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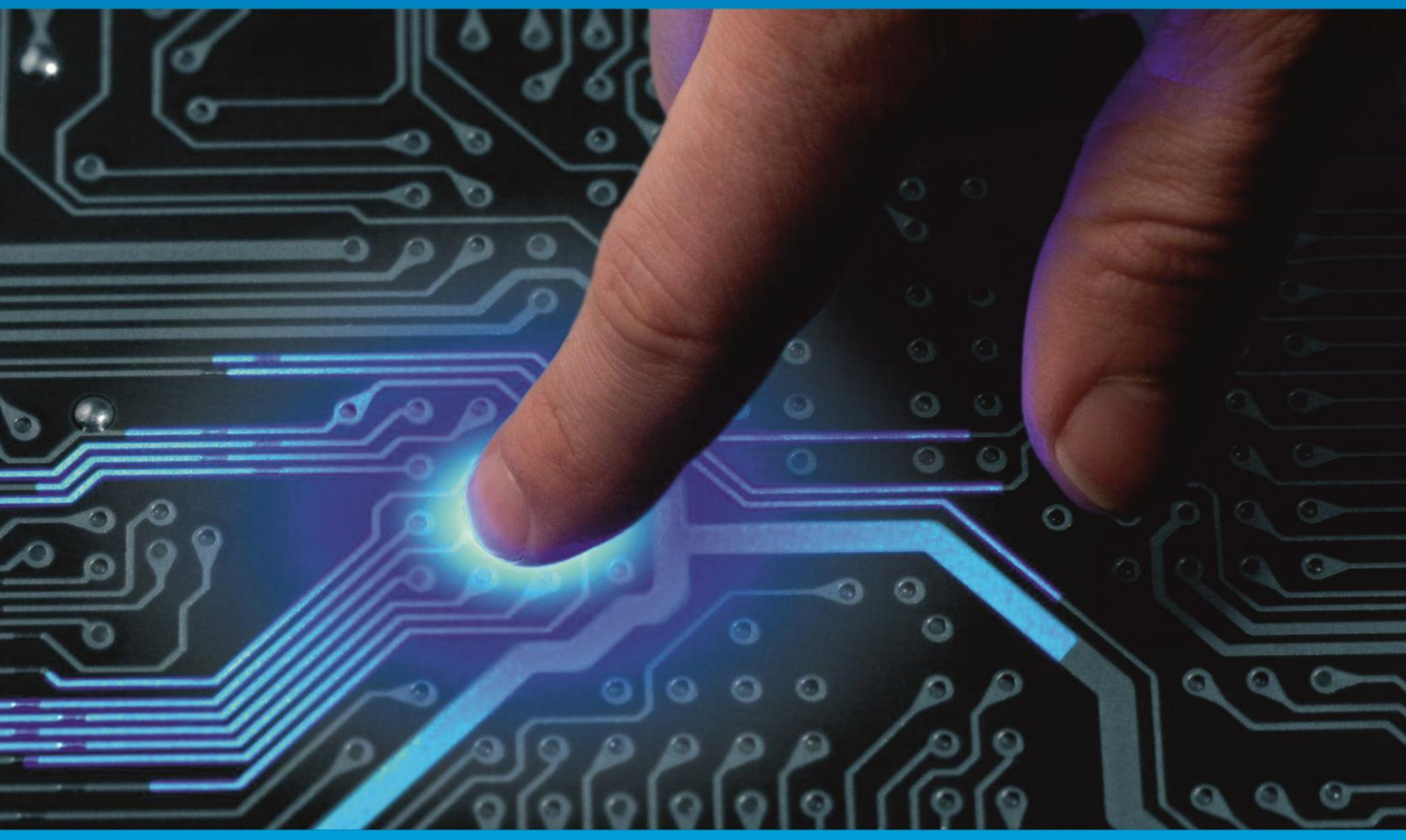

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A Survey on Job Scheduling with Resources in IoT

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ABSTRACT: The field of IoT contains various challenges. The Internet of things requires multiple resources to be handled at a time. As well job sequencing require proper resources to process respectively with time. Multiple heterogeneous ubiquitous devices are connected in IoT through an ad-hoc network. They will exchange data, services with each other. Their functionality changes with required service. Available resources can be utilized for optimal job sequencing. Intelligence can be generated using data and requirement, to provide solution.

KEYWORDS: Internet of Things, Learning and adaptive system [68T05], Scheduling, Resource Utilization

I. INTRODUCTION

In computer system, job scheduling is used for allocation of available resources to process different tasks. For that purpose job scheduler is used to manage arriving jobs as well pending jobs at system. Which analyzes job request with it's characteristics and change their sequence into queue. There is lots of scheduling algorithms available for job scheduling into operating system such as FCFS, priority, shortest job first, round-robin scheduling, etc [1][2]. The job scheduler gathers processor status and analysis(scan) of jobs in queue. In case of empty queue first-fit policy used. And in case of multiple jobs, then characteristics of job affect on job sequencing. It contains characteristics as job size, priority, execution time, dead line, arrival time, required resources, etc.[1]. Each job contains different parameters.

There are numbers of scheduling algorithm available as per requirement. First-come-first-server is sequential scheduling algorithm works as queue with one side entry and other side exit. There is no comparison between jobs is done, execution is done as it is. But contains many drawbacks like unwanted task can consume resources which are required by other tasks. Jobs with minimum deadline will die or cant able to get service itself. Job with highest priority comes at end then it will be starving until previous jobs executed. Priority scheduling algorithm used to change sequence of jobs with their priority. Priority of jobs are different for operations and weightage. Shortest job first(SJF) scheduling is used to batch task with smaller burst time or duration. So jobs with maximum burst time will be executed later. SJF scheduling algorithm is optimal if all resources are available. Round Robin scheduling algorithm executes each process for fixed time of interval. Fixed time interval is known as quantum into round robin. Once process is executed for fixed time then other process swapped in and executed for same time. Context switching used into process to save preempted process.

Poisson distribution is discrete probability distribution that provides number of jobs occurred into fixed interval of time or space. It used expectation and variance to calculate occurrence of job with respect to time.

Internet of Things(IoT) is the network of connected physical devices over internet with different geographical location. In IoT 'thing' means any kind of physical device which communicate with other devices via networking. Networking may be wireless, wired, bluetooth, infrared, etc. communication protocols. For example fitbit bands come under this category, they are not directly connected to internet but connected to mobile phone or computer. And internet connection is available on mobile phone.

Ubiquitous computing concept is used into Internet of Things. Each thing in the IoT also called ubiquitous device. Currently most of devices made with IoT capabilities so they can interface with other system via physical or software interface protocols. For example Raspberry Pi is micro processing device used to communicate with other embedded devices such as direct serial pin inputs. It can be also connected to other devices via bluetooth or WiFi. Internet of Thing provide access independent of platform, distance, etc.. Using remote procedure call device will be controlled to perform certain task.

Resource utilization is used to manage available resources efficiently. To allocate tasks required resources need to be available. Like problem occurs in shop, Producer-consumer problem resource need to maintained. Without proper resources job won't able to execute, so resource management is required. For resource management into the IoT can be done like producer-consumer problem. Known and unknown request can be managed by available information into system. Identification can be used to handle know tasks. Combination of job scheduling algorithm designed to generate

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definite result. Also to generate more optimal solution jobs can arranged with execution time and location. It will provide horizontal and vertical classification to choose it.

In case of ubiquitous operations fixed technique of job execution will not work in different positions and possibilities. Decisions making needed with available resources to get definite results. Resource management and job scheduling strategy are required. Workload, resources, scheduling requirements and other major component based rules required for fairness of jobs execution. Resources can be anything that can be used like memory space, networking, storage devices, green energy storage, etc.

Now-a-days computers, mobile phones, ubiquitous devices and internet are wholly dependent on human beings for information. So the problem is that people are not good at attention, accuracy and time so they will not capture accurate data.

II. LITERATURE SURVEY

While executing jobs on machine different parameters are considered by system. Such as job size, priority, required resources, execution time, arrival time, occurrences, etc. Kento Aida in his paper Effect of job size characteristics on job scheduling performance\cite{paper1} states that about categorizing jobs by it's parameters to change their sequence. Jobs can be differentiated with required resources, like smaller jobs, bigger jobs with same parameters. Shortest job first model can be used to execute jobs with lower execution time. Arrival time can be mapped with other dependent jobs to group into one batch process. Arrival of job in all system is considered to be poisson distribution. Jobs on a parallel computers as

$$\text{load} = \lambda.p/m.\mu \quad \text{(eq.1)}$$

Here, λ denotes an arrival rate of a job, and μ states meanservice rate on a parallel computer, that is, $1/\mu$ representsmean execution time of a job. Also p and m denotes mean jobsize in workload.

Many parameters regarding tasks/jobs are required for jobsequencing. Those characteristics provide weightage to jobs,values of characteristics changes importance level of jobin decision making. Job size, execution time, arrival time,deadline, resources required, identification no., priority, owner,etc. were considered in scheduling algorithm [1], [2].

In paper a resource-allocation queueing fairness measureDavid Raz, Hanoch Levy[2] states the necessity ofprovidingresources to all jobs. For fairness measure, we consider generalqueueing model like single server queueing model. Wherestream of arrival customer demotes C_1 , C_2 , ..., at system.a_i would be approach of customer, s_i is the total servicerequirement of C_i. d_i is departure of C_i, s_i (t) to be fractionof the capacity of the server devoted to C_i. Then system at t :

$$\sum_{i|t\epsilon(a_i,d_i)} s_i(t) = 1 \quad \text{(eq.2)}$$

C_i at t , D_i (t) is defined as the amount of service grantedto C_i , the quantity of warranted service of C_i at epoch t is denoted as R_i (t), that is :

$$D_i(t) = si(t) - Ri(t) = si(t) - 1/N(t) \quad \text{(eq.3)}$$

$$D_i = \int_{a_i}^{d_i} D_i(t)\delta t = \int_{a_i}^{d_i} (s_i(t) - 1/N(t))\delta t \quad \text{(eq.4)}$$

where,

- $\sum_i D_i(t) = 0$
- $\sum_i s_i(t) = 1$
- $\sum_i R_i(t) = N(t)(1/N(t)) = 1$

Therefore,

$$E[D] = 0 \quad \text{(eq.5)}$$

Kishor Trivedi[3] discuss use of the Poison process for real time applications. Poisson distribution with job scheduling provides organized scheduler. Poisson distribution states events which occurs after fixed time interval. Poisson rate used to differentiate between processes. For example, Electrical Power failure have high priority in case of computing devices, resource handling. So, it need quick execution for power handling. Poison distribution used for applications such as number of incoming telephone calls, the number of job arrival at file server, etc. Probability of number of events occur into fixed time interval or space, if these events occur with a known average rate independently is known as poisson distribution. They were counted when occurred constantly and independently of time. P (J jobs in interval) obtained from poisson distribution function. This is denoted as

$$\text{P(k events in interval)} = e^{-\lambda}\frac{\lambda^k}{k!} \quad \text{(eq.6)}$$

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where

- k = 0, 1, 2, . . .;
- e = (Euler's number) the base of natural logarithms
- Λ = the average number of events per interval
- k! = k(k-1)(2-2)...2*1

It represents the probability that a random variable X takes on the value x:

$$\text{Prob}(K=k) = p_k(\lambda) = P(\text{k events in interval}) \quad \text{(eq.7)}$$

M.J. Gonzalez Jr. and J.W. SOH [4] explains importance of periodic job scheduling of independent processes to optimize time in their paper periodic job scheduling in a distributed processor system. Each job can be grouped according to it's parameters such as execution time and it's frequency. In system, set of jobs execute periodically (frequencies) and arbitrary execution times. The computational requirement C od a set of jobs can be represented as C = J_i , < where i = 1, 2, ...,N, where the J_i represents individual jobs and N is total number of jobs to be executed. Let, E_i represent the maximum execution time of J i , and f i execution rate then, J_i : (f_i , E_i), $1 \leq i \leq N$. T_i is repetition period, inverse off i . Jobs scheduling of independent periodic jobs can be done with a binary frequency distribution.

Scheduling algorithms are changed with available resources and user demand. Job characteristics were used by already available scheduling algorithms. Set of jobs execute periodically (frequencies) and arbitrary execution times. For fixed number of jobs in fixed time periodic job scheduling is done.

G. Hayhurst[5], [6] research paper explain about job scheduling optimization. while performing job scheduling on system, all resources should be considered. That means some resources can not be left out of utilization. For example scheduling jobs A, B, C there are three processors available for execution. But only two are allocated into processing. That will cause extra time as well some part of computation remains idle. which can be used to improve performance and utilization[6]. To fully utilize computer system resources some parameters need to be considered such as wasted time, unnecessary delay, active schedule. Time when machine becomes idle in between two job is known as wasted time. In active schedule, wasted time and unnecessary delay can be overcome. Unnecessary delay is gap caused after processing particular job. It can be represented as Active schedules =< N umber in set of F easible Schedules =< (N!) M , where N = No. of jobs, M = No. of machines.

In paper job scheduling is more important than processor allocation for hypercube computers Philip Krueger, TenHwang[7] states importance of managing resources. They proposed two steps for managing resources as choosing job to execute among waiting jobs(job scheduling) and allocation of resources or processor. Managing incoming jobs with available resources is must into computation. Dynamic scheduling is applicable into job scheduling to switch to current demanding job. Cause static method will not be able to change sequence of jobs. Dynamic scheduler will provide two independent function such as job scheduler and process allocation. In that case, job scheduler will keep changing positions of jobs accordingly with ready jobs. And processor allocation will provide access to particular resources to complete that execution. Combination of both will provide increased performance.

Maryline Chetto in his paper optimal scheduling for raltime jobs in energy harvesting computing systems [8] mentions each job contains release time, deadline, required computation time with required energy. So he proposed semi-online earliest deadline first algorithm can be used in real-time scheduling theory without energy constraints. Environmental energy is available in abundance, which use used by plats, animals and also by human by daily life activity. But it cannot be used for machines, electronic devices directly. For that purpose it should be available in electrical form. Energy harvesting system are used to convert environmental energy into required form and stored for further use. Devices such as solar panel, piezoelectricity, thermo-electricity, and physical motions used. Each job can be classified by it's characteristics. And that can be used to calculate processing time between arrival time to jobs deadline. in this paper two issues are discussed. Firstly runtime scheduling, provides scheduling algorithm to meet all deadlines. Secondly, feasibility test used to check if scheduling system provide solution to overcome all deadline or not. Earliest deadline first job scheduling used to process jobs with lower deadline first.

Clemens Moser, Jian-Jia Chen, Lothar Thiele in power management in energy harvesting embedded system with discrete service levels[9] explains about power management into embedded systems. Embedded devices power consumption changes with time and working frequency but energy harvesting devices can not provide extra power in case of extra power needed. He has proposed system model which contains energy harvesting model, energy storage model, Service model. Service model decide at what time extra power consumption can be possible and how much. Greedy approach used for service allocation into embedded system. Energy source devices collect harvested energy and stored into energy devices. Where scheduler takes decisions for allocation from available energy and predictor. Where 'K' predicts intervals in future, $E_H(k)$ for accumulated energy harvested for k-th frame. Maximum energy is provided by $E_C\ (k-1) + E_H\ (k) - e_k$.

In paper scheduling of frame-based embedded systems with rechargeable batteries[10], Andre Allavena and Danial Mosse mentions about automatically recharging discharging batteries. Threshold used to detect min-max level of

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battery $\Delta E = E_{max} - E_{min}$. Two different scheduling tasks used as recharging tasks and dissipating tasks. Recharging tasks are used to charge battery itself after it goes down below E min. Dissipating tasks are used to assign resources to other jobs, where battery level decreases after allocation. Allavena and Mosse proposed an algorithm to work in fixed speed CPU and varing speed CPU.

Chatterjee, Levan, Lanham, Zerrudo proposed particle swarm optimization technique for job scheduling in paper job scheduling in cloud datacenters using enhanced particle swarm optimization[11]. In homogeneous environment scheduling for resource allocation is possible like used in operating system for processes. But in datacenters, scheduling become more complex cause of time-constraints, infrastructure, multiple resources. Therefore algorithms are proposed from natural world as ant colony, particle swarm optimization, artificial bee colony and many more. Particle swarm optimization is method of optimizing continuous nonlinear functions. There are two methods proposed into paper as Naive Scheduling Algorithms for Cloudlets and Particle Swarm Optimization. Also discussed experimental setup into real time applications.

C. Moser, D. Brunelli in real-time scheduling with regenerative energy[12] proposed method optimal scheduling algorithm that handles energy and time domain both constraints. In wireless sensor network, single node energy management handled with battery-operated embedded system. Explains about working of difference between earliest deadline first and lazy scheduling algorithm. It illustrates the sensor node with energy harvesting unit and a rechargeable battery - can be used to task defined by an arrival time, required resources and deadline.

III. CONCLUSION

This paper explains method used energy harvesting devices, wireless network device, independent task scheduling. Different techniques used to achieve required goal. There are very few methods for using external resources into ubiquitous devices. Scheduling algorithms with resource handling can be used to satisfy that.

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