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A SIMULATOR FOR SCHEDULING DUAL TUB WASHING MACHINE-AN EMBEDDED SYSTEM CASE STUDY

Rajesh Kumar Garg

Lecturer, Electronics & Comm. Engg.

Seth Jai Parkash Polytechnic

Damla, Yamuna Nagar-135001

Haryana (INDIA)

email- rajesh_damla@yahoo.co.in

Vikram Singh

Professor

Deptt of Computer Science & Applications

Chaudhary Devi Lal University

Sirsa, Haryana (INDIA)

email- vikramsinghkuk@yahoo.com

Abstract: This paper describes the use of simulation concept in scheduling of washing activities of a washing machine (dual tub)-an embedded system .The embedded systems contain programmed instruction running via processor chips. Embedded systems are programmable devices or systems which are generally used to control or monitor the devices. Simulation is used to observe the dynamic behavior of model of a real or imaginary system. Indeed, by simulating the complex system we are able to understand its behavior at low cost. The Program Evaluation and Review Technique is a network model that allows for randomness in activity completion times. In this paper, activities and nodes for preparing network diagram are taken for washing machine and then apply simulation to identify the critical and near critical activities, so that scheduling process is organized and managed economically.

Keywords: Activity, Criticality Index**.** Simulation, Scheduling, Washing machine,

I INTRODUCTION

The case of semi automatic machine is considered in this work. The washing machine can operate under three modes- fully automatic, semi automatic and manual mode. Under fully automatic mode user intervention requirement may be zero. Once the system is started in this mode, it performs its work independently and after the completion of work it should notify the user about the completion of work. But in this case there is wastage of water and the started cycle stops only after completion of the work. In semi-automatic mode also, user interferences are nil. But user has to choose any one of the semi-automatic mode in which washing conditions are predefined. Once the predefined mode is started the washing machine performs its job and after completion it informs the user. In manual mode, continuous intervention of user is required. User has to specify which operation he wants to do and has to provide related information to the control system. For example, if user wants to spin only, he has to choose 'spin' option in manual mode. Then the system asks the user to enter the spin time, amount of water and the load. After these data are entered, the user starts the machine. When the specified operation is completed system informs the user by alarm. When the lid is open system will not work. If door is accidentally opened in between wash operation, then the system stops working in minimum possible time. (Raj Kamal, 2005)

Simulation is used to observe the dynamic behavior of model of a real or imaginary system. (Baci, 1998) Semi automatic washing machine is discussed here. It is an embedded system. The embedded systems contain programmed instruction running via processor chips. Embedded systems are programmable devices (Vahid & Givargis, 2005) or systems which are generally used to control or monitor the devices.

The washing machine has front panel consists of a keypad and LCD display. Keypad provides semi automatic and manual wash options to the user. LCD display is convenient to convey machine information to user. Single phase universal motor has been used to design prototype due to its simplicity. The system described with the help of simulation will provide all basic features of a washing machine like washing, rinsing, spinning etc .for semi automatic mode The washing process is simulated and critical activities are found on which maximum emphasis should be laid by engineers at the time of designing such a system.

II NETWORK REPRESENTATION OF WASHING ACTIVITIES OF WASHING PROCESSNG

The PERT is used here for simulating washing process. For this, a network diagram is being prepared in which activity is a task and nodes are the events after completion of one or more activities. Graphs having loops /cycles can always be reduced to a cyclic graph (Beizer, 1990) There is no loop in the activity network so it can be simulated otherwise it can not be simulated.

In this case study, there are fifteen activities of washing process of dual tub washing machine and seven nodes: Start, Filled, Washed, Rinsed, Drained, Spinned, End. These nodes are interconnected through different activities in network diagram and each activity has its weight depending upon their use. The weights are estimated randomly and generated using beta distribution. It has been assumed that weight assigned to each activity follow a Uniform distribution. A series of random weights is generated using Box Muller transformation (Banks,1996)

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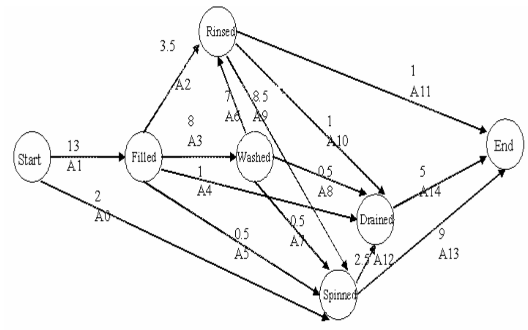

Figure1. Network representation of washing process activities of Dual Tub Washing Machine

The developed simulator identifies the critical and near critical activities. The description of activities is given as follows: - Water filling activities pertains activity A1 having weight 13. Washing activity is A3 having weight 8. A2 is rinsing activity with weight 3.5. A0 carrying weight 2 and A5 carrying weight 0.5, A7 carrying weight 0.5 and A9 carrying weight 8.5 are spinning activities. Draining activities are A4 having weight 1, A8 having weight 0.5, A10 having weight 1 and A12 having weight 2.5. Ending activities pertain activity A9 weight 9, activity A11 weight 1 and A14 weight 5.

Table 1 shows the interconnection of activities and nodes. For example, activity A3 has Starting Node 2 and Finishing Node 3. Similarly activity A11 has Starting Node 4 and Finishing Node 7 so on. (Narsingh Deo, 2008) and (Averill M, 2008)

Table1. START and FINISH for activities of Figure 1

ACTIVITY (I)	S[I]	F[I]
1(A0)	1	5

2(A1)	1	2
3(A2)	2	4
4(A3)	2	3
5(A4)	2	6
6(A5)	2	5
7(A6)	3	4
8(A7)	3	5
9(A8)	3	6
10(A9)	4	5
11(A10)	4	6
12(A11)	4	7
13(A12)	5	6
14(A13)	5	7
15(A14)	6	7

III ALGORITHM

The simulation program will move through following steps:

1. Read the number of activities N, number of nodes M, activity numbers I.

2.Read Start and finish node numbers S[I] and F[I] ,mean MUE[I] and standard deviation SIGMA[I] of activity weights and length of simulation run LRUN=1000.

3 Initially initialize frequency of occurrence of activities FREQ [I] =0.

4. Initialize the critical activity count CRIT [I], which records the number of times an activity becomes critical during the simulation run, to zero.

5. Initialize a variable ERROR =.001(a small value)

6. Set a new variable RUN=1

7 Generate the activity weights W [I] for I=1,N for simulation run using normal distribution.

8. Carry out the forward pass computation.

9. Carry out the backward pass computation, mark the critical activities and update the critical activity count CRIT [I] and FREQ [I].

10. Increment the value of RUN by 1.

11. Check the value of RUN is less than or equal to length of simulation run, LRUN. If so go to step 7.Otherwise calculate the criticality index and show results.

IV MODEL AND PLATFORM USED FOR SIMULATION

This simulator is designed using C++ language under Windows operating system on an Intel compatible machine. The system discussed here is stochastic and dynamic in nature. The next – event discrete simulation model has been used for conducting simulation experiment.

Table 2 Input data for Simulator

Activity (I)	**S[I]**	**F[I]**	**A[I]**	**M[I]**	**B[I]**	**MUE [I]**	**SIGMA [I]**
A0	1	5	0.5	2	4	2.08	0.34
A1	1	2	10	13	15	12.83	0.69
A2	2	4	3	3.5	6	3.83	0.25
A3	2	3	5	8	14	8.50	2.25
A4	2	6	0.5	1	2	1.08	0.06
A5	2	5	0	0.5	1	0.50	0.03
A6	3	4	5	7	12	7.50	1.36
A7	3	5	0.2	0.5	1	0.53	0.02
A8	3	6	0.5	0.5	2	0.75	0.06
A9	4	5	6	8.5	13	8.83	1.36
A10	4	6	0.5	1	2	1.08	0.06

A11	4	7	0.5	1	2.5	1.17	0.11
A12	5	6	0.5	2.5	3	2.25	0.17
A13	5	7	6	9	14	9.33	1.78
A14	6	7	4	5	10	5.67	1.00

Where, A [I] = optimistic estimate for each activity, M [I] = most likely duration for each activity, B [I] = most pessimistic estimate for each activity.

MUE [I] = (A [I] +4 * M [I] +B [I])/6

SIGMA [I] = $((B [I] - A [I])/6)^2$

The simulator is provided with following fixed input: N=15 (Number of activities in washing process), M=7 (Number of functions in the washing process), LRUN=1000 (Number of simulation runs), ERROR= .001. Average (MUE) and variance (SIGMA) for weights of activities are shown in Table 2. User can enter values of N, M, ERROR and LRUN in the designed simulator. If the parameter ERROR is changed the results are also changed. Criticality indices of activities are the outputs of the simulator and given in the Table 3. First column in the table 3 is the activities and other is the critical index of respective activity. Criticality index is the measure of number of times the corresponding activity constitutes a part the critical path out of LRUN times. The value of critical index is 1 of activities A1, A3, A6 and A9 and other activities have value less than 1.The values of activities A12 and A14 are equal and equal to 0.401. The activity A13 has value 0.878.

V DISCUSSION ON RESULTS

The out put of the simulator is shown in the form of bar chart in figure 2 and values of critical index in Table 3.

Table3. Criticality Index Table

Activities	**Critical Index**
A0	0
A1	**1**
A2	0
A3	**1**
A4	0
A5	0
A6	**1**
A7	0
A8	0
A9	**1**
A10	0
A11	0
A12	0.401
A13	**0.878**
A14	0.401

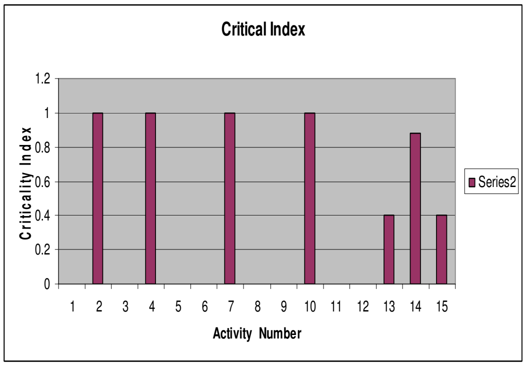

Figure2. Criticality Index bar chart

On analyzing the out put is observed that criticality indices of activity A1 (2), A3 (4), A6 (7), A9 (10) and A13 (14) are more than other activities. It means that filling activity, washing activity, rinsing activity, spinning activity and ending activity are more operated. The activities nos. A1, A3, A6, and A9 and A13 should be scheduled more carefully as compared to other activities.

VI CONCLUSION

Critical activities for washing process of dual tub washing machine are as obtained as output from simulator. Any failure in them will result in failure of washing process of washing machine. Experts must be employed for scheduling critical activities. In this way, the designed simulator will help in scheduling of washing activities of washing process of dual tub washing machine without practical implementation**.** The simulator will be helpful for further planning and development of embedded systems.

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