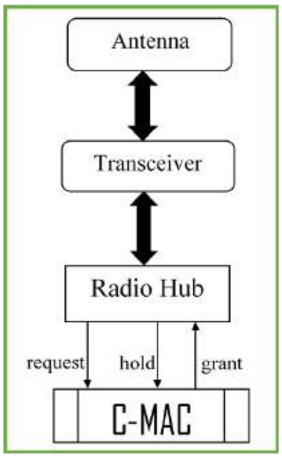


Figure 3: Interface of the proposed C-MAC module

block diagram shows the basic operation of the proposed C-MAC. At first, all the RH will pass through the Hub-Cycle because non have received the token, and it is set initially to zero. Then, the C-MAC compares all the RH checks for the RH_i with most packets and assigns tokens to it. When the RH_i completed its MHC_i, the particular RH information will be stored in the hub-cycle module until all the RHs have received the tokens.

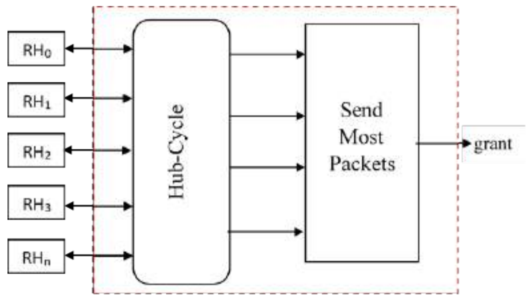


Figure 4: The C-MAC Scheme

In the next round, any RH that has received a token in the previous cycle will stop at the Hub-Cycle module, and only the RH that has not received the token will get to C-MAC. Thus, the number of RHs to be compared in C-MAC will be reduced as the simulation progresses, and lesser time will be required to select the RH with the most packets. Hence, this improves the overall system performance and ensures full utilization of wireless resources in WiNoC. When RH_R is set to 1, the Hub-Cycle will be initialized again. This procedure will continue until the end of the simulation, as indicated in the simulation setup.

IV. Results and Discussion

A. Simulation Setup

C-MAC was simulated using a cycle-accurate network-on-chip simulation [17] that allows one to estimate system performance. We use 16-RHs (4*4) deployed over a conventional wired mesh-based architecture with 64-cores (8*8). Wormhole switching mechanism [23] was adopted for both wired and wireless links. To provide a deadlock-free shortest path routing in mesh architecture, we adopted dimension order XY-routing [24]. The C-MAC is located in the center of the topology for authorizing RHs to use the wireless medium. The wireless NoC topology used for this research is shown in Fig. 2. The simulation runs for 100,000 clock cycles and with the first 1,000 warmup cycles. The simulations were repeated ten times, and the results were averaged for better accuracy.

The simulation parameters used for this research are summarized in Table I, the results, and analysis in Section IV-B. The traffic distribution used in this experiment are; Random, Hotspot, Shuffle, and Transpose traffic models for the synthetic traffic. While the Fluidanimate, Blackscholes, Freqmine, and Swaption traffic models for application traffic (SPLASH-2 and PARSEC) to validate the performance of C-MAC.

Table I: SIMULATION SETUP

PARAMETER	DESCRIPTION
Network Sizes	8*8 (64 cores)
Number of Radio Hub	4*4
Synthetic Traffic Distribution	Hotspot, Random, Shuffle, and Transpose
Application Traffic Distribution	Fluidanimate, Blackscholes, Freqmine, and Swaption
Number of Channels	1
Simulation_Time Cycles	100 000
Technology	65 nm
Clock Frequency	1 Ghz
Switching Mechanism	Wormhole
Radio Access Control	Conventional Token Ring, RACM, Propose C-MAC
Selection Strategies	Random
Flit Size	32 bits
Routing Algorithm	XY
Wireless Data Rate	16Gbps
Wireless Communication	Millimeter-Wave

B. Results and Analysis

This section compares the proposed C-MAC mechanism with the conventional method [25] and RACM mechanism [20]. The metrics used for evaluation in this paper are; network throughput, average network latency, and energy consumption. The data rate in bits per second that a network allows per input port is known as throughput. Latency is the amount of time it takes for a packet to access the network, from the time the head of the packet arrives at the input port to the moment the tail of the packet departs the output port. It is measured as the number of clock cycles it takes to send a single packet from source to destination. The total energy in WiNoC is the average energy (which includes both switch and link energy) needed to transit a complete packet from source to destination.

In this experiment, the WiNoC simulator models the progress of the data flits accurately per clock cycle accounting for those flits that reach the destination and those stalled. Fig. 5a–d and 7a are the synthetic traffic distributions of the average network latency, and energy consumption simulated results, while network throughput is shown in Table II. We observed from the simulation results that the C-MACs algorithm has a lower average delay at a varying packet injection rate (PIR) than the conventional method and RACM mechanism. It is mainly due to the proposed algorithm reducing the time taken to complete the radio hub circle by centrally control token allocation to each RH and allocating tokens to RHi with the most packets in each cycle.

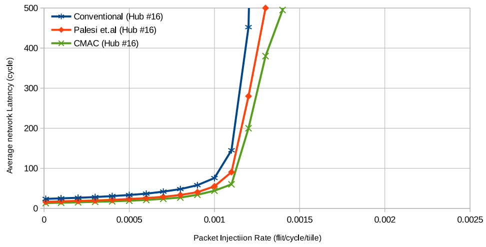
The network throughput increases with an increase in packet injection rate. An increase in unsuccessful packet delivery leads to lower throughput and degraded system performance. The proposed mechanism leads to lower contention among the input ports of the RHs, hence reduces the dynamic power consumption. The proposed method consumes less energy than the conventional method and RACM due to better wireless links and less contention of the input ports. Hence, the proposed mechanism in WiNoC has a better performance than RR MAC and RACM mechanisms. The proposed C-MAC mechanism shows more advantages on efficient decision-making over the conventional method and RACM mechanism. The proposed C-MAC shows better performance on the synthetic traffic patterns, at an average of 37% throughput improvement than the conventional method and 11% compared to RACM, while it has average network latency at 12.75% compared to the conventional method and 6.25% compared to RACM.

Table II: Network throughput of the 8*8-core with 16_RHs under Synthetic traffic patterns

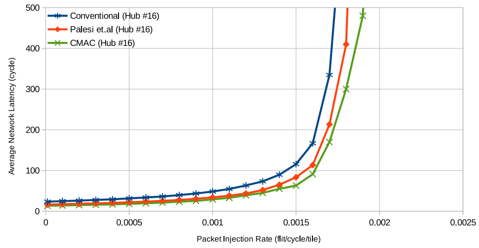
Traffic Patterns	PIR	CM	RACM	CMAC
Hotspot	$1 * 10^{-5}$	0.005	0.007	0.007
	$1 * 10^{-4}$	0.051	0.063	0.069
	$1 * 10^{-3}$	0.511	0.634	0.683
	$2 * 10^{-3}$	0.628	0.779	0.842
Random	$1 * 10^{-5}$	0.005	0.006	0.007
	$1 * 10^{-4}$	0.050	0.063	0.068
	$1 * 10^{-3}$	0.509	0.633	0.686
	$2 * 10^{-3}$	0.930	1.150	1.238
Shuffle	$1 * 10^{-5}$	0.005	0.007	0.007
	$1 * 10^{-4}$	0.051	0.063	0.068
	$1 * 10^{-3}$	0.515	0.635	0.681
	$2 * 10^{-3}$	0.941	1.165	1.256
Transpose	$1 * 10^{-5}$	0.005	0.006	0.007
	$1 * 10^{-4}$	0.051	0.064	0.068
	$1 * 10^{-3}$	0.514	0.633	0.684
	$2 * 10^{-3}$	1.020	1.268	1.360

PIR = Packet Injection Rate, RACM = Radio Access Control Mechanism, CM = Conventional Method, CMAC = Centralized Medium Access Control

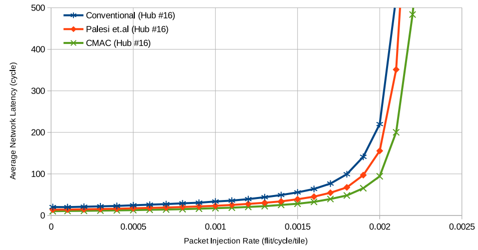
The PARSEC and SPLASH-2 application traffic distributions for an average latency simulation results are shown in Fig. 6a-b. Fig. 7b is the energy consumption, and the network throughput is shown in Table III. The application traffic has a similar output traffic pattern because GEM5 was used to generate it. The placement of task to cores is fixed with a fixed distance between source and destination. The simulation results show that the C-MACs algorithm has a lower average delay at varying PIR than the conventional method and RACM algorithm. The proposed method increases the network throughput, and the higher the throughput in the network, the more effective the system will perform.



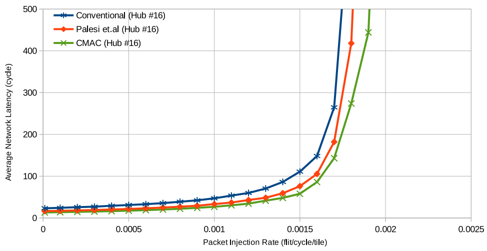
(a) Hotspot Traffic



(b) Random Traffic



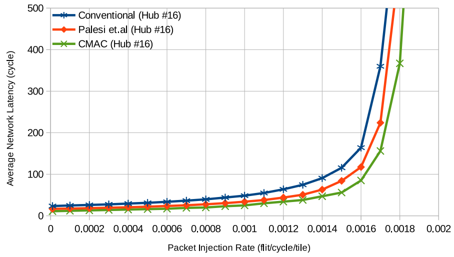
(c) Transpose Traffic



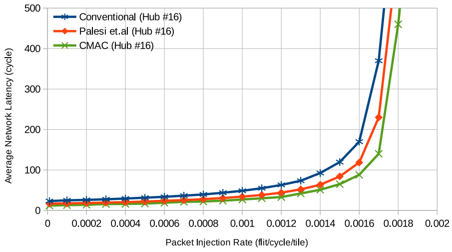
(d) Shuffle Traffic

Figure 5: Average Latency of the 8*8-core with 16_RHs under Synthetic traffic patterns

The diagram in Fig. 7b shows that the C-MAC uses less energy than the conventional method and RACM mechanism. Thus the lower the energy consumption in any system design, the better the power characteristic in the system architecture. This improvement is due to the proposed algorithm centrally controls token allocation to each RH. Hence, the proposed mechanism in WiNoC has better performance than the conventional method and RACM mechanism. The proposed C-MAC performance improvement on application traffic patterns is at an average of 33% throughput improvement compared to the conventional methods and 8% compared to RACM, while it has average network latency of 11% compared to the conventional method and 5% compared to RACM.



(a) Blackscholes Traffic



(b) Fluidanimate Traffic

Figure 6: Average Latency of the 8*8-core with 16_RHs under Application traffic patterns

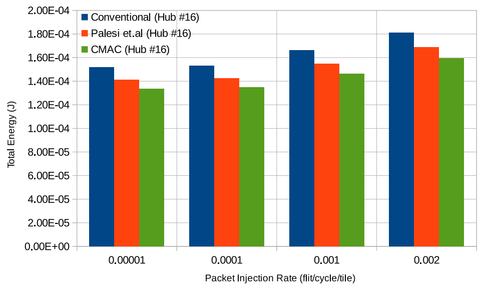
Table III: Network throughput of the 8*8-core with 16_RHs under Application traffic patterns

Traffic Patterns	PIR	CM	RACM	CMAC
Blackscholes	$1 * 10^{-5}$	0.005	0.006	0.007
	$1 * 10^{-4}$	0.051	0.062	0.069
	$1 * 10^{-3}$	0.511	0.633	0.683
	$2 * 10^{-3}$	0.931	1.149	1.238
Fluidanimate	$1 * 10^{-5}$	0.005	0.006	0.007
	$1 * 10^{-4}$	0.052	0.063	0.069
	$1 * 10^{-3}$	0.514	0.632	0.682
	$2 * 10^{-3}$	0.932	1.148	1.239
Freqmine	$1 * 10^{-5}$	0.005	0.007	0.007
	$1 * 10^{-4}$	0.051	0.064	0.069
	$1 * 10^{-3}$	0.509	0.633	0.681
	$2 * 10^{-3}$	0.930	1.150	1.239
Swaption	$1 * 10^{-5}$	0.005	0.007	0.007
	$1 * 10^{-4}$	0.051	0.064	0.068
	$1 * 10^{-3}$	0.509	0.632	0.686
	$2 * 10^{-3}$	0.930	1.149	1.239

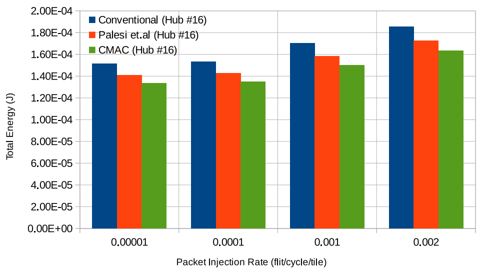
PIR = Packet Injection Rate, RACM = Radio Access Control Mechanism, CM = Conventional Method, CMAC = Centralized Medium Access Control

V. Conclusions and Future Work

In this paper, we presented a C-MAC mechanism that improves the utilization of the radio medium in WiNoCs, by dynamically adjusting the token of RHs allocation based on the most packets in each RHs in the cycle. The simulation results under synthetic and application traffic patterns show that the proposed C-MAC arbitration mechanism performs better than the conventional method and RACM by reducing



(a) Transpose Traffic



(b) Blackscholes Traffic

Figure 7: Energy Consumption of the 8*8-core with 16_RHs

the average latency, improving the network throughput, and consuming less energy in WiNoC. The C-MAC shows up to 37% and 11% improvement in throughput on the synthetic traffic patterns over the conventional method and RACM. We target to investigate the implementation of the proposed C-MAC on other WiNoC architecture such as iWise, McWiNoC, and WCube in the future.

Acknowledgment

This work has been supported in part by Universiti Teknologi Malaysia (UTM) Research University Grant, with grant number: Q.J130000.2651.17J05.

References

[1] S. Deb, A. Ganguly, P. P. Pande, B. Belzer, and D. Heo, "Wireless NoC as interconnection backbone for multicore chips: Promises and challenges," *IEEE Journal on Emerging and Selected Topics in Circuits and Systems*, vol. 2, no. 2, pp. 228–239, 2012.

[2] S. Deb, K. Chang, X. Yu, S. P. Sah, M. Cosic, A. Ganguly, P. P. Pande, B. Belzer, and D. Heo, "Design of an energy-efficient CMOS-compatible NoC architecture with millimeter-wave wireless interconnects," *IEEE Transactions on Computers*, vol. 62, no. 12, pp. 2382–2396, 2013.

[3] N. Mansoor, A. Vashist, M. M. Ahmed, M. S. Shamim, S. A. Mamun, and A. Ganguly, "A Traffic-Aware Medium Access Control Mechanism for Energy-Efficient Wireless Network-on-Chip Architectures," *arXiv Networking and Internet Architecture*, 2018.

[4] P. Dai, J. Chen, Y. Zhao, and Y. H. Lai, "A study of a wire-wireless hybrid NoC architecture with an energy-proportional multicast scheme for energy efficiency," *Computers and Electrical Engineering*, vol. 45, pp. 402–416, Jul 2015.

[5] S. Abadal, M. Nemirovsky, E. Alarcón, and A. Cabellos-Aparicio, "Networking Challenges and Prospective Impact of Broadcast-Oriented Wireless Networks-on-Chip," *Proceedings of the 9th International Symposium on Networks-on-Chip - NOCS '15*, pp. 1–8, 2015.

[6] D. DiTomaso, A. Kodi, D. Matolak, S. Kaya, S. Laha, and W. Rayess, "A-WiNoC: Adaptive Wireless Network-on-Chip Architecture for Chip Multiprocessors," *IEEE Transactions on Parallel and Distributed Systems*, vol. 26, no. 12, pp. 3289–3302, Dec 2015.

[7] N. Mansoor, P. J. S. Iruthayaraj, and A. Ganguly, "Design Methodology for a Robust and Energy-Efficient Millimeter-Wave Wireless Network-on-Chip," *IEEE Transactions on Multi-Scale Computing Systems*, vol. 1, no. 1, pp. 33–45, 2015.

[8] K. Chang, S. Deb, A. Ganguly, X. Yu, S. P. Sah, P. P. Pande, B. Belzer, and D. Heo, "Performance evaluation and design trade-offs for wireless network-on-chip architectures," *ACM Journal on Emerging Technologies in Computing Systems (JETC)*, vol. 8, no. 3, p. 23, 2012.

[9] F. Rad, M. Reshadi, and A. Khademzadeh, "A survey and taxonomy of congestion control mechanisms in wireless network on chip," *Journal of Systems Architecture*, vol. 108, p. 101807, 2020.

[10] S. Abadal, M. Nemirovsky, E. Alarcón, and A. Cabellos-Aparicio, "Networking challenges and prospective impact of broadcast-oriented wireless networks-on-chip," in *Proceedings of the 9th International Symposium on Networks-on-Chip*. ACM, 2015, p. 12.

[11] S. Abadal, A. Mestres, J. Torrellas, E. Alarcón, and A. Cabellos-Aparicio, "Medium Access Control in Wireless Network-on-Chip: A Context Analysis," *IEEE Communications Magazine*, pp. 1–8, 2018.

[12] G. Piro, S. Abadal, A. Mestres, E. Alarcón, J. Solé-Pareta, L. A. Grieco, and G. Boggia, "Initial MAC Exploration for Graphene-enabled Wireless Networks-on-Chip," *Proceedings of ACM The First Annual International Conference on Nanoscale Computing and Communication - NANOCOM' 14*, pp. 1–9, 2007.

[13] V. Vijayakumaran, M. P. Yuvaraj, N. Mansoor, N. Nerurkar, A. Ganguly, and A. Kwasinski, "CDMA enabled wireless network-on-chip," *ACM Journal on Emerging Technologies in Computing Systems (JETC)*, vol. 10, no. 4, p. 28, 2014.

[14] S. Abadal, A. Mestres, J. Torrellas, E. Alarcón, and A. Cabellos-Aparicio, "Medium Access Control in Wireless Network-on-Chip: A Context Analysis," *IEEE Communications Magazine*, vol. 56, no. 6, pp. 172–178, 2018.

[15] N. Mansoor, M. S. Shamim, and A. Ganguly, "A demand-aware predictive dynamic bandwidth allocation mechanism for wireless network-on-chip," in *Proceedings of the 18th ACM/IEEE System Level Interconnect Prediction 2016 Workshop, SLIP 2016*. Association for Computing Machinery, Inc, jun 2016, pp. 1–8.

[16] Y. Ouyang, Y. Zhao, K. Xing, Z. Huang, H. Liang, and J. Li, "Design of wireless network on chip with priority-based MAC," *Journal of Circuits, Systems and Computers*, vol. 28, no. 8, pp. 228–239, 2019.

[17] V. Catania, A. Mineo, S. Monteleone, M. Palesi, and D. Patti, "Cycle-Accurate Network on Chip Simulation with Noxim," *ACM Transactions on Modeling and Computer Simulation*, vol. 27, no. 1, pp. 1–25, 2016.

[18] A. Ganguly, M. M. Ahmed, R. Singh Narde, A. Vashist, M. S. Shamim, N. Mansoor, T. Shinde, S. Subramaniam, S. Saxena, J. Venkataraman, and Others, "The Advances, Challenges and Future Possibilities of Millimeter-Wave Chip-to-Chip Interconnections for Multi-Chip Systems," *Journal of Low Power Electronics and Applications*, vol. 8, no. 1, p. 5, 2018.

[19] A. I. Fasiku, M. Nadzir Bin Marsono, P. E. Numan, A. Lit, and S. Rusli, "Wireless Network On-Chips History-Based Traffic Prediction for Token Flow Control and Allocation," *ELEKTRIKA- Journal of Electrical Engineering*, vol. 18, no. 3, pp. 21–26, Dec 2019.

[20] M. Palesi, M. Collotta, A. Mineo, and V. Catania, "An efficient radio access control mechanism for wireless network-on-chip architectures," *Journal of Low Power Electronics and Applications*, vol. 5, no. 2, pp. 38–56, Mar 2015.

[21] J. Wang, Y. Li, Q. Peng, and T. Tan, "A dynamic priority arbiter for Network-an-Chip," *Proceedings - 2009 IEEE International Symposium on Industrial Embedded Systems, SIES 2009*, pp. 253–256, 2009.

[22] F. Rad, M. Reshadi, and A. Khademzadeh, "A novel arbitration mechanism for crossbar switch in wireless network-on-chip," *Cluster Computing*, pp. 1–14, 2020.

[23] J. Duato, "Interconnection Networks - An Engineering Approach," *Journal of Chemical Information and Modeling*, vol. 53, no. 9, pp. 1689–1699, 2019.

[24] A. I. Fasiku, S. Rusli, and M. N. B. Marsono, "Characterization of Subnets, Virtual Channel and Routing on Wireless Network-on-Chip Performance," in *2020 IEEE Student Conference on Research and Development (SCOReD)*. IEEE, Sep 2020, pp. 117–121.

[25] V. Catania, A. Mineo, S. Monteleone, M. Palesi, and D. Patti, "Noxim: An open, extensible and cycle-accurate network on chip simulator," *Proceedings of the International Conference on Application-Specific Systems, Architectures and Processors*, vol. 2015-Sept, pp. 162–163, 2015.