# JUST QUEUING: POLICY-BASED SCHEDULING MECHANISM FOR PACKET SWITCHING NETWORKS

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# JUST QUEUING: POLICY-BASED SCHEDULING MECHANISM FOR PACKET SWITCHING NETWORKS

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**by**

**Yaser Shamsulhak Miaji**

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# Abstrak

Keberleluasaan Internet dan aplikasinya menyebabkan pertambahan terhadap permintaan pengguna bagi mendapatkan lebih banyak perkhidmatan pada harga yang berpatutan. Kepelbagaian trafik Internet memerlukan beberapa pengkelasan dan pemberian keutamaan dilakukan kerana terdapat kategori trafik menghendaki lengahan dan kehilangan bingkisan yang sedikit berbanding yang lain. Mekanisma penjadualan bingkisan yang sedia ada lebih cenderung kepada keseimbangan di antara tiga ciri utama iaitu keadilan, kerumitan dan perlindungan. Oleh itu, persoalan yang masih wujud ialah bagaimana untuk meningkatkan ciri-ciri keadilan dan perlindungan melalui pelaksanaan penjadualan yang kurang rumit. Kajian ini mencadangkan penambahbaikan dalam mekanisma penjadualan bingkisan dengan ciri-ciri keadilan serta perlindungan yang mampan serta pelaksanaan yang mudah bagi meningkatkan kualiti perkhidmatan khususnya untuk aplikasi masa nyata. Elemen tambahan diterapkan dalam persamaan utama keadilan bagi memperbaiki ciri keadilan. Kajian ini menggunakan dasar caj terhad yang memberikan perlindungan kepada pengguna biasa. Dalam aspek kerumitan, algoritma genetik digunakan kerana ianya mempunyai kelebihan bagi menyimpan skor kecergasan baris gilir pada ruang storan berasingan yang berpotensi meminimumkan kerumitan algoritma. Kesepaduan antara pendekatan konsep, analisis dan eksperimen mengesahkan kecekapan mekanisma yang dicadangkan. Keputusan penilaian menunjukkan taburan lebar jalur yang adil setanding dengan mekanisma popular Weighted Fair Queuing (WFQ). Malah dari aspek perlindungan, keputusan yang diperolehi adalah lebih baik berbanding mekanisma WFQ dan dua mekanisma penjadualan lain. Mekanisma yang dicadangkan juga menunjukkan ciri kerumitan mencapai tahap O(log(n)) yang dianggap rendah. Memandangkan mekanisma ini adalah terhad kepada rangkaian berwayar, kajian lanjut harus dilakukan di masa hadapan bagi penambahbaikan untuk digunapakai dalam rangkaian mudah alih ad-hoc atau mana-mana rangkaian tanpa wayar yang lain. Selain itu, mekanisma yang dicadangkan ini boleh ditambahbaik lagi untuk meningkatkan penggunaannya dalam rangkaian pensuisan litar maya seperti rangkaian mod penghantaran tak segerak.

Kata kunci: Baris Gilir, Mekanisme Penjadualan, Dasar Caj, Algoritma Genetik, Rangkaian Pensuisan Bingkisan, WFQ, OPNET.

# Abstract

The pervasiveness of the Internet and its applications lead to the potential increment of the users' demands for more services with economical prices. The diversity of Internet traffic requires some classification and prioritisation since some traffic deserve much attention with less delay and loss compared to others. Current scheduling mechanisms are exposed to the trade-off between three major properties namely fairness, complexity and protection. Therefore, the question remains about how to improve the fairness and protection with less complex implementation. This research is designed to enhance scheduling mechanism by providing sustainability to the fairness and protection properties with simplicity in implementation; and hence higher service quality particularly for real-time applications. Extra elements are applied to the main fairness equation to improve the fairness property. This research adopts the restricted charge policy which imposes the protection of normal user. In terms of the complexity property, genetic algorithm has an advantage in holding the fitness score of the queue in separate storage space which potentially minimises the complexity of the algorithm. The integrity between conceptual, analytical and experimental approach verifies the efficiency of the proposed mechanism. The proposed mechanism is validated by using the emulation and the validation experiments involve real router flow data. The results of the evaluation showed fair bandwidth distribution similar to the popular Weighted Fair Queuing (WFQ) mechanism. Furthermore, better protection was exhibited in the results compared with the WFQ and two other scheduling mechanisms. The complexity of the proposed mechanism reached O(log(n)) which is considered as potentially low. Furthermore, this mechanism is limited to the wired networks and hence future works could improve the mechanism to be adopted in mobile ad-hoc networks or any other wireless networks. Moreover, more improvements could be applied to the proposed mechanism to enhance its deployment in the virtual circuits switching network such as the asynchronous transfer mode networks.



Keywords: Queuing, Scheduling Mechanism, Charge Policy, Genetic Algorithm, Packet Switching Networks, WFQ, OPNET.

## Declaration Associated with this Thesis

Some parts of this work have published or accepted in the following articles:

**1.** Yaser Miaji and Suhaidi Hassan, A Survey on the Chronological Evolution of Timestamp Schedulers in Packet Switching Networks, in the Proceedings of the 2nd IEEE International Conference on Broadband Network & Multimedia Technology, 2009 (IC-BNMT '09), pp. 213-219, Beijing, China, 18-20 Oct. 2009. Published by the IEEE, Indexed in ISI and Scopus, ISBN: 978-1-4244-5005-3. Library of Congress Number: 2009903988

**2.** Yaser Miaji and Suhaidi Hassan, Just Queueing (JQ): Scheduling Algorithm for the Internet, in the Proceedings of the First International Conference on Networks and Communications 2009 (NetCom-09), pp. 161-165, Chennai, India, 27-29 Dec. 2009. Published by the IEEE Computer Society, Indexed by Scopus, Los Alamitos, California, USA, ISBN 978-0-7695-3924-9.

**3.** Yaser Miaji and Suhaidi Hassan, A Comparative Survey of Scheduling Mechanisms in the Internet, in the Proceedings of the IEEE Region 10 Conference (TENCON 2009), pp. 1-6, Singapore, 23-26 Nov. 2009. Published by the IEEE, Indexed in ISI and Scopus, ISBN: 978-1-4244-4547-9. Library of Congress Number: 2009903904.

**4.** Yaser Miaji, Osman Ghazali and Suhaidi Hassan, Survey on the Event Orderings Semantics Used for Distributed System, Journal of Computer Science and information Technology (IJCSIT), Volume 2, Number 3, pp 150-158, India, June 2010, ISBN: 978-1-4244-5005-3, Library of Congress Number: 2009903988, http://airccse.org/journal/ijcsit2010_curr.html.

**5.** Yaser Miaji and Suhaidi Hassan, A Novel Max-min Definition to Achieve an Optimum Fairness in Scheduling Packets over the Internet, in the Proceedings of the 4th International Symposium in Information Technology ITSIM2010, Volume 2, Number 1, pp 871-821, Kuala Lumpur, Malaysia, 15-17 June 2010, Published by the IEEE, Indexed in Scopus, ISBN: 978-1-4244-6716-7, IEEE Catalogue Number: CFP1033E-PRT.

**6.** Yaser Miaji and Suhaidi Hassan, Comparative Simulation of Scheduling Mechanism in Packet Switching Network, in the Proceeding of NetApps 2010 conference, pp 141-147, Alor Setar, Malaysia, 22-23 Sep. 2010, Published by the IEEE, Indexed in Scopus, ISBN: 978-1-4244-8048-7.

**7.** Yaser Miaji and Suhaidi Hassan, Charge Allocation Concept for Fairer Resource Sharing in Best Effort Network, Proceeding of NetApps 2010 conference, pp. 135-140, Alor Setar, Malaysia, 22-23 Sep. 2010, Published by the IEEE, Indexed in Scopus, ISBN: 978-1-4244-8048-7.

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**9.** Yaser Miaji and Suhaidi Hassan, "Top-Down Approach for the Development of Scheduling Mechanism in Packet-Switching Networks," International Journal of Computer Science and Information Security (IJCSIS), USA, vol. 8, pp. 167-173, July 2010, ISSN 1947-5500.

**10.** Yaser Miaji and Suhaidi Hassan, "Analytical Comparison of Fairness Principles for Resource Sharing in Packet-Based Communication Networks," International Journal of Computer Science and Information Security (IJCSIS), USA, vol. 8, pp. 149-156, July 2010, ISSN 1947-5500.

**11.** Yaser Miaji and Suhaidi Hassan, "The Evolution of Fairness Principles for Resource Sharing in Packet-Switching Networks", In the proceeding of 2nd International Conference on Information and Multimedia Technology (ICIMT 2010), vol. 1, pp. 415-422, Honk Kong, China, 28-30 Dec. 2010, Published by the IEEE, Indexed in ISI and Scopus, ISBN: 978-1-4244-8881-0, IEEE Catalogue Number: CFP1053I-PRT.

**12.** Yaser Miaji and Suhaidi Hassan, "The Effect of Concurrent Connection in the Fairness and Protection of Scheduling Mechanism in the Internet", In the Proceeding of 2nd International Conference on Information and Multimedia Technology (ICIMT 2010), vol. 2, pp. 429-433, Honk Kong, China, 28-30 Dec. 2010, Published by the IEEE, Indexed in ISI and Scopus, ISBN: 978-1-4244-8881-0, IEEE Catalogue Number: CFP1053I-PRT.

**13.** Yaser Miaji and Suhaidi Hassan, "The Impact of Concurrent Connection in the Fairness and Protection of Shared Link in Packet Switching Networks", In the Proceeding of SEiT Social Economic and information Technology, Hadyai, Thailand, 23-25 Nov. 2010.

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# List of Abbreviations

| | |
|---|---|
| **CBQ** | Class Based Queueing |
| **DDRR** | Dynamic Deficit Round Robin |
| **Delay-EDD** | Delay Earlier Due Date |
| **DRR** | Deficit Round Robin |
| **FIFO** | First In First Out |
| **FQ** | Fair Queueing |
| **FTP** | File Transfer Protocol |
| **GPS** | Generalised Process Sharing |
| **GPS-M** | Generalised Process Sharing with Maximum rate control |
| **GrFQ** | Greedy Fair Queueing |
| **HPFQ** | Hierarchical Packet Fair Queueing |
| **HSDRR** | Hierarchical Shaped Deficit Round Robin |
| **IETF** | International Engineering Task Force |
| **IP** | Internet Protocol |
| **IPTV** | Internet Protocol Television |
| **Jitter-EDD** | Jitter Earlier Due Date |
| **LFVC** | Leap Forward Virtual Clock |
| **MD-SCFQ** | Minimum Delay Self Clocked Fair Queueing |
| **MSPFQ** | Mean Start Potential Fair Queueing |
| **NSPFQ** | New Start Potential Fair Queueing |
| **OTPQ** | One Timestamp Per Queue |
| **PQ** | Priority Queueing |
| **QoS** | Quality of Service |
| **RFB** | Relative Fairness Bound |
| **RPS** | Rated Proportional Server schedulers |
| **RR** | Round Robin |
| **SCFQ** | Self Clocked Fair Queueing |

| | |
|---|---|
| **SFQ** | Start Time Fair Queueing |
| **SMTP** | Simple Message Transfer Protocol |
| **SPFQ** | Starting Potential Fair Queueing |
| **SRR** | Smoothed Round Robin |
| **SVC** | Shaped Virtual Clock |
| **SWFQ** | Simplified Weighted Fair Queueing |
| **TCP** | Transmission Control Protocol |
| **TS** | Time Stamp Schedulers |
| **UDP** | User Datagram Protocol |
| **VC** | Virtual Clock |
| **VoIP** | Voice over IP |
| **WF2Q** | Worst Case Weighted Fair Queueing |
| **WF2Q-M** | WF2Q with Maximum Rate Control |
| **WFI** | Worst Case Fair Index |
| **WFQ** | Weighted Fair Queueing |
| **WRR** | Weighted Round Robin |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Overview

Scheduling mechanism is the key factor for prompt transmission of packets in a datagram network. Scheduling is concerned about the "which" and "when" issues of such a transmission [1]. Its primary issue is deciding which packet is to be transmitted and from which queue. The second issue is deciding when this packet is to be transmitted or in other words the promptness. Therefore, there are two functions that are to be addressed by the scheduling mechanism, namely ordering and promptness [2].

These functions are tightened by five properties namely; fairness, protection, complexity, flexibility, and bounding delay [3]. A more specific issue is the combination of all five properties in one single scheduling mechanism. The trade-off between these five properties had actually been investigated in many previous studies. Consequently, designing a scheduling mechanism that combines all these properties optimally is a challenge.

This research had concentrated on adopting different methods for implementing a scheduling mechanism. These newly adopted concepts and algorithms have resulted in a combined scheduling mechanism based on charge policy as the primary change in scheduling design. Section 1.2 provides a general background about the research topic. Section 1.3 presents the research motivation. The following sections are concerned about the statement of problem which is followed by research objectives, research scope, and the significance of the research. The outline of the dissertation is described in Section 1.8. Finally, the chapter summary is shown in Section 1.9.

## 1.2 Background

The ubiquitousness of the Internet and the pervasiveness of its applications lead to the potential increase in the users' demands for more services with economical prices [4]. Furthermore, the emergence of new applications in daily usage, such as videoconferencing, online gaming, and voice conversation, has resulted in a pressing necessity for novel mechanisms and policies to serve this steep improvement in the

The contents of the thesis is for internal user only

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