An Optimized Round Robin Central Processing Unit Scheduling Algorithm with Dynamic Time

Quantum

Ms. Smitha Nayak
Assisstant Professor
Department of Computer Science,
Muscat College
Muscat, Oman
Smitha@muscatcollege.edu.om

Dr. Yogesh Kumar Sharma
Professor
Department of Computer Science & Engineering
Andhra Pradesh, India
dr.sharmayogeshkumar@gmail.com

Mr. Ritvik Nayak
Student
Department of Computer Science & Engineering, MIT
Manipal, India
Ritvik1753@gmail.com

Abstract— Traffic signals ensure safe driving and regulated flow of traffic at road intersections. With increasing number of cars on the roads, it has become very essential to regulate traffic so that mobility of people residing in Oman is much smoother. Controlling road traffic has been a very challenging task especially at the intersections. Conventionally traffic signal control systems are scheduled in such a way that the vehicles at an intersection move in a fixed pre-timed slot manner. This fixed pre-timed controller approach fails to minimize the waiting time of vehicles at the traffic intersections as it does not sense the queue size of vehicles at the traffic signal. Many a times the traffic flow is not uniform, sometimes traffic is more from a particular direction or probably an accident has occurred in that lane which leads to increasing size of the queue and also the waiting time for people in that lane of intersecting road. In such cases it is often seen The Royal Oman Police (ROP) taking over the traffic signals and controlling the flow of traffic for smooth flow of traffic. To overcome this problem an adaptive and intelligent traffic signal control system is proposed in such a way that a traffic signal controller is installed with a wireless sensor which works on the basis of checking the queue size of vehicles in a particular lane and switches to green or stays in green for longer duration for that lane. It also sends an alert to the telecom companies and the radio channels in Oman to inform the slow moving traffic news to the people of Oman.

Keywords—Scheduling, RTOS, Round Robin, Priority Scheduling, dynamic quantum, localized sensors, microcontrollers, REST web service, Apache Tomcat.

I. INTRODUCTION

The most important component of a computer is the Central Processing Unit (CPU). All the requests for execution by CPU are maintained in a wait queue and are then executed in best efficient manner. This is known as CPU Scheduling. Operating system is mainly responsible for managing computer hardware by providing a platform for execution of programs efficiently. Multitasking and multiprocessing environments are used by modern operating systems for executing tasks that are waiting in the wait queue for CPU time. CPU time is very important. Time is most important aspect when it comes to computers and this depends mainly on how efficiently CPU is scheduled to get the best throughput is least time. If any process has to wait for very long time for execution at the CPU then this is called as starvation where some other process are getting all the CPU time.

Let us now look at some of the terminologies used in CPU Scheduling.

Arrival Time: Arrival time is the time at which process arrive at main memory [1].

Burst Time: Burst time is the time for which process holds the CPU [1].

Waiting Time: Waiting time is amount of time process waiting in ready queue [1].

Turnaround Time: Turnaround time means time of arrival minus time of completion [1].

Response Time: Response time means time of arrival minus first response by CPU [1].

Throughput: Number of process completed per unit time [1].

Response Time: Response time is the time from the submission of a request until first response is produced [1].

A process has to go through certain phases before getting the CPU time. Job scheduler and dispatcher decide on which process is to be executed next based on the best scheduling algorithm for that particular task.

Earlier the traffic signals were manually operated by the police by blowing whistles and hence the police could keep the traffic regulated by watching which lane has more cars waiting. This

system needed to be changed as it would become difficult for the police to stay to control traffic during adverse weather conditions and also increasing pollution was a threat to their health. Technology advancements were a major contribution to the change of this traditional approach. Then came the coordinated traffic lights which were manually operated by the police. These manually operated traffic lights were more prone to mechanical failure.

As per John Halkias and Michael Schauer [8], In the United States alone, people must collectively wait 296 million hours every year, averaging one hour per person, due to bad timing of traffic control systems.

In some parts of the world, for higher speed approaches for moving traffic, there is also a control strategy to reduce the occurrence of the yellow interval when high speed vehicles are at a critical location on the approach to the signal known as the dilemma zone.

A very challenging task is to control road traffic with an enormous effort to expand road infrastructure by many city planners. However, expanding the road infrastructure with increasing vehicles is not an optimal solution [3].

With the advancements in technology and also due to the immense amount of traffic increase on the road, new and more complex control methods with modern computerized traffic signaling systems are utilized. All these methods share a common goal that is to maximize the traffic throughput at controlled intersections in the shortest amount of time while maintaining driver safety. Different countries use different algorithms to control traffic in a signal.

CPU scheduling is most important aspect of Distributed Systems which helps us to understand how processes are managed by implementation of various algorithms. The selection of algorithm depends upon the type of process or task. Various CPU scheduling algorithms are there. Most common ones are First Come First Serve (FCFS), Shortest Job First (SJF), Shortest Response Time First (SRTF), Round Robin, Priority scheduling etc.

In real time operating systems (RTOS) most of the tasks are periodic in nature that is, they need to be executed in a particular manner. Periodic data is usually taken from sensors, server control, and real-time monitoring systems. In real time operating systems, these periodic tasks utilize most of the processor computation power. Some timing constraints need to be set for these periodic tasks which also affect the output of the system [2]. When we have many tasks queued up for processing the scheduling algorithms are used to decide the order of execution of these tasks. These scheduling algorithms are chosen for best achievement of desired results.

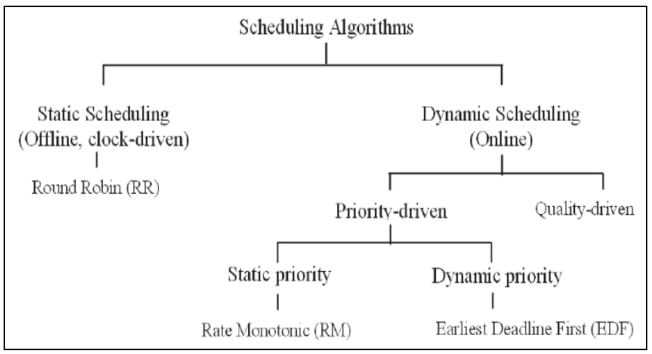

Figure1: Scheduling Algorithm types

In offline or clock driven scheduling a task is selected for execution based on a predetermined schedule. This sequence is repeated after specific interval of time. For example if we have three tasks T_1, T_2 and T_3 then T_1 will execute first then T2 and then T_3.

In online or dynamic scheduling approach, a task gets executed based on its priority, which is determined in real time based on some set rules. The priorities of the tasks change during execution.

In fixed priority algorithms the priority of a task is fixed and does not change during execution. For example if the kth job of a task T_1 has higher priority than the kth job of task T_2 according to some specified scheduling event, then every job of T_1 will always execute first then the job of T_2 will be executed [2].

In dynamic priority algorithms various jobs of a task might change their priority during their next execution.

One of the most common scheduling algorithms used by most traffic signals is a clock driven static scheduling approach that is Round Robin. Round-robin scheduler generally employs time-sharing, giving each job a time slot or quantum and interrupting the job (pre-emptive) if it is not completed by then. The job is resumed next time a time slot is assigned to that process [16].

The selection of quantum is a very important aspect in Round Robin algorithm. Round Robin algorithm degenerates to First Come First Serve (FCFS) if the quantum chosen is too large. On the contrary if the quantum chosen is too small it will lead to more context switching and leads to increase in the overhead.

Normally in a 4-leg intersection, what is seen in Oman is that the traffic controlling systems are microcontroller based system which involve a predefined time interval set for each lane at the intersection. In Oman if the intersection has four lanes or roads it is observed that the signal remains green for each of the lanes for 30 seconds before switching to the adjacent lane. This is Round Robin algorithm where a fixed time slot is allotted to each lane.

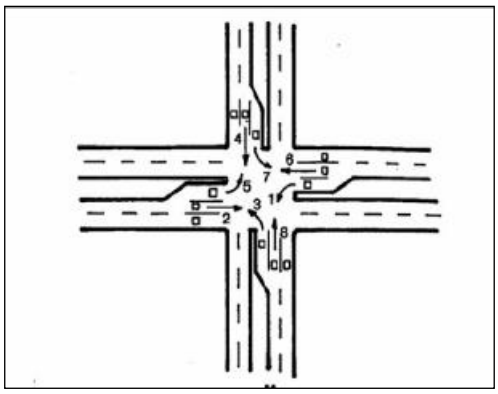

Figure2: 4-Leg intersection lane [4]

At some traffic signals in Oman, the signal has a sensor which detects that a particular lane has no cars and immediately switches the green light to the next lane. This saves the time for other people from waiting unnecessarily for a lane which has no traffic. The problem with the Round Robin approach of scheduling traffic signal is that the flow of traffic can be erratic at times with a particular lane having more vehicles coming than the others. Reason can be that a movie might have just got over or the traffic might have been redirected to that lane for some special event or even an accident. If this situation is not handled immediately it can lead traffic increasing incredibly leading to more traffic blockage in that lane or it can even lead to a deadlock.

II. RELATED WORK

Ms. Sarika Rakhade [6] has proposed an approach where the sensors are placed at equal distance along one side of road, which will monitor the number of vehicles under its coverage area. Depending on number of vehicles present in one direction, sensor produces 1 (Active HIGH) as outcome with respect to a vehicle, otherwise 0 (LOW). The density is calculated by summing number of 1's present. Then it is categorized into four levels high, medium, low and null. Depending on the category of density, signal's timing is decided.

Zhao B., Zhang C., Zhang L [7] have introduced an ITLS algorithm based on Genetic

Algorithm (GA) merging with Machine Learning (ML) algorithm. This algorithm schedules the time phases of each traffic light according to each real-time traffic flow that intends to cross the road intersection, whilst considering next time phases of traffic flow at each intersection by ML. In order to get each next time phases of traffic flow, they have used Linear Regression (LR) algorithm as ML algorithm.

III. Research Design and Methods

In general, different times of day have different requirements - peak hours, slow hours, night time, weekends – so different ways of scheduling traffic lights is needed based on what we think will give the best performance of the traffic conditions.

The solution to the problem of Round Robin implementation of traffic scheduling can be an implementation of an algorithm, priority scheduling, which is activated after sensing the increasing traffic in a lane in the intersection. The priority scheduling algorithm needs a sensor at the traffic signal intersection. This sensor can estimate the size of the cars waiting in the queue at a traffic signal.

A. Traffic intersection and signal lights

i. Our assumption is, every traffic intersection will have multiple traffic lanes going in each direction. Usually the traffic intersection is assumed to have three to four lanes.
ii. Each lane permits movement in only one direction.
iii. Each lane will have a traffic light/signal. This signal will switch between thee colors viz. Green, Yellow and Red.
iv. We assume that traffic sensors are already placed at various traffic intersections. These sensors sense number of vehicles in a particular lane and transmit data.

B. Data collection and computation paradigms

The application can be designed using two paradigms.

Paradigm 1: Localized sensor data collection and processing

The sensors collect data and send it to the sensor modules. The sensor modules are located at the site of the traffic signals. These modules execute round robin scheduling algorithm based on the sensor data, and generate commands for the signal microcontrollers. The microcontrollers change the signal lights as per the time duration allocated to them.

Paradigm 2: Localized sensor data collection and remote data processing

The sensors collect the data and send it to the sensor modules. The sensor modules transmit the data over a secure network to a server cluster. The servers execute algorithms on the incoming sensor data and generate microcontroller commands and allocate signal time. These commands are transmitted back to the sensor modules located at the traffic intersections. The microcontrollers act upon the commands and the signals are changed accordingly.

C. Sensor data collection algorithm

An algorithm needs to be developed according to which the sensors will start calculating the number of vehicles and will stop calculating after a satisfactory condition is met, to transmit data. The algorithm should reset the counters to 0 either after the sensors transmit data or the signal light completes its one full cycle. (A full cycle can be defined as Green->Yellow->Red).

D. Round-robin process prioritization and time slice algorithm

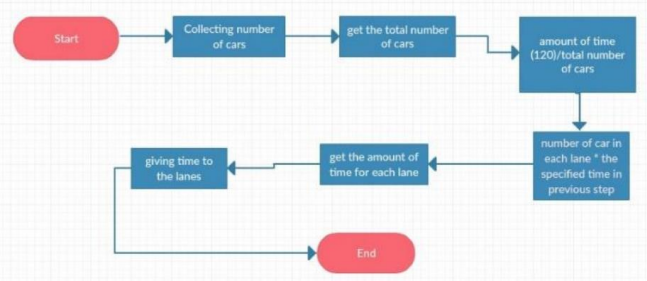

Figure2: Flowchart showing the process [24]

The round robin algorithm receives sensor data as input.
The sensor data contains details like:

(1) time
(2) signal/ intersection id
(3) lane id
(4) number of vehicles

The time that the signal should stay green that is the time slice or the quantum is directly proportional to the number of vehicles waiting in that lane. A general formula needs to be developed that will determine the time the signal should stay green depending on the number of vehicles in that lane. The algorithm computes the time value and assigns it to a process. This process will be sent to the signal microcontroller. The algorithm will also take care of edge cases where two adjacent lanes have same number of vehicles and/ or opposite lanes have same number of vehicles. All processes will go through a round robin prioritization scheduling and will be assigned a rank. The processes will be executed based on the priority rank. Each process will be assigned to a signal. Once the signal turns green, the process executes and will keep the signal color green for the time slice allocated to that process. This method will increase the waiting time of the lane which has lesser traffic.

IV. PROOF OF CONCEPT AND SCOPE

The scope of this research includes below modules/components:

1. Sensor simulator
   An application that will simulate the sensor data. The simulation will mock various traffic patterns like peak time, non-peak time, holidays, festivals and accidents. The sensor data simulator will send input data to the round-robin algorithm for signal time, process prioritization and scheduling computation.
2. Round-robin algorithm
   A distributed application that will compute signal duration and process time slice by processing incoming sensor data.
3. Test harness
   A test harness that will test sensor data simulator and round robin algorithms first in isolation and then end to end. The Test harness will also govern and simulate peak load on the systems.

V. METHODOLOGIES & TECHNICAL SPECIFICATIONS

It is recommended that we have a standalone application for sensor data simulation. The round robin algorithm will act as the core business logic and will be deployed behind a RESTful web service. Sensor data simulator will send data to the round robin web service via REST post. The web service response will contain “stay green” time for every signal. The microcontrollers will spin up processes based on the response received from the web service. Web service monitoring dashboard will be developed to monitor the web service and the data processing in almost real time.

The technologies we recommend are:

1. Core java for sensor data simulator.
2. RESTful web services and core java for round robin algorithm development.
3. Apache Tomcat servers for the web service deployment and monitoring.

4. Microcontrollers to control the signal lights.
5. Java Swing or java script for algorithm monitoring dashboard development.
6. A cluster of at least 2 servers load balanced to simulate distributed nature of the round robin algorithm.
7. Sensor data format will be JSON.

VI. SIGNIFICANCE/ IMPACT

In the current modern world, it is highly important for a developed country like Oman to improve and excel in their public service and regulation system for the benefit of the fellow citizens. With most of the people shifting to the urban area like Muscat, for reasons like education, better job opportunities, better life style and standard of living, the rate of increase in the population is found to be proportional to the rate of increase in the number of cars/ vehicles on the road. The clustering of traffic may depend on the area or time of the day or even an unexpected event.

As discussed earlier, the current traffic signal system in Oman uses the sensor system and round robin algorithm to manage the traffic system. This is not efficient to handle sudden increase in traffic due to some unavoidable situations. In the current scenario, such sudden events have to be attended by Royal Oman Police officials which may in turn take time to regularize the traffic flow.

The prioritized system that has been suggested in this proposal intended to deliver an optimized solution for handling Oman's traffic signal system. The implementation of this application will save time and prevent unexpected delays for the people in Oman especially the working class.

VII. FUTURE ENHANCEMENT

All the vehicles in Oman are equipped with the radio facilities which the passengers mostly listen to. AI present, the radio stations sometimes broadcasts the news on unexpected road blocks only when they get the information from someone calling them. So this information may not be reliable since there is no proper method available to check the authenticity of the received information. Whenever the traffic signal shifts to priority scheduling, the suggested alert system will be sending the location of the traffic signal to all the main Oman telecom companies and the radio stations so that they can broadcast this information to the public on move. So this awareness will enable the people to take a deviation or use a parallel roadway to reach their destination without entering into the block. This will prevent the add-ons to the existing traffic block.

VIII. EXPECTED RESEARCH OUTPUT

The proposed research intends to suggest an automatic and intelligent traffic signal system on four way roads that is basically achievable and relevant to the Oman's traffic system. All cases found during analysis are matched with some of the crucial factors such as waiting time, queue length, throughput at the crowded signal. The sensors identify the most crowded lane and the algorithm allocates a high priority to that lane that is the green light signal is kept for longer time. The second and the third crowded lanes will be given similar priorities.

This Algorithm minimizes the delays experienced by the vehicles waiting in an overcrowded traffic intersection.

IX. LIMITATION

One of the limitations of this priority based Round Robin approach with dynamic quatum or slice time is that it does not facilitate or consider the passage of any emergency vehicles to get to their destination in a shortest period of time. Some

research also proposed that a voice sensor should be made available at the traffic signal which identifies the alarm or siren and changes the priority of that particular lane or high and turns on the green light for that lane. All other lanes signal is changed to red with low priority.

REFERENCES

[1] https://www.scaler.com/topics/round-robin-scheduling-in-os/

[2] Microcontrollerslab, "Scheduling algorithms for real time embedded systems", June 27th 2018

[3] Evarist Nabaasa, Tonny E Bulega, "Scheduling and optimisation of traffic lights on a T Junction using wireless sensor netork", International Journal of Scientific Knowledge, July 23, Vol 3, No. 3. ISSN 2305-1493

[4] Sharma, Yogesh Kumar; Yadav, R. N. B. V. & Anjaiah P. (21 Nov. 2019), "The comparative analysis of open stack with cloud stack for infrastructure as a service", International Journal of Advanced Science and Technology, Volume 28, Issue 16, Pages 164 – 174.

[5] Maram Bani Younes, Azzedine Boukerche, "An Intelligent Traffic Light scheduling algorithm through VANETs", in 39th Annual IEEE Conference on Local Computer Networks Workshops, 20 October 2014

[6] Faisal A. Al-Nasser, Magdi S Mahmoud, "Wireless Sensors Network Application: A Decentralized Approach for Traffic Control and Management", In book: WIRELESS SENSOR NETWORKS – TECHNOLOGY AND APPLICATIONS, Chapter: 16, Publisher: INTECHOPEN, Editors: Mohammad A. Matin, pp.348 – 374

[7] Sharma, Dr. Y. K. & S, Pradeeep (2019), "Performance escalation and optimization of overheads in the advanced underwater sensor networks with internet of things", International Journal of Innovative Technology and Exploring Engineering, ISSN: 2278-3075, Vol. 08, Issue-11, Pp. 2299-2302, Publisher – BEIESP

[8] https://en.wikipedia.org/wiki/Round-robin_scheduling

[9] Ms. Sarika Rakhade, "Survey on Adaptive Traffic Signal Re-Timing In Vehicular Ad-Hoc Network", International Journal of Computer Science and Information Technologies, Vol. 5 (6) , 2014, 7525-7527

[10] Zhao B., Zhang C., Zhang L. (2015), "Real-Time Traffic Light Scheduling Algorithm Based on Genetic Algorithm and Machine Learning", In: Hsu CH., Xia F., Liu X., Wang S. (eds) Internet of Vehicles - Safe and Intelligent Mobility. IOV 2015. Lecture Notes in Computer Science, vol 9502. Springer, Cham

[11] John Halkias and Michael Schauer. "Red light, green light". In: Public roads 68.3 (2004).

[12] "A comparison of algorithms used in traffic control systems", Degree Project in Technology, First Cycle, 15 Credits STOCKHOLM, SWEDEN 2018

[13] R. Wunderlich, I. Elhanany and T. Urbanik, "A stable longest queue first signal scheduling algorithm for an isolated intersection," 2007 IEEE International Conference on Vehicular Electronics and Safety, Beijing, China, 2007, pp. 1-6, doi: 10.1109/ICVES.2007.4456393.

[14] "Traffic Light Scheduling, Value of Time, and Incentives", Proceedings of the Twenty-Seventh International Joint Conference on Artificial Intelligence (IJCAI-18)

[15] https://www.cl.cam.ac.uk/teaching/1617/OpSystems/pdf/05-Scheduling-Algorithms.pdf

[16] "Intelligent Traffic Control System Based On Round Robin Scheduling Algorithm", International Journal of Scientific and Research Publications, Volume 5, Issue 8, August 2015, ISSN 2250-3153

[17] https://www.ajer.org/papers/Vol-7-issue-5/ZR0705364369.pdf

[18] Suleiman Ebaiya Abubakar, Sahabi Ali Yusuf, Afolabi A. Obiniyi and Abdullahi Mohammed, "Modified Round Robin with Highest Response Ratio Next CPU Scheduling Algorithm using Dynamic Time Quantum", Sule Lamido University Journal of Science & Technology Vol. 6 No. 1&2 [March, 2023], pp. 87-99,

[19] Dibyendu Barman, "Dynamic Time Quantum in Round Robin Algorithm (DTQRR) Depending on Burst and Arrival Time of the Processes", International Journal of Innovative

Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075

[20] N.SRILATHA,K.MASTANIMURTAZA NAZ and B.GANGA BHAVANI, "An Optimized Round Robin with Dynamic and Static Quantum (ORDS)", International Journal of Pure and Applied Mathematics, Volume 118 No. 16 2018, 243-253 ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version) url: http://www.ijpam.eu

[21] Sharma, Y. K, "Web Page Classification on News Feeds Using Hybrid Technique for Extraction. Information & Communication Technology for intelligent system", Series Print ISSN, 2190-3018.

[22] Uferah Shafi, Munam Shah, Abdul Wahid, Kamran Abbasi, Qaisar Javaid, Muhammad Asghar, and Muhammad Haider, "A Novel Amended Dynamic Round Robin Scheduling Algorithm for Timeshared Systems", The International Arab Journal of Information Technology, Vol. 17, No. 1, January 2020

[23] Md. Firoj Ali, Rafiqul Zaman Khan, "Distributed Computing: An Overview, Int. J. Advanced Networking and Applications", Volume: 07 Issue: 01 Pages: 2630-2635 (2015) ISSN: 0975-0290

[24] Hozan Khalid Hamarashid, Miran Hama Rahim Saeed, Soran Saeed, "Designing a Smart Traffic Light Algorithm (HMS) Based on Modified Round Robin Algorithm", Kurdistan Journal of Applied Research (KJAR) | Print-ISSN: 2411-7684 – Electronic-ISSN: 2411-7706 | kjar.spu.edu.iq Volume 2 | Issue 1 | June 2017 |, DOI: 10.24017/science.2017.1.8

[25] Sharma, D. Y. K., & Pradeep, S. (2019), "Deep Learning based Real Time Object Recognition for Security in Air Defense". Proceedings of the 13th INDIACom, 64-67.

[26] Md. Zahangir Alam, Mahfuzulhoq Chowdhury and Parijat Prashun Purohit, "Development of an Intelligent Traffic Management System Based on Modified Round-Robin Algorithm", International Journal of Control and Automation Vol. 7, No. 12 (2014), pp. 121-132 http://dx.doi.org/10.14257/ijca.2014.7.12.12

[27] Eric Aghiomesi Irunokhai, Afolayan A. Obiniyi, S.E.Abdullah, "Vehicle Traffic Control System Using Modified Smart Optimized Round Robin Scheduling Algorithm", American Journal of Engineering Research (AJER), Volume-7, Issue-5, pp-364-369

[28] Gaurav Dudeja, Aman Awana, Manish Jathan, "Traffic Density Management using Round Robin scheduling with Varied Time Quantum and Traffic Analysis", International Journal on Recent and Innovation Trends in Computing and Communication, Volume: 4 Issue: 10, ISSN: 2321-8169

[29] Rokade, M. D., & Sharma, Y. K. (2021, March). "MLIDS: A Machine Learning Approach for Intrusion Detection for Real Time Network Dataset". International Conference on Emerging Smart Computing and Informatics (ESCI) (pp. 533-536).

[30] Mary N Peter, M. Pushpa Rani, "Traffic Management for Smart Cities using Traffic Density and Swarm Algorithm to Inform Diversion Route", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958 (Online), Volume-9 Issue-3, February 2020