Assessment of Response Time for New Multi Level Feedback Queue Scheduler

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Abstract—Response time is one of the characteristics of scheduler, happens to be a prominent attribute of any CPU scheduling algorithm. The proposed New Multi Level Feedback Queue (NMLFQ) Scheduler is compared with dynamic, real time, Dependent Activity Scheduling Algorithm (DASA) and Locke’s Best Effort Scheduling Algorithm (LBESA). We abbreviated result of NMLFQ scheduler in comparison with dynamic best effort schedulers with respect to response time.

Keywords—NMLFQ, scheduler, process, queue, deadline, preemption, priority, Multi Level, DASA, LBESA, Dynamic, Best Effort and algorithm.

I. INTRODUCTION

In a multiprocessing environment of computer, the operating system’s theme is to assign the execution time for various processes. The main component of kernel that creates the “selection” is called the scheduler [1][4][31][44][51]. The representation of the policy of scheduler employed is called the scheduling algorithm. Numerous different scheduling algorithms have been deduced over the years.

II. REVIEW OF DYNAMIC BEST EFFORT REAL-TIME SCHEDULING ALGORITHMS

At least two flavors of best-effort real-time scheduling algorithms exists. This comprises of the Dependent Activity Scheduling Algorithm (DASA) and Locke’s Best Effort Scheduling Algorithm (LBESA) [2][6][38][42][49].

In fact, the DASA and LBESA scheduling algorithms are comparable with the canonic Earliest Deadline First (EDF) algorithm during under-loaded conditions. In this case, the EDF promises to meet entire deadlines and is always optimal. However, in the case of an over-loaded circumstance, DASA and LBESA attempt to increase the total task benefit [12][17][34].

The author R.K. Clark et al. [43], demonstrates that DASA more often, overtakes LBESA for the duration of over-loaded circumstances. Peng Li and Ravindran [41], confirms that DASA overtakes the Robust Earliest Deadline First (RED) scheduling algorithm [15][19][35].

Burns A et al. [10], asserts that alternative features of DASA and LBESA are utilized for the development of MK7.3 kernel. R.K. Clark et al. [43], emphasizes that wide-ranging characteristics of DASA and LBESA are exploited for the growth of Alpha real-time operating system [13][16].

According to R.K. Clark et al. [43], DASA and LBESA are the decent, benefit accrual scheduling algorithms. Both of these algorithms are employed to utmost extent for the growth of mission critical systems [25][26].

The characteristic and performance measurement parameters of each of the scheduler are known from previous work of others. The literature survey provided several outstanding noticeable features [9][14][27][32].

After studying policy mechanisms of different available schedulers, a New Multilevel Feedback Queue (NMLFQ) scheduling algorithm is proposed. NMLFQ includes all necessary modules to compete as a real time scheduler applied in embedded system domain [18][22].

The MLFQ principle of operation is used in NMLFQ scheduling algorithm in such a way that the response time is reduced and the functionality of the scheduling is improved [21][23][33]. The maximum number of queues and the quantum burst time for each queue are found using dynamic method. In NMLFQ scheduling, the operating system can modify the number of queues and the quantum of each queue according to the obtainable processes, deadline and as well as urgency consideration of the process (Garcia P. et al. [16]).

In Earliest-Deadline-First scheduling (EDF) priority level for every task is neglected. It primarily concentrates on completion of each task. It focuses on selection of task with nearest deadline for execution. Respectable CPU utilization will be gained, only when the chosen task is having precise deadline [3][20][36][42]. The canonic algorithm for real-time operating systems is EDF. It practices dynamic scheduling principle. The ready process from pool of priority queue is to be selected. The chosen process from the queue will be searched, for the process nearest to its deadline. The selected process is then scheduled to begin execution. The main drawback of the algorithm is, as and when the system is overloaded, the set of processes will miss deadlines and the system leads to deadlock.
Fig. 1, demonstrates the problem of missing of tasks in response to a deadline. The X axis corresponds to the values of time in milliseconds. Y axis corresponds to light weight processes or small threads. In the example of a load sharing of several time restraint jobs, response is expected at accurate time \cite{5}\cite{7}\cite{39}\cite{47}\cite{53}. As the fig. 1, illustrates, request is made at 3 milliseconds. The response is expected within deadline period. Here a dispatch latency of 1 millisecond is suffered during the operation. Henceforth the response is sent after the deadline period. The response is sent at 4 milliseconds missing the deadline, in turn results in invalid response. The data object is passing some vital data to another object involving many processes and threads. We expect to have a response to a request within three milliseconds. The requirement will be perfect if the system reacts within two milliseconds. If the response comes after three milliseconds, the job execution crashes. There exists a sleek time of 1 millisecond from 3 to 4 milliseconds. So here the task missing the deadline results in invalid response.

In general a scheduler is written precisely to respect application priorities. It is necessary for real time applications need to be developed with limited dispatch latency \cite{8}\cite{10}\cite{28}\cite{40}\cite{45}. The term dispatch latency designates the amount of time a system takes to respond to a request for a process to begin operation. The complete application response time comprises of the interrupt response time, the dispatch latency and the application's response time. The system detects that a process with higher priority than the interrupted process is now ready to dispatch and dispatches the process. The time to switch context from a lower priority process to a higher priority process is comprised in the dispatch latency time.

The shorter version of the pseudo-code of NMLFQ scheduler is described in the following section. This includes dynamic priority of arriving processes. Construction of queue is performed by loading with, certain number of processes to carry out small jobs \cite{11}\cite{20}\cite{29}\cite{37}.

Depending on the load of jobs for the scheduler, the numbers of processes are dynamically varied in ready queue. We can designate several levels of queues, depending on waiting condition of processes and urgency conditions of tasks. At any instant of time and with any number of processes and jobs to be completed, scheduler must guarantee meeting the deadlines of the hard real-time tasks.

```java
/* This method add the process to the readyQueue based on priority. It will check the priority and moves the other processes in readyQueue accordingly. */
METHOD BEGIN : public void addAtFront(int priority, Process temp)
    Enumeration enumitr = pQueue.keys();
    WHILE BEGIN : (enumitr.hasMoreElements())
        IF BEGIN : (!(priority <(Integer)enumitr.nextElement()))
            pQueue.put(priority, temp);
            readyQueue.add(temp);
        IF END
    WHILE END

PUBLIC CLASS BEGIN : DynamicPriority
    VARIABLE : Vector<Process> readyQueue =new Vector();
    VARIABLE : Hashtable<Integer, Process> pQueue = new Hashtable<Integer, Process>();
    VARIABLE : public Process p=null;
    VARIABLE : public Process removedProcess=null;
    CONSTRUCTOR BEGIN : DynamicPriority()
        //Initially loading Queue with some number of processes.
```

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METHOD BEGIN : public void insertIntoPQueue(int priority, Process process)
    //Adding process to the Queue and also into readyQueue
    IF BEGIN :(process != null)
        pQueue.put(priority, process);
        readyQueue.addAll(pQueue.values());
        System.out.println("process is added into Ready Queue");
    IF END
    ELSE BEGIN
        System.out.println("process is null");
    ELSE END
METHOD END

METHOD BEGIN : public Process removeAtEnd(int index)
    //Removing the process from the index specified from both readyQueue and pQueue
    readyQueue.remove(index);
    RETURN : return(pQueue.remove(index));
METHOD END

METHOD BEGIN : public void planningBased()
    IF BEGIN (true)
        //Task is accepted for execution
        //Resource are allocated.
        //Responds in time
    IF END
METHOD END

METHOD BEGIN : public void bestEffortBased()
    IF BEGIN : (true)
        MONITOR BEGIN
            Enumeration enumitr = pQueue.keys();
            Vector sorted = new Vector();
            WHILE BEGIN : (enumitr.hasMoreElements())
                int dynArr = (Integer)enumitr.nextElement();
                sorted.add(dynArr);
            WHILE END
            Collections.sort(sorted);
            FOR BEGIN (int i=0;i<sorted.size();i++)
                //Before calling shortest job first set the priority for the job.
                ExecutingProcess((Process)sorted.get(i++));
            FOR END
            MONITOR END
    IF END
METHOD END

METHOD MAIN BEGIN : public static void main(String[] args)
    // TO-DO Auto-generated method stub
    //Creating Queue
    CALLING METHOD : new DynamicPriority();
    //Removing processes from Queue
    CALLING METHOD : new DynamicPriority(2);
    CALLING METHOD : new DynamicPriority(110);
    MONITOR BEGIN
        CALLING METHOD : new DynamicPriority().addAtFront(2,Runtime.getRuntime().exec("ps -ef"));
        CALLING METHOD : new DynamicPriority().planningBased();
        CALLING METHOD : new DynamicPriority().bestEffortBased();
        MONITOR END
        CATCH BEGIN (IOException e)
            // TO-DO Auto-generated catch block
            e.printStackTrace();
        CATCH END
    METHOD MAIN END
CLASS END

A job is a function of many tasks or processes. Division of jobs into task modules is performed from analysis of jobs. All the steps of NMLFQ scheduler are summarized in fig. 2. This model depicts the coordination amongst various modules of scheduler. Jobs are divided into task modules after the analysis of the nature of jobs. The history of jobs is maintained for future use. The processes are allocated to lock the resources with the control of interrupt handler. The task controller is made to govern for time stamping of deadline. It also supervises ready, pending, blocked and sleeping tasks. The evaluation of priority levels of processes, ordering of processes and division into time slices is controlled by scheduler through the task controller. The peripherals are associated to the CPU through input output controller. This
occasionally makes use of context switching. Several queues are supervised by a substantial queue controller. As stated earlier, mapping of processes to critical resource is achieved by semaphores. Dynamic prioritization is a vital task of scheduler, which necessitate raising or scaling of priority of processes.

III. NMLFQ COMPARISON WITH BEST-EFFORT REAL-TIME SCHEDULING ALGORITHMS - DASA AND LBESA

The NMLFQ real time scheduler is compared with existing best-effort real-time scheduling algorithms. This comprise of the Dependent Activity Scheduling Algorithm (DASA) and Locke’s Best Effort Scheduling Algorithm (LBESA) [20][52][54]. The comparison of NMLFQ scheduler with DASA and LBESA is accomplished for twenty test cases. The results of NMLFQ, DASA and LBESA for twenty different set of inputs are reckoned. The results provided ameliorate characteristics for CPU utilization, overall turnaround time, average turnaround time, average waiting time and average response time of schedulers. The comparative results are analyzed for several processes correspondingly, as shown in fig. 3 and generalized graph of hundreds of processes can also be drawn. Fig. 3, exemplifies, Average Response time for NMLFQ scheduler, compared with real time DASA and LBESA schedulers for twenty testcases, proves 10 to 25% reduction of response time. In this research paper, We have depicted the performance with respect to Average Response time for NMLFQ scheduler

Fig. 3, proves as per the achieved results, average response time for NMLFQ scheduler, compared with real time DASA and LBESA schedulers for twenty testcases, illustrates 10 to 25% reduction of response time in each subsidiary stage.

Fig. 1 Task missing the deadline results in invalid response.
Fig. 2 Model of detailed conceptual view of NMLFQ including several modules.

Fig. 3 Average Response time for NMLFQ scheduler, compared with real time DASA and LBESA schedulers for twenty testcases, depicts 10 to 25% reduction of response time in each subsidiary stage.
IV. CONCLUSIONS

In this research paper, we have discussed the themes associated with NMLFQ scheduler. The basic review of dynamic best effort real-time scheduling algorithms is explained. Comparison of proposed scheduler is made, with best-effort real-time scheduling algorithms - DASA and LBESA. Eventually, Model of detailed conceptual view of NMLFQ including several modules is also discussed in short.

REFERENCES

[1] Abdelzaher T. F., Sharma V., and Lu C., “A Utilization Bound for Aperiodic Tasks and Priority Driven Scheduling”, in IEEE Transactions on Computer, Volume 53, Number 3, Page(s): 334-350, 2004.

[2] Albert Haque, “An Analysis and Comparison of Processor Scheduling Techniques”, University of Texas at Austin, abahque@cs.utexas.edu, December 7, 2012.

[3] Arezou Mohammad and Selim G. Akl, “Scheduling Algorithms for Real-Time Systems”, Technical Report No. 2005-499, Natural Sciences and Engineering Research Council of Canada, School of Computing, Queen’s University, July 15, 2005.

[4] Ashiq Anjum, Richard McClatchey, Arshad Ali and Ian Willers, “Bulk Scheduling With Diana Scheduler”, in proceedings of IEEE Transactions on Nuclear Science, ISSN 0018-9499, Volume 53, Issue 6, Page(s): 3818-3829, 2006

[5] Ayan Bhunia, “Enhancing the Performance of Feedback Scheduling”, International Journal of Computer Applications, ISSN 0975 – 8887, Volume 18, Number 4, March 2011.

[6] Baskiayar S and Meghanathan N, “A Survey of Contemporary Real-time Operating Systems”, Informatics, Volume 29, Auburn University, Auburn, USA, Page(s): 233–240, 2005.

[7] Becchetti, L., Leonardi, S. and Marchetti S.A., “Average-Case and Smoothed Competitive Analysis of the Multilevel Feedback Algorithm”, Mathematics of Operation Research, Volume 31, Number 1, February, Page(s): 85–118, 2006.

[8] Behera H. S., Rakesh Mohanty, Sabaynesh Sahu and Sourav Kumar Bhoi, “Comparative Performance Analysis of Multi-Dynamic Time Quantum Round Robin (MDTQRR) Algorithm with Arrival Time”, Indian Journal of Computer Science and Engineering, IJCSE, ISSN: 0976-5166, Volume 2, Number 2, Page(s): 262-271, Apr-May 2011.

[9] Brehner G and Diesell O, “Chip-based Reconfigurable Task Management”, in Field-Programmable Logics and Applications (FPL’01), Springer Verlag, Berlin, Germany, Page(s): 182–191, 2001.

[10] Burns A, Tindell K and Wellings A.J. “Fixed priority scheduling with deadline prior to completion”, in proceedings of Sixth Euromicro Workshop on Real-time systems, Research Group Department of computer science University of York, UK, Page(s): 138 – 142, 1994.

[11] Cai Sueng and Hugh Anderson, “Queueing Theory”, Operating System, Group Project Report, Group 36, NUS, National University of Singapore, school of computing, 2007 - 2008.

[12] David B. Stewart, Donald E. Schmitz, and Pradeep K. Khosla, “The Dynamic Best Effort Real-time Computing”, in proceeding of the sixteenth ACM Symposium on Operating Systems Principles, ACM SOSP ’97, ISBN:0-89791-916-5, Page(s): 198-211, 1997.

[13] Micro digital, “Simple Multitasking Executive”, in proceedings of online document SMX RTOS, smxinfo, Embedded Software Outfitters, SMX, Symmetry Innovations, Australia, December 2004.

[14] Mohammad Reza Effat Parvar, Karim Faez, Mehdi EffatParvar, Mehdi Zarei, Saeed Safari, “An Intelligent MLFQ Scheduling Algorithm (IMLFQ) with Fault Tolerant Mechanism”, in proceedings of Sixth International Conference on Intelligent Systems Design and Applications, ISDA’06, Volume 3, Page(s): 80-85, Oct 2006.

[15] Mohammad Reza Effat Parvar, Mehdi Effat Parvar, Abolfazl Toroghi Haghighat, Reza Mahini, Mehdi Zarei, “An Intelligent MLFQ Scheduling Algorithm (IMLFQ)”, in proceedings of International Conference on Parallel and Distributed Techniques and Applications, PDPTA, Las Vegas, Nevada, USA, Page(s): 1033-1036, June 2006.

[16] Mohammad Reza Effat Parvar, Akbar Berman, Mehdi EffatParvar, “IMLFQ Scheduling Algorithm with Combinational Fault Tolerant Method”, in proceedings of International Conference on Formenatica Systems Sciences and Engineering, Prague, Czech Republic, Jan 2006.

[17] Mohamed Reza Effat Parvar, Mehdi Effat Parvar, Saeed Safari, “A Starvation Free IMLFQ Scheduling Algorithm Based on Neural Network”, International Journal of Computational Intelligence Research, ISSN 0973-1873, Volume 4, Number.1, Page(s): 27–36, 2008.

[18] Panduranga Rao M.V. and Shet K.C., “Study and Development of a New Multi Level Feedback Queue Scheduler for Embedded Processor”, International Journal of Computer Sciences and Engineering Systems. IJCSES, ISSN 0973-4406, Volume 4, Number 3, Page(s): 203-213, July 2010.

[19] Panduranga Rao M.V. and Shet K.C., “A Simplified Study of Processor Scheduler for Real Time Operating System”, International Journal of Computational Cognition. IJCC, ISSN 1542-5908 (online); ISSN 1542-8060 (print), Volume 8, Number 3, Page(s): 5-16, September 2010.

[20] Panduranga Rao M.V. and Shet K.C., “A Research in Real Time Scheduling Policy for Embedded System Domain”, CLEF Electronic Journal, ISSN 0717–5006. Volume 12, Number 2, Paper 4, August 2009.
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PAUL DI FRANCESCO, "Design and implementation of a MLFQ scheduler for the Bacula backup software", Master thesis in Global Software Engineering, Universita degli Studi dell’Aquila, Italy, 2011/2012.

PENG LI and BINNY RAVINDRAN, “Fast, Best-Effort Real-Time Scheduling Algorithms”, IEEE Transactions on Computers, Volume 53, Issue 9, Page(s): 1159-1175, Sept 2004.

RAYMOND KEITH CLARK, “Scheduling Dependent Real-Time Activities”, PhD Thesis, School of Computer Science, Carnegie Mellon University, CMU-CS-90-155, August 1990.

RAYMOND KEITH CLARK, JENSEN E.D and ROUQUETTE N.F., “Software organization to facilitate dynamic processor scheduling”, in IEEE Workshop on Parallel and Distributed Real-Time Systems (WPDRS), Page(s): 122b, 2004.

SAMI KHURI, HSU-CHIN HSU, “Visualizing the CPU Scheduler and Page Replacement Algorithms”, Proceedings of the 30th ACM SIGSCE Technical Symposium on Computer Science Education, SIGSCE ’99, New Orleans, Louisiana, USA, ACM Press, New York, Page(s): 227-231, March 1999.

SHAROOR FEIZABADI et al., “Utility Accrual Scheduling With Real-Time Java”, On The Move to Meaningful Internet Systems, OTM Workshops, ISBN 978-3-540-39662-9, Page(s): 550-563, 2003.

SHAROOR S. FEIZABADI, “Garbage Collection Scheduling for Utility Accrual Real-Time Systems”, PhD Thesis, Virginia Polytechnic Institute & State University, Blacksburg, Virginia, December 7, 2006.

SIFAT ISLAM et al., “Concurrence Compliant Embedded System Modeling Methodology”, in 2nd Annual IEEE International Systems Conference, SysCom 2008, ISBN: 978-1-4244-2149-7, Montreal, Canada, Page(s): 1-8, April 2008.

SILBERSCHATZ, A., P.B. GALVIN and G. GAGNE, “Operating Systems Concepts”, 7th Edn., John Wiley and Sons, USA., ISBN: 13: 978-0471694663, Page(s): 944, 2004.

SIMONE O and SOUMA L, “On Task Scheduling Accuracy: Evaluation Methodology and Results”, in The Journal of Supercomputing, Volume 27, Number 2, Page(s): 177-194, 2004.

SUKANYA SURANAUWARAT, “A CPU Scheduling Algorithm Simulator”, Session F2H. 37th ASEE / IEEE Frontiers in Education Conference, Milwaukee, WI, Page(s): F2H-19 - F2H-24, October 10-13, 2007.

TANENBAUM A.S., “Modern Operating Systems”, 3rd Edn., Prentice Hall, ISBN: 13: 978013606633, Page(s): 1104, 2008.

TORREY, L.A., COLEMAN, J and MILLER, B.P., “A Comparison of the Interactivity in the Linux 2.6 Scheduler and an MLFQ Scheduler”, Software Practice and Experience, John Wiley & Sons, Ltd, Volume 37, Number 4, Page(s): 347-364, 2007.

YASHUWANTH C and RAMESH R, A New Scheduling Algorithms for Real Time Tasks, International Journal of Computer Science and Information Security, IJCSIS, ISSN 1947-5500, Volume 6, Number 2, Page(s): 61-66, 2009.

ZHU QUAN and JONG-MOON CHANG, “A Statistical Framework for EDF Scheduling”, in Journal on IEEE Communication Letters, Volume 7, Number 10, Page(s): 493-495, 2003.