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Computer-Based Resource Allocation System in a Dynamic Environment Using Real-Time Traffic Light System

Oyebola Akande[*], Yaw Mensah[**], Funmilayo A. Kasali[***], Wumi Ajayi[****]
[*] *Department of Computer Science, Babcock University, Ilisan-Remo, Ogun State, Nigeria*
Email: [1] akandeo@babcock.edu.ng,
[**,****]*Department of Software Engineering, Babcock University, Ilisan-Remo, Ogun State, Nigeria*
[***]*Department of Computer Science and Mathematics, Mountain Top University, Ogun State, Nigeria*
[2]mensahy@babcock.edu.ng, [3]fkasali@mtu.edu.ng, [4]ajayiw@babcock.edu.ng,

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Abstract:

Resource allocation is one of the vital processes carried out by a computer and the importance of proper resource allocation cannot be overemphasized. There can be challenges when related to resource allocation which can harm a system operating in a dynamic environment. For example, if an individual need is overemphasized, it can lead to inefficient allocation, or local optimization; however, it can cause global inefficiencies that result in a decrease in the productivity of the system. Another challenge involves resource availability which changes frequently. When such unpredictability arises, bandwidth along with other factors may vary over even small intervals of time. This research aimed at understanding the basis of proper resource allocation in a dynamic environment and will be achieved using modelling and simulation of a real-time traffic system to determine how resources can be allocated properly to resolve issues of traffic congestion.

Keywords — Real-time, Traffic-light, Resource allocation, Dynamic environment.

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I. INTRODUCTION

Computing resources (hardware or software), are virtualized and allocated as services from providers to users. These computing resources can be allocated dynamically upon the requests and preferences of users. Out-of-date system-centric resource management architectures cannot process the resource assignment task and dynamically allocate the available resources in a cloud computing environment. Since the users can be able to access applications and data of the "Cloud" from anywhere at any time, it is challenging for the cloud service providers to allocate the cloud resources dynamically and efficiently [1].

Resource allocation manages system resource reservation and allocation tools and implementation. Future communication systems will be categorised by high data rates, diversity in the type of transmitted data and a swift evolution towards increasingly network-centric architectures. This places a growing demand on the efficient utilization of system resources including transmitted power, time and assigned channel bandwidth [2]. Mostly cloud computing uses heterogenous large-scale computing infrastructure because different applications requires different hardware e.g. workflow extensive computing might need standard and cheap hardware; scientific computing might need specific hardware other than CPU (Central processing unit) like GPU (Graphics processing unit) or ASIC (Application-specific integrated circuit). To capitalize on cloud utilization, the volume of requirements for applications will be calculated so that minimal cloud computing infrastructure devices shall be procured and maintained [1]. The adoption in the Enterprise increases as well as Information and communications technology (ICT) increases corporate productivity which needs a non-stop running server, leads to the increase in hardware purchase costs, as well as peripheral costs and environmental damage coming from the power consumption of the servers and the cooling facilities [3]. To alleviate the above lacuna and prevent idle time and redundancy on the part of these systems there is a need to develop a system that will efficiently manage these computer resources and manages their allocation. This study aims to design and create a system that will optimize and allocate resources efficiently. The case study would be the resource allocation of the traffic light system.

II. RELATED WORKS

In [4], 14 heuristics were proposed for resource allocation in the cloud. The scheduling heuristics consist of two phases: task ordering, where tasks are ordered before execution (when possible), and task mapping, where tasks are mapped to available (vacant) Cloud resources.

The scheduling and execution of bag-of-tasks applications (BoTs) in Clouds are implemented based on arrays of virtualized Cloud resources that start being exhausted right after their allocation ignoring whether tasks are being executed. In addition, BoTs may be executed in potentially diverse sets of Cloud resources, which may be either previously allocated for a fixed or unfixed number of hours or dynamically reallocated as needed [5]. In [5], the authors proposed an allocation mechanism that is dynamic and that can reallocates based on-demand. Moreover, an agent-based Cloud BoT scheduling line of attack supports parallel and concurrent scheduling and execution of BoTs, and parallel and concurrent dynamic composition and selection of Cloud resources (by making use of the well-known contract net protocol) [5].

A. *Resource allocation and its types*

We can begin by defining allocation. In a broad sense, it can be defined as how resources can be distributed e.g., responsibility, money, credit etc. In science and engineering, this translates to money, consumables, time, space and services. Naturally, there needs to be a "fair" way to distribute these resources [6]. The ways of distributing resources:

1) Allocation by Merit

This can be seen as a reward system of sorts. This view suggests that rewards should be distributed according to productivity, effort or demonstrated ability.

2) Allocation by Social Worth

Allocation by social worth tends to take a practical view towards resources, directing them towards those who appear most likely to contribute to the common good. Social worth implies that resources should be for the greatest good of majority of the people. In social worth resources are allocated using indices such as age, seniority, rank and expertise.

3) Allocation by Need

When resources are allocated based on need, it tends to be pointing to basic human rights. This refers to the basic human rights i.e., food, shelter and clothing. This view suggests that every person has the same right to some minimal level of given resources.

4) Allocation by Equal or Random Assignment

Allocation by equal or random assignment takes the view that no rational, unbiased way can be found to distribute resources. This is used when no other allocation method works.

B. Resource allocation for a traffic light system

The major terms which describe a traffic signal operation include the signal phases, cycle length, and offsets. The signal phase of a traffic light system states the way the signals work. They can either be simple, two-phase plans or can be customized to allow protected/permitted movements and lead/lag phases. In an intersection with heavy left-turning traffic and heavy diverging through movements, a protected left-turn phase would probably be included either before the opposing traffic is released (lead phase) or after it is stopped (lag phase). The offset between successive traffic signals is defined as the difference in time between the start of the green phase at an upstream intersection as related to the start of the green phase at an adjacent downstream intersection. The cycle length is the total time required for the completion of a sequence of signal phases and is typically between 60 to 120 seconds for a four-legged intersection [7].

C. Mode of Operation

There are different types of traffic signal control in existence, from the individual intersection with pre-timed control to an entire grid with adaptive control [8]. From the simplest to the most difficult, here are the different modes of operation of a traffic light system:

1. Pre-timed

In this mode of operation, the signal phases and the cycle lengths are set based on predetermined rates by a master controller. Pre-timed signal control is suitable for regions with very predictable traffic flow.

2. Progression Schemes

This is an easy method of synchronizing traffic along an arterial road commonly found in many urban areas. The signals can be set manually to run in a continuous, synchronous manner.

3. Actuated

Traffic demands as registered by the actuation of a vehicle and/or pedestrian detectors determine how an actuated traffic system operates. Although different types of actuated controllers exist, their primary purpose is to adjust the signal's pre-timed phase lengths in response to traffic flow. When sensors don't detect vehicles approaching, that phase can be skipped by the controller. The traffic flow is a function of the green time for each approach which fluctuates between maximum and minimum lengths depending on the flow. Cycle lengths and phases are adjusted at intervals set by vehicle actuation of pavement loops.

4. Traffic Responsive

In this approach, a library exists with different plans. When inputs are received from signals (either a single signal or a grid of signals), a suitable plan will be selected from the library and adopted by the system.

5. Adaptive Control Strategies (ACS)

This kind of system at this time is the most cutting-edge and complex control system available. It is very similar to the traffic responsive mode because of how they both receive data through sensors, but instead of selecting timing plans from the library, the system creates a suitable timing plan with the aid of an online computer [8].

III. THE PROPOSED SYSTEM MODEL

Resource allocation is considered in static environments (i.e., the number of resources does not change). The factor being considered is the average time spent on queue. When 'N' numbers of cars arrive randomly and independently to join an infinite-capacity queue (Lanes). The cars in the queue awaiting processing to be assigned to the exit lane. The traffic light uses the resources (camera and sensor) to look into the incoming lanes (T-Junction with four lanes). If at one of these four lanes the jam is longer than the rest, this lane gets green for a long time until it can reduce the congestion at this lane. The cycle goes on with checking other lanes to reduce congestions or jams. To prevent a situation whereby only a lane continues to move, a time limit is introduced for the green phase duration.

Assumptions:

1. The number of cars/vehicles in the system is very large
2. The impact of a single car on the performance of the system is insignificant
3. Arrival rate $\lambda_i, i = \{1,2,3 \dots \dots \dots . n\}$ represents the average number of arrivals per unit time in limit
4. $R = \{r\}$ is the set of resources
5. $C = \{c\}$ is the set of cars
6. t_g and t_r are the durations of the green and red light respectively
7. Traffic light cycle = $t_g + t_r$
8. ɗ is the looking distance for the resources
9. ɳ is the number of cars within ɗ in the interval 0 to t

At any point, the state of the system

$$X_{(k)} = \{D_{(k)}, E_{(k)}\}$$

Where $D_{(k)} = \{i: cars\ i\ in\ ɗ\}$

$E_{(k)} = \{i: cars\ I\ that\ have\ exited\ the\ system\}$

Availability of a resource/car at a certain moment is:

$$availability = (R \cup C) \times T \rightarrow \{0,1\}$$

Where T is the time horizon

Probability density distribution is

$$P_ɳ(t) = \frac{(\lambda t)^ɳ}{ɳ!} e^{-\lambda t}$$

The mean performance of the system is:

$$\rho = \frac{\lambda}{\mu}$$

Where $\mu = average\ exit\ rate$

The queuing model for the problem is shown below:

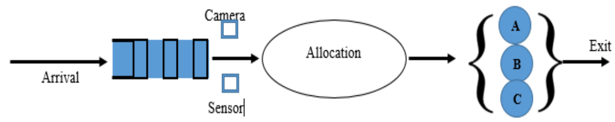

Figure 1: Queuing model for Single lane

The following Figure 2 is the simulation model of the real-time traffic light system:

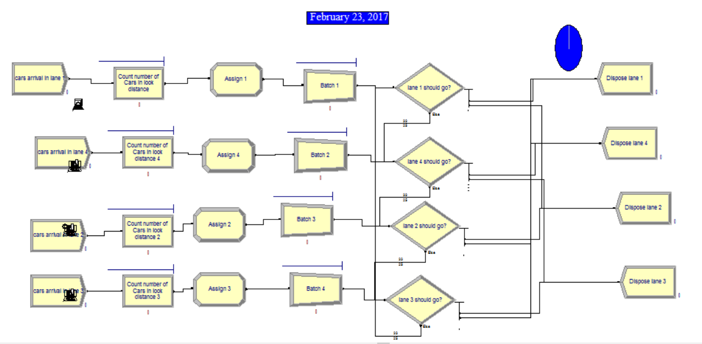

Figure 2: Model of the real-time traffic light system

For the simulation of a real-time traffic light simulation Arena 14 software was used for the modelling and simulation. It is a very effective and applicable instrument for simulation of call Center, telecommunication queuing systems, and manufacturing material processes.

IV. IMPLEMENTATION AND OUTPUT

Figures 3 shows a modeled T junction with 4 lanes and traffic light where cars are managed according to the size of cars in the queue which await processing to be assigned to the exiting lane.

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Figure 3: Image of a T junction with 4 lanes and traffic light

Figures 4 and 5 shows the detail information about the car in the queue which awaits processing to be assigned to the exiting lane.

Create - Basic Process

	Name	Entity Type	Type	Value	Units	Entities per Arrival	Max Arrivals
1	cars arrival in lane 1	Cars	Random (Expo)	1	Minutes	1	Infinite
2	cars arrival in lane 2	Cars	Random (Expo)	1	Seconds	1	Infinite
3	cars arrival in lane 3	Cars	Random (Expo)	1	Minutes	1	Infinite
4	cars arrival in lane 4	Cars	Random (Expo)	1	Minutes	1	Infinite

Figure 4: Description of the creation process

Process - Basic Process

	Name	Type	Action	Priority	Resources	Delay Type	Units	Allocation	Minimum	Value	Maximum
1	Count number of Cars in look distance	Standard	Seize Delay Release	Medium(2)	2 rows	Triangular	Seconds	Value Added	.5	1	1.5
2	Count number of Cars in look distance 4	Standard	Seize Delay Release	Medium(2)	2 rows	Triangular	Seconds	Value Added	.5	1	1.5
3	Count number of Cars in look distance 2	Standard	Seize Delay Release	Medium(2)	2 rows	Triangular	Seconds	Value Added	.5	1	1.5
4	Count number of Cars in look distance 3	Standard	Seize Delay Release	Medium(2)	2 rows	Triangular	Seconds	Value Added	.5	1	1.5

Figure 5: Description of the processing module

Figure 6 shows the processes carried out by the traffic light on car on the queue which are awaiting to be assigned to an exiting lane.

Decide - Basic Process

	Name	Type	
1	lane 1 should go?	N-way by Chance	2 rows
2	lane 2 should go?	N-way by Chance	2 rows
3	lane 3 should go?	N-way by Chance	2 rows
4	lane 4 should go?	N-way by Chance	2 rows

Figure 6: the decide process

There are four process modules and decide modules that represent the branching probability of the entity. The options of the decision making can be based on probability or condition. It uses the N-way by the chance decision-making process. N-way allows for any number of conditions or probabilities to be specified as well as an "else" exit. The N-way by chance is a nested if-else percentage. The percentage used are 33 and 25 per cent.

For example:

```
if (lane 1 > lane 2)
        Lane 1 = true
else if (lane 2 > lane 3)
        Lane 2 = true
else if (lane 3 > lane 4)
        Lane 3= true
else
        Lane 4= true
```

V. CONCLUSION

In a century that is technologically driven and dynamic, it is of optimum importance that resource allocation is as efficient and seamless as possible, hence the need for a computer-based resource allocation system, using a real-time traffic light system. Resource allocation should be a welcomed innovative development in as many organisations as possible. There are always new technologies that will help evolve and impact knowledge. Regular system testing and maintenance of the traffic light system should be conducted to avoid failure and crash of the system.

However, like every feature of engineering, there is still the possibility for further improvement and research on the project as proposed in the recommendations below.

Future work could be done to further improve efficiency, electric power condition limitation as well as the requirements for the installation and deployment. With these additional improvements, the standard could be raised for future traffic light systems. The 4-way traffic light system can also be integrated with an intelligent device that does a study of various traffic junctions and makes projections as to when and where traffic is sure to occur, based on past observations. This would further inform drivers and road users and make them conscious when selecting roads for movement.

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