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Comparative Study of Extensive Round Robin Scheduling by Data Model Approach under Markov Chain

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Abstract: **For optimum usage of CPU, suitable process management is fundamental requirement in scheduling. When a number of jobs are processed, scheduler moves among all processes through a particular strategy so effective resource utilization can be done. During processing, complications may arise because of various factors resulting into rest or idle state of scheduler and processing might get gridlocked. In this paper, transition of CPU is represented by elaborating round robin scheduling scheme over more than one states including waiting state. To study data values, Markov chain model is proposed under two schemes. For analysis, data model approach has been adapted where data sets are created on the basis of mathematical linear data model. Schemes are compared on efficiency parameters through simulation study and graphical analysis.**

Keyword: CPU scheduling, Markov chain, Stochastic process, Transition probability, StateDiagram

I. INTRODUCTION:

Operating system constantly manages all accessible resources in optimum way during scheduling. It handles multiple processes in such a way that they can be scheduled in efficient manner. During scheduling of multiple processes, CPU decides which of the process is to be executed next from ready queue. Processes are managed in terms of size, memory requirement, burst time etc. through various scheduling algorithms.

Scheduling involves randomization which can be studied by probabilistic study. The movement of scheduler over multiple processes can be analyzed through stochastic study of the system. Stochastic processes and their application in various fields have given an elaborated study in the field of computer science ([1],[2])

For effective processing various scheduling schemes are available ([3],[4],[5],[6]).An application ofMarkov chain model is derived for the study of transition probabilitiesin space division switches in computer networks [7].

A model is proposed by representing that scheduling algorithms can be improved in multi programming environment with special reference to task, control and efficiency [8]. The performance of overall system can be improved by involving randomization in round robin scheduling [9]. A new algorithm is proposed to allocate time quantum in a new way for round robin scheduling scheme using integer programming [10]. A general class of multi-level queue scheduling schemes are derived and studied under a Markov Chain model for CPU transitions under specific sets [11]. A modified mean deviation round robin scheduling using random sorting is derived for effective scheduling [12].

In this paper two scheduling schemes are discussed which are based on round robin scheduling. In first scheme transition of scheduler is random over all process states while in second scheme, movement of scheduler is limited. Both the schemes are analyzed through simulation study.

II. PROPOSED UNRESTRICTED MULTI PROCESS EXTENSIVE ROUND ROBIN SCHEDULING SCHEME

Consider a general level round robin scheduling scheme having four processes P_1, P_2, P_3 and P_4 in ready queue. One more state P_5= W as rest state is also considered. For processing a time quantum is decided for each process. Here ***n***will indicate as n^{th}time quantum allotted by scheduler for process execution (n=1, 2, 3, ….). The scheme is based on randomized transition of scheduler over all processes state. Initially Scheduler can pick any of process from P_1, P_2, P_3 and P_4. If any process gets complete within allotted time quantum then it get out of ready queue otherwise it remains in waiting queue and wait for next quantum to allot for its processing. Rest state will be an idle state which accepts random transition of scheduler over itself from any of process $P_{i.}$.

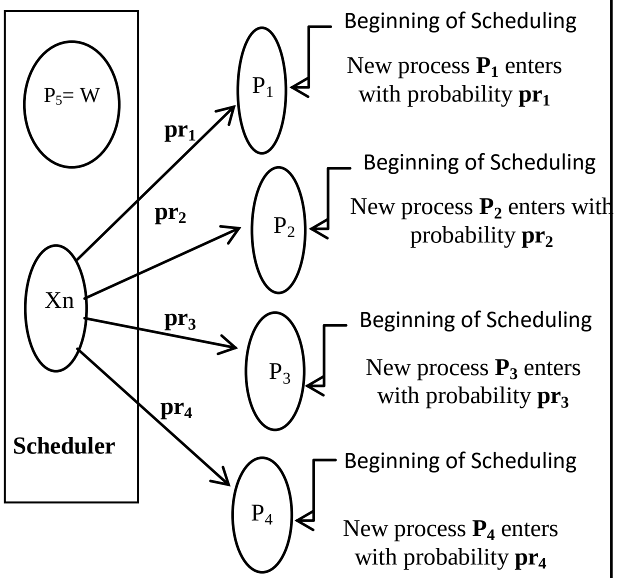


Figure 2.1: System diagram ofproposedmulti process scheduling

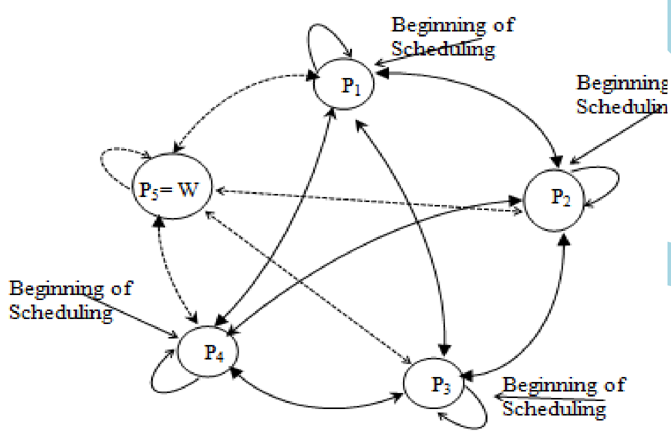


Figure 2.2: Transition diagram of random movement of scheduler

MARKOV CHAIN MODEL ON PROPOSED SCHEDULING SCHEME

Consider $\{X^{(n)}, n \geq 1\}$ as Markov chain where $X^{(n)}$ is scheduler state at n^{th} time quantum. State space for random variable X can be $\{P_1, P_2, P_3, P_4, P_5\}$ and scheduler $X^{(n)}$ can move over these states in different time quantum. Initial probabilities of the states are selected as:

$$\left.\begin{aligned} p\left[X^{(0)} = P_1\right] &= pr_1 \\ p\left[X^{(0)} = P_2\right] &= pr_2 \\ p\left[X^{(0)} = P_3\right] &= pr_3 \\ p\left[X^{(0)} = P_4\right] &= pr_4 \\ p\left[X^{(0)} = P_5\right] &= 0 \end{aligned}\right]$$

Where $pr_1 + pr_2 + pr_3 + pr_4 = \sum_{i=1}^{4} pr_i = 1$

Suppose $S_{ij}(i, j = 1,2,3,4,5)$ be transition probabilities of $X^{(n)}$ over states then transition probability matrix will be,

$$\begin{array}{c|ccccc} & \multicolumn{5}{c}{\longleftarrow X^{(n)} \longrightarrow} \\ X^{(n-1)} & P_1 & P_2 & P_3 & P_4 & P_5 \\ \hline P_1 & S_{11} & S_{12} & S_{13} & S_{14} & S_{15} \\ P_2 & S_{21} & S_{22} & S_{23} & S_{24} & S_{25} \\ P_3 & S_{31} & S_{32} & S_{33} & S_{34} & S_{35} \\ P_4 & S_{41} & S_{42} & S_{43} & S_{44} & S_{45} \\ P_5 & S_{51} & S_{52} & S_{53} & S_{54} & S_{55} \end{array}$$

Here, $S_{15} = \left(1 - \sum_{i=1}^{4} P_{1i}\right)$, $S_{25} = \left(1 - \sum_{i=1}^{4} P_{2i}\right)$,

$S_{35} = \left(1 - \sum_{i=1}^{4} P_{3i}\right)$, $S_{45} = \left(1 - \sum_{i=1}^{4} P_{4i}\right)$ and

$S_{55} = \left(1 - \sum_{i=1}^{4} P_{5i}\right)$

Where $0 \leq S_{ij} \leq 1$

The state probability that scheduler will be on process P_1 after first quantum can be obtained as,

$$\begin{aligned} p\left[X^{(1)} = P_1\right] = {} & p\left[X^{(0)} = P_1\right] \times p\left[X^{(1)} = P_1 / X^{(0)} = P_1\right] + \\ & p\left[X^{(0)} = P_2\right] \times p\left[X^{(1)} = P_1 / X^{(0)} = P_2\right] + \\ & p\left[X^{(0)} = P_3\right] \times p\left[X^{(1)} = P_1 / X^{(0)} = P_3\right] + \\ & p\left[X^{(0)} = P_4\right] \times p\left[X^{(1)} = P_1 / X^{(0)} = P_4\right] \end{aligned}$$

$$\left. = \sum_{i=1}^{4} pr_i . S_{i1} \right] \quad \text{...... 2.1.1}$$

Continuing as same remaining state probabilities after the first quantum will be,

$$\left.\begin{aligned} p\left[X^{(1)} = P_2\right] &= \sum_{i=1}^{4} pr_i . S_{i2} \\ p\left[X^{(1)} = P_3\right] &= \sum_{i=1}^{4} pr_i . S_{i3} \\ p\left[X^{(1)} = P_4\right] &= \sum_{i=1}^{4} pr_i . S_{i4} \\ p\left[X^{(1)} = P_5\right] &= \sum_{i=1}^{4} pr_i . S_{i5} \end{aligned}\right] \quad \text{...... 2.1.2}$$

In the similar fashion, state probabilities after second quantum will be ,

$$\begin{aligned} p\left[X^{(2)}=P_1\right] = {} & p\left[X^{(1)}=P_1\right] \times p\left[X^{(2)}=P_1/X^{(1)}=P_1\right] + \\ & p\left[X^{(1)}=P_2\right] \times p\left[X^{(2)}=P_1/X^{(1)}=P_2\right] + \\ & p\left[X^{(1)}=P_3\right] \times p\left[X^{(2)}=P_1/X^{(1)}=P_3\right] + \\ & p\left[X^{(1)}=P_4\right] \times p\left[X^{(2)}=P_1/X^{(1)}=P_4\right] + \\ & p\left[X^{(1)}=P_5\right] \times p\left[X^{(2)}=P_1/X^{(1)}=P_5\right] \end{aligned}$$

$$p\left[X^{(2)}=P_1\right] = \sum_{l=1}^{5}\left(\sum_{i=1}^{4} pr_i . S_{ij}\right).S_{j1} \quad \text{.... 2.1.3}$$

$$\left.\begin{aligned} p\left[X^{(2)}=P_2\right] &= \sum_{l=1}^{5}\left(\sum_{i=1}^{4} pr_i . S_{ij}\right).S_{j2} \\ p\left[X^{(2)}=P_3\right] &= \sum_{l=1}^{5}\left(\sum_{i=1}^{4} pr_i . S_{ij}\right).S_{j3} \\ p\left[X^{(2)}=P_4\right] &= \sum_{l=1}^{5}\left(\sum_{i=1}^{4} pr_i . S_{ij}\right).S_{j4} \\ p\left[X^{(2)}=P_5\right] &= \sum_{l=1}^{5}\left(\sum_{i=1}^{4} pr_i . S_{ij}\right).S_{j5} \end{aligned}\right] \quad \text{...... 2.1.4}$$

Generalized expressions for n quantum are :

$$\left.\begin{aligned} p\left[X^{(n)}=P_1\right] &= \sum_{m=1}^{5} \ldots\ldots \sum_{l=1}^{5}\sum_{k=1}^{5}\sum_{j=1}^{5}\sum_{i=1}^{4} pr_i . S_{ij} . S_{jk} \ldots\ldots S_{m1} \\ p\left[X^{(n)}=P_2\right] &= \sum_{m=1}^{5} \ldots\ldots \sum_{l=1}^{5}\sum_{k=1}^{5}\sum_{j=1}^{5}\sum_{i=1}^{4} pr_i . S_{ij} . S_{jk} \ldots\ldots S_{m2} \\ p\left[X^{(n)}=P_3\right] &= \sum_{m=1}^{5} \ldots\ldots \sum_{l=1}^{5}\sum_{k=1}^{5}\sum_{j=1}^{5}\sum_{i=1}^{4} pr_i . S_{ij} . S_{jk} \ldots\ldots S_{m3} \\ p\left[X^{(n)}=P_4\right] &= \sum_{m=1}^{5} \ldots\ldots \sum_{l=1}^{5}\sum_{k=1}^{5}\sum_{j=1}^{5}\sum_{i=1}^{4} pr_i . S_{ij} . S_{jk} \ldots\ldots S_{m4} \\ p\left[X^{(n)}=P_5\right] &= \sum_{m=1}^{5} \ldots\ldots \sum_{l=1}^{5}\sum_{k=1}^{5}\sum_{j=1}^{5}\sum_{i=1}^{4} pr_i . S_{ij} . S_{jk} \ldots\ldots S_{m5} \end{aligned}\right| \quad \text{... 2.1.5}$$

RESTRICTED TRANSITION OVER PROPOSED SCHEDULING SCHEME

By applying specific conditions over unrestricted scheduling, movement of scheduler can be regulated and new scheduling scheme can be generated.

Restricted scheduling over extensive round robin scheme

Here the scheduler movement is limited in such a way that scheduler can pick first process state P_1 initially and after completion of allotted time quantum, scheduler can move towards next process state or previous state or may remain at same state. During scheduling, rest state can be achieved from anywhere. That is itaccepts random transition of scheduler. If any processes is concluded, then it is send out of ready queue otherwise it leftovers in waiting queue for reprocessing till nextallotted time quantum. As scheduler can pick P_1 initially hence its initial state probability will be 1 while for remaining states it will be 0.

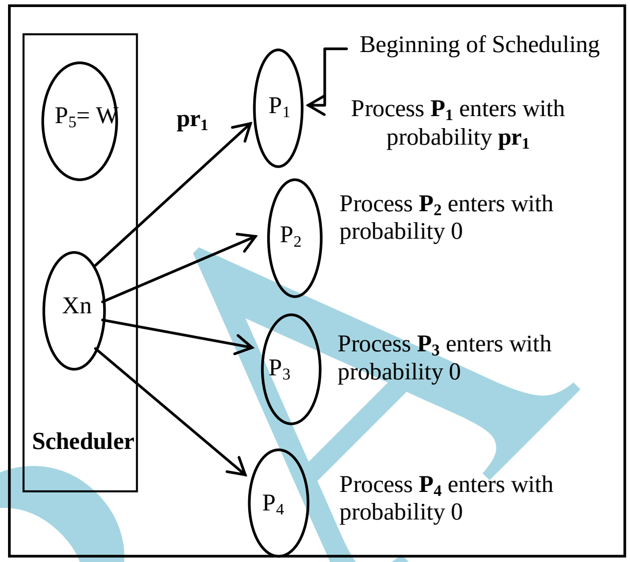


Figure 2.2.1: System diagram of Restricted Scheduling Scheme

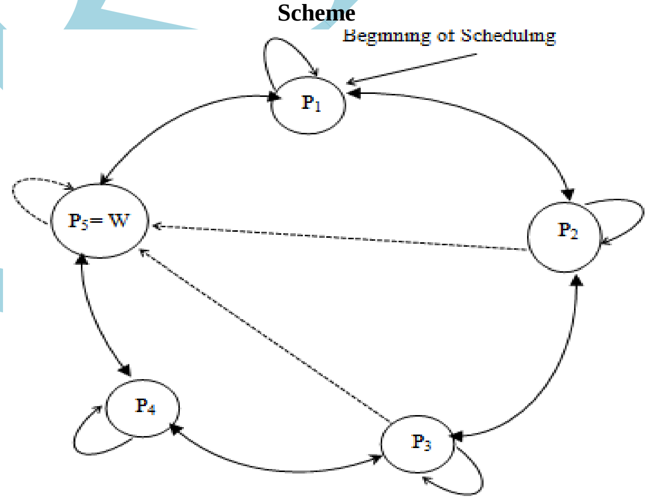


Figure 2.2.2: Transition Diagram of Restricted Scheme

In transition probability matrix under scheme A, an Indicator function $\mathbf{L_{ij}}$is defined for i, j=1,2,3,4,5 such that,

$\mathbf{L_{ij}} = \mathbf{0}$ when (i=1, j=3,4), (i=2, j=4), (i=3, j=1), (i=4, j=1,2), (i=5, j=1,2,3,4)

$\mathbf{L_{ij}} = \mathbf{1}$ otherwise

Now using **Eq. 2.1.1 and Eq. 2.1.2** unrestricted scheme state probabilities for scheme A after the first quantum will be,

$$\left.\begin{aligned} p\left[X^{(1)}=P_1\right] &= S_{11}.L_{11} \\ p\left[X^{(1)}=P_2\right] &= S_{12}.L_{12} \\ p\left[X^{(1)}=P_3\right] &= S_{13}.L_{13} \\ p\left[X^{(1)}=P_4\right] &= S_{14}.L_{14} \\ p\left[X^{(1)}=P_5\right] &= S_{15}.L_{15} \end{aligned}\right] \quad \text{.......... 2.2.1}$$

Similarly by using **Eq. 2.1.3** and **2.1.4** of unrestricted scheme, state probabilities after the Second quantum will be

$$\left.\begin{aligned}
p\left[X^{(2)}=P_1\right] &= \sum_{i=1}^{5}(S_{1i}.L_{1i}).(S_{i1}.L_{i1})\\
p\left[X^{(2)}=P_2\right] &= \sum_{i=1}^{5}(S_{1i}.L_{1i}).(S_{i2}.L_{i2})\\
p\left[X^{(2)}=P_3\right] &= \sum_{i=1}^{5}(S_{1i}.L_{1i}).(S_{i3}.L_{i3})\\
p\left[X^{(2)}=P_4\right] &= \sum_{i=1}^{5}(S_{1i}.L_{1i}).(S_{i4}.L_{i4})\\
p\left[X^{(2)}=P_5\right] &= \sum_{i=1}^{5}(S_{1i}.L_{1i}).(S_{i5}.L_{i5})
\end{aligned}\right] \quad ....2.2.2$$

Generalized expressions for **n** time quantum are:

$$\left.\begin{aligned}
p\left[X^{(n)}=P_1\right] &= \sum_{m=1}^{5}....\sum_{k=1}^{5}\left\{\sum_{j=1}^{5}\left(\sum_{i=1}^{5}S_{1i}L_{1i}\right)S_{ij}L_{ij}\right\}S_{jk}L_{jk}.....S_{m1}L_{m1}\\
p\left[X^{(n)}=P_2\right] &= \sum_{m=1}^{5}....\sum_{k=1}^{5}\left\{\sum_{j=1}^{5}\left(\sum_{i=1}^{5}S_{1i}L_{1i}\right)S_{ij}L_{ij}\right\}S_{jk}L_{jk}.....S_{m2}L_{m2}\\
p\left[X^{(n)}=P_3\right] &= \sum_{m=1}^{5}....\sum_{k=1}^{5}\left\{\sum_{j=1}^{5}\left(\sum_{i=1}^{5}S_{1i}L_{1i}\right)S_{ij}L_{ij}\right\}S_{jk}L_{jk}.....S_{m3}L_{m3}\\
p\left[X^{(n)}=P_4\right] &= \sum_{m=1}^{5}....\sum_{k=1}^{5}\left\{\sum_{j=1}^{5}\left(\sum_{i=1}^{5}S_{1i}L_{1i}\right)S_{ij}L_{ij}\right\}S_{jk}L_{jk}.....S_{m4}L_{m4}\\
p\left[X^{(n)}=P_5\right] &= \sum_{m=1}^{5}....\sum_{k=1}^{5}\left\{\sum_{j=1}^{5}\left(\sum_{i=1}^{5}S_{1i}L_{1i}\right)S_{ij}L_{ij}\right\}S_{jk}L_{jk}.....S_{m5}L_{m5}
\end{aligned}\right] \quad ...2.2.3$$

III. SIMULATION STUDY

In order to compare the above two scheduling schemes under a common setup of Markov chain model, simulation study is required. For that state transition probabilities are managed through a linear mathematical data model with two parameters *a* and *d*. Their values are obtained in linear order. Here ***'i'*** stands for process number and his values increases according to row wise. Model of matrix is as,

$X^{(n)}$

$X^{(n-1)}$

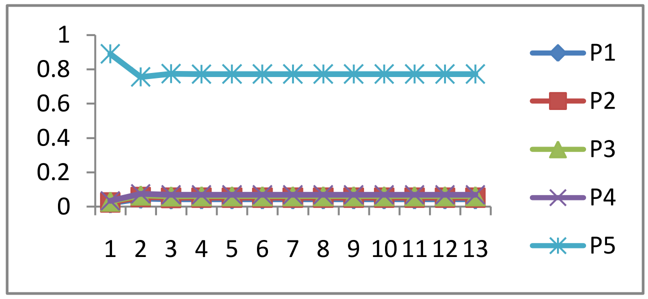
$X^{(n)} \longrightarrow$

$X^{(n-1)}$	P_1	P_2	P_3	P_4	P_5
P_1	a	$a+d.i$	$a+2d.i$	$a+3d.i$	$1-(4a+6d.i)$
P_2	$a+d.i$	$a+2d.i$	$a+3d.i$	$a+4d.i$	$1-(4a+10d.i)$
P_3	$a+2d.i$	$a+3d.i$	$a+4d.i$	$a+5d.i$	$1-(4a+14d.i)$
P_4	$a+3d.i$	$a+4d.i$	$a+5d.i$	$a+6d.i$	$1-(4a+18d.i)$
P_5	$a+4d.i$	$a+5d.i$	$a+6d.i$	$a+7d.i$	$1-(4a+22d.i)$

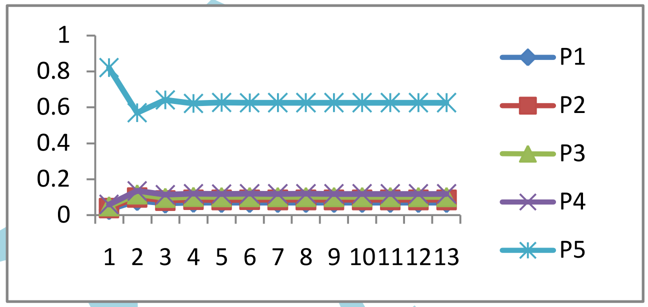
IV. SIMULATION STUDY OF UNRESTRICTED SCHEDULING SCHEME

On the basis of obtained element transition probability matrices for different values, graphical analysis for unrestricted multi process scheduling scheme is as,

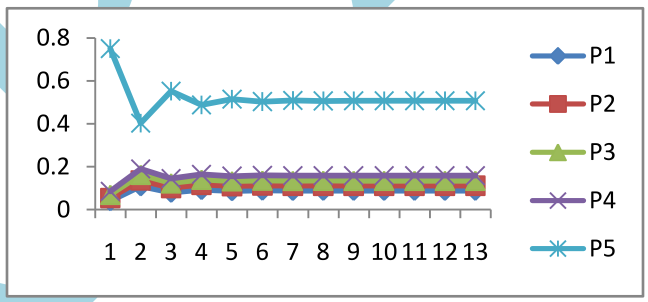
Case 1: when a = 0.010



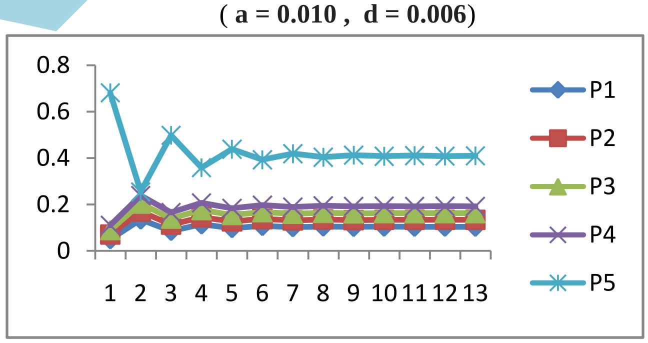
(a = 0.010,d = 0.002)



(a = 0.010 , d = 0.004)

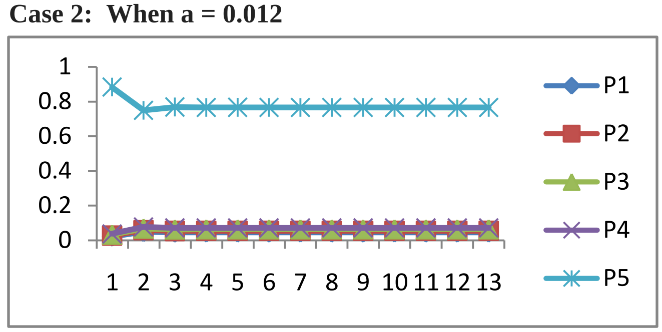


(a = 0.010 , d = 0.006)

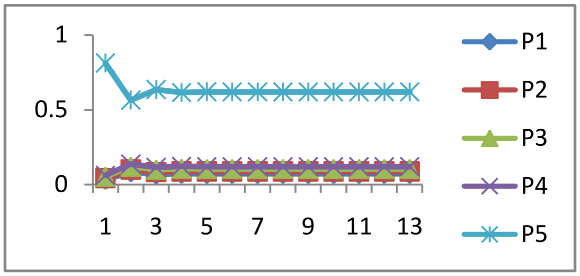


(a = 0.010 , d = 0.008)

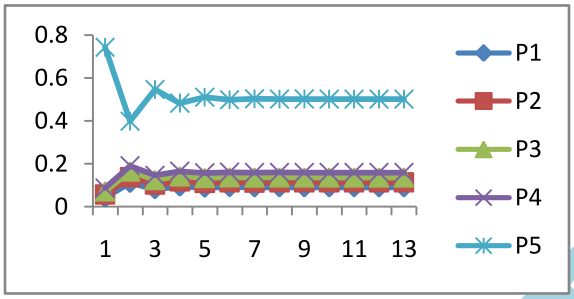
Case 2: When a = 0.012



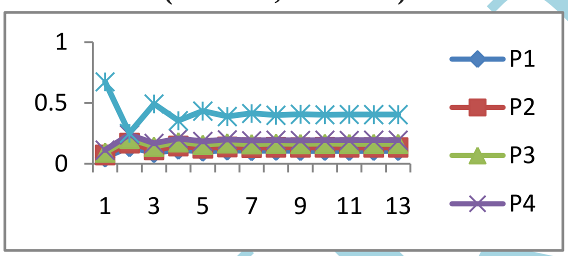
a = 0.012, d = 0.002)



(a = 0.012, d = 0.004)

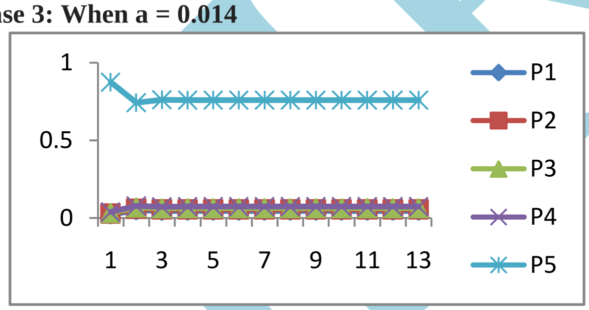


(a = 0.012, d = 0.006)

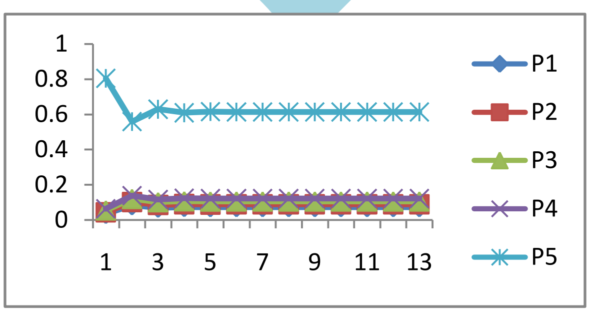


(a = 0.012, d = 0.008)

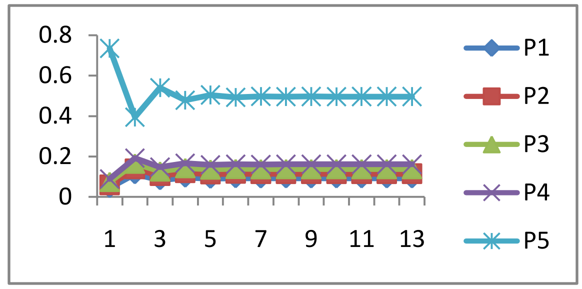
Case 3: When a = 0.014



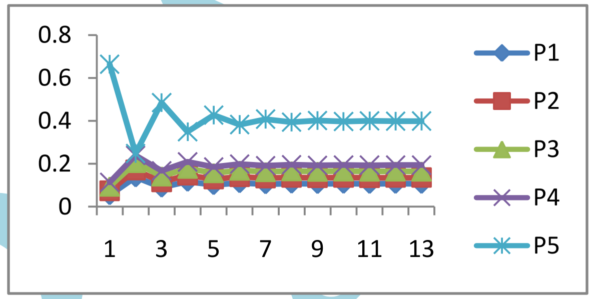
(a = 0.014, d = 0.002)



(a = 0.014, d = 0.004)

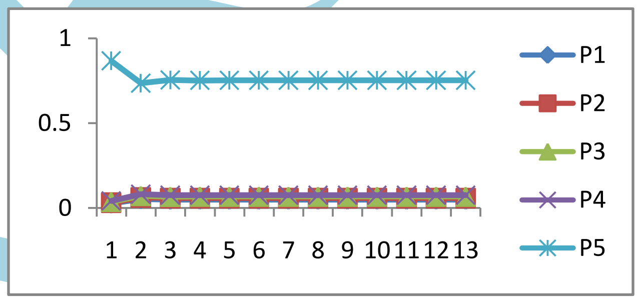


(a = 0.014, d = 0.006)

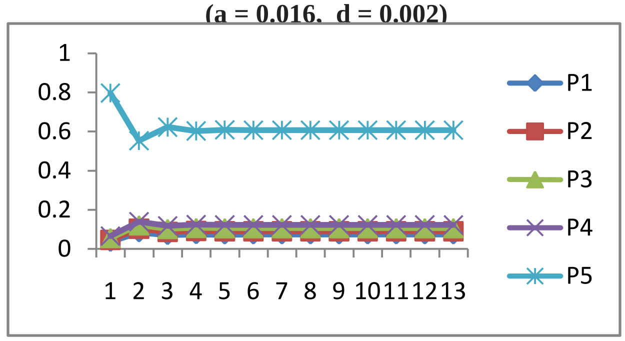


(a = 0.014, d = 0.008)

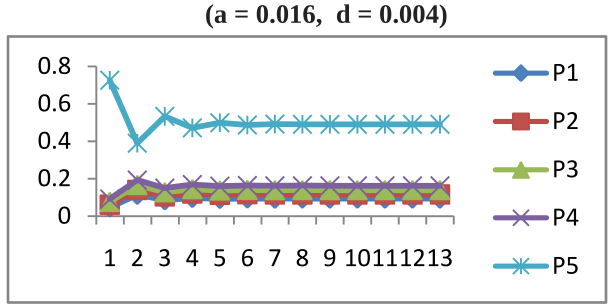
Case 4: When a = 0.016



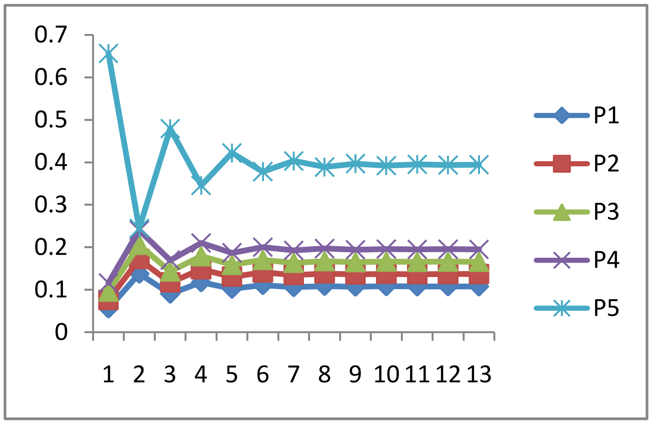
(a = 0.016, d = 0.002)



(a = 0.016, d = 0.004)

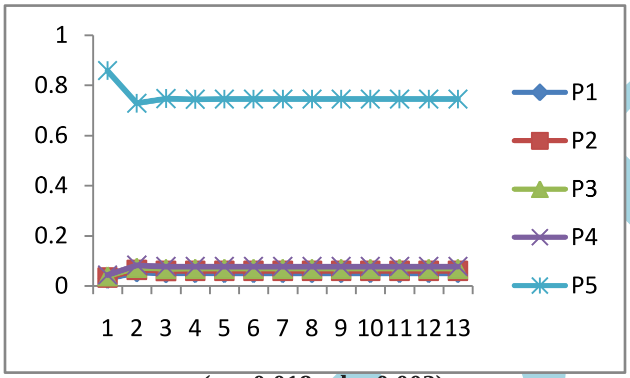


(a = 0.016, d = 0.006)

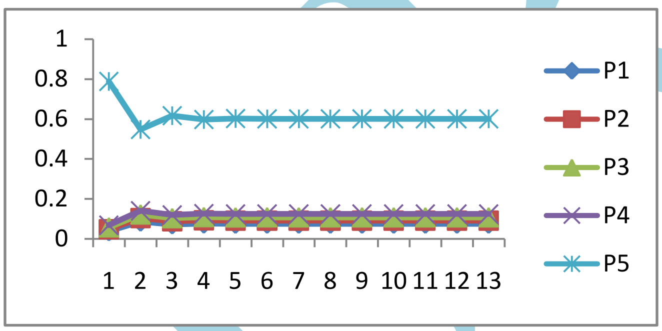


(a = 0.016, d = 0.008)

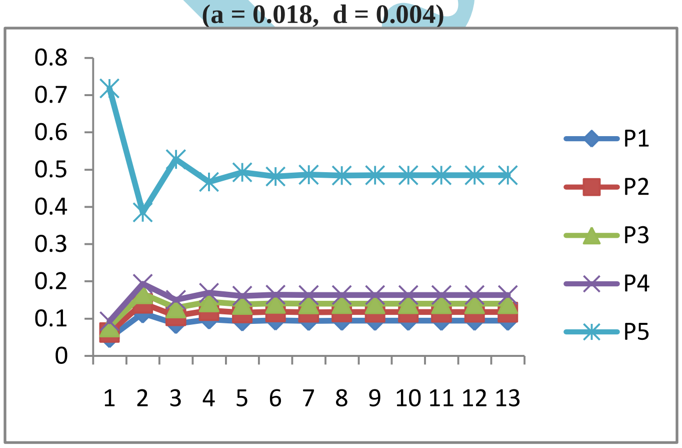
Case 5: When a = 0.018



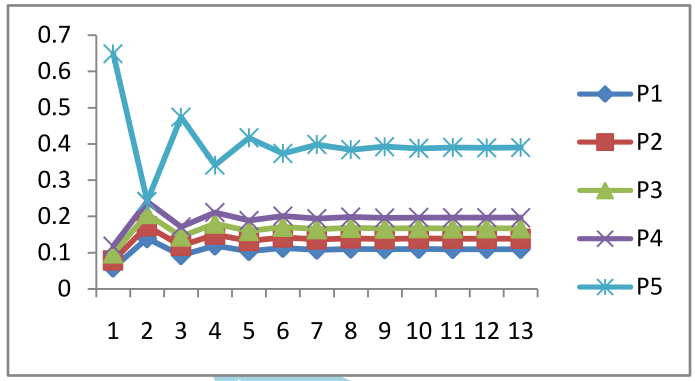
(a = 0.018, d = 0.002)



(a = 0.018, d = 0.004)



(a = 0.018, d = 0.006)

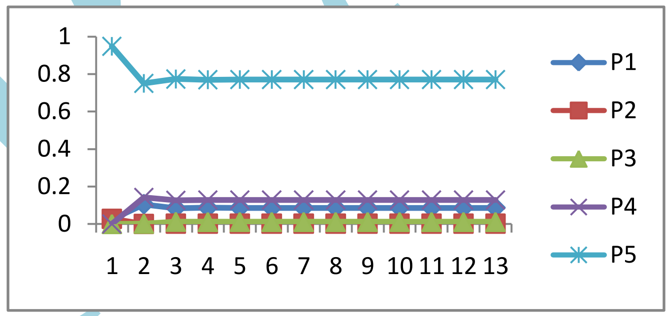


(a = 0.018, d = 0.008)

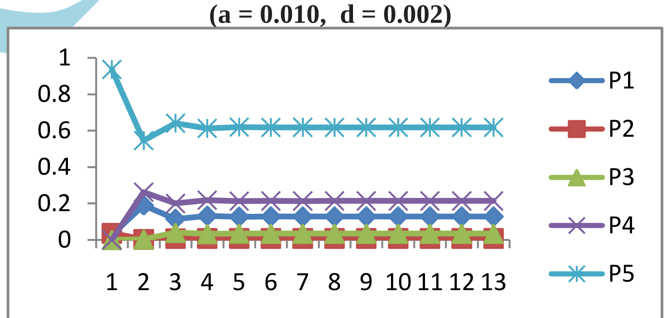
V. SIMULATION STUDY FOR RESTRICTED SCHEME:

The Transitional probability matrices and its graphical analysis is under scheme A is as,

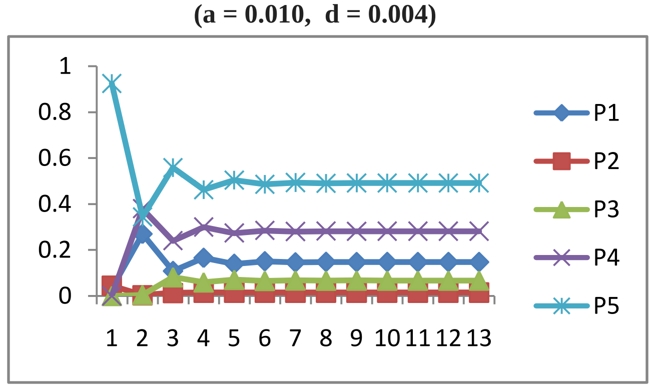
Case 1: when a = 0.010



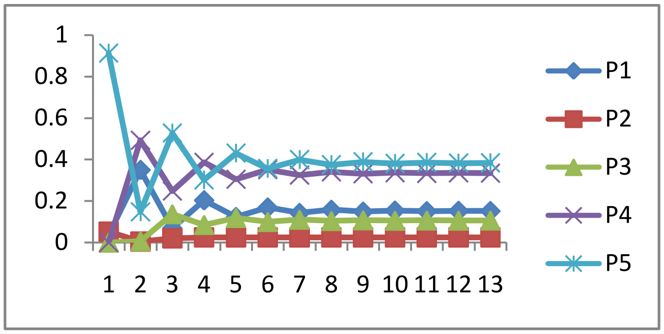
(a = 0.010, d = 0.002)



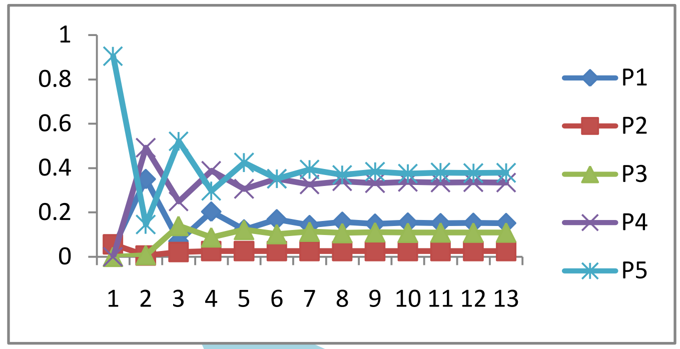
(a = 0.010, d = 0.004)



(a = 0.010, d = 0.006)

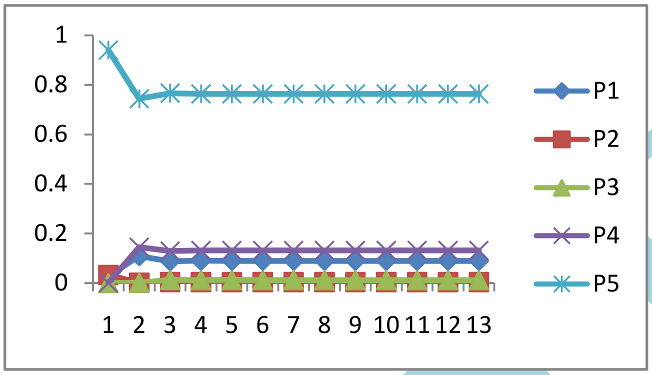


(a = 0.010, d = 0.008)

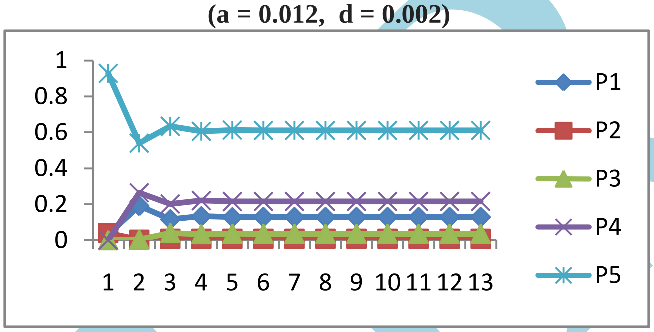


(a = 0.012, d = 0.008)

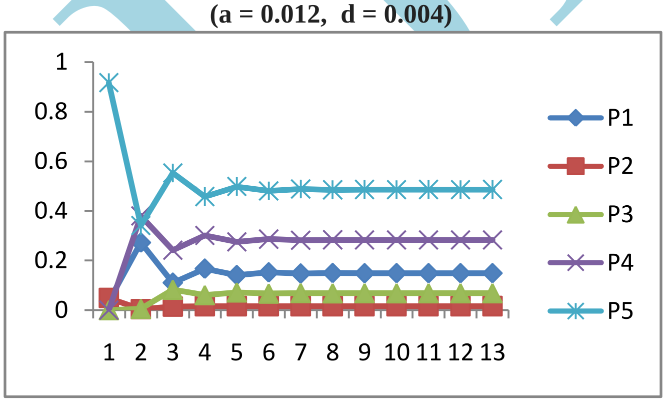
Case 2: when a = 0.012



(a = 0.012, d = 0.002)

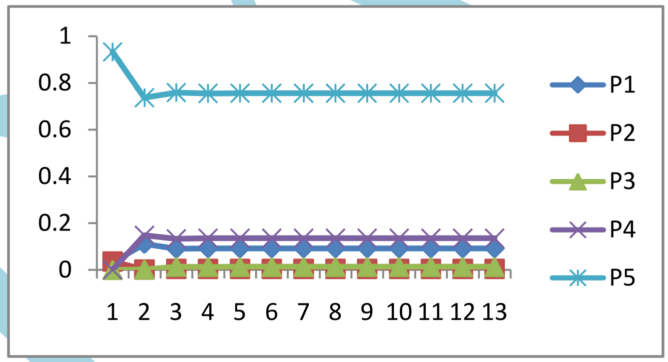


(a = 0.012, d = 0.004)

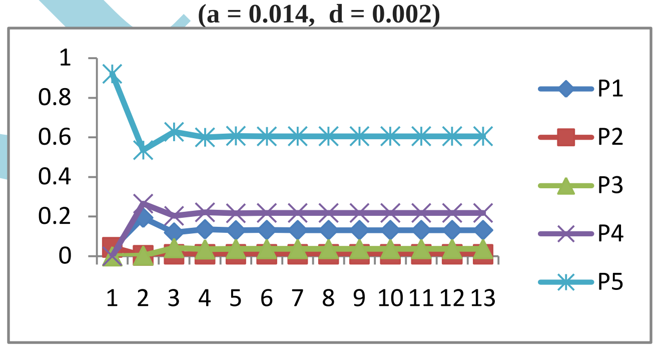


(a = 0.012, d = 0.006)

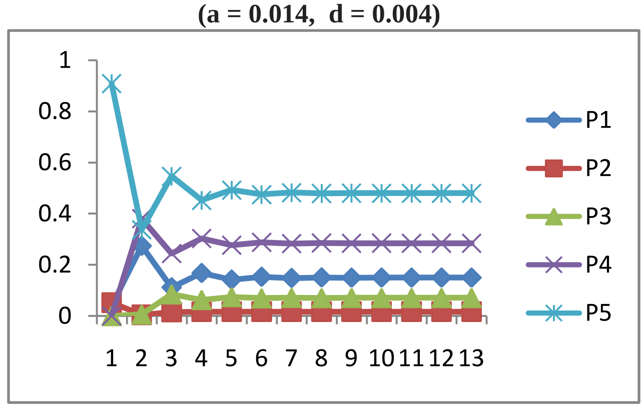
Case 3: when a = 0.014



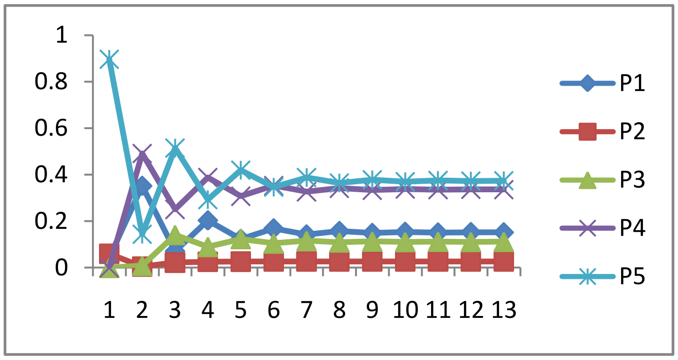
(a = 0.014, d = 0.002)



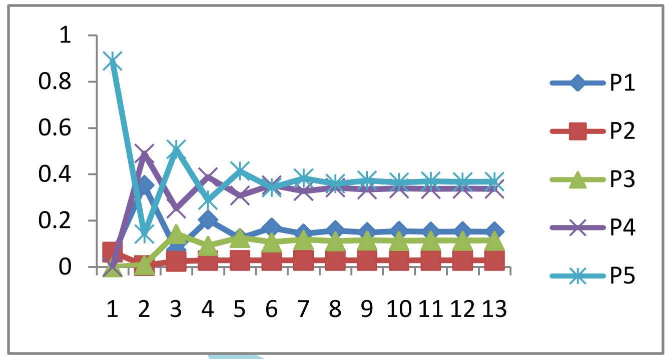
(a = 0.014, d = 0.004)



(a = 0.014, d = 0.006)

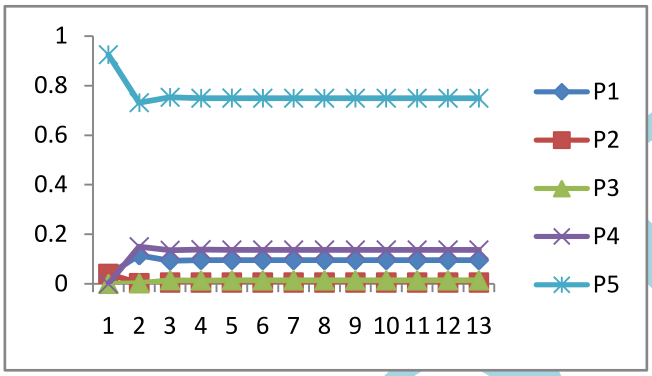


(a = 0.014, d = 0.008)

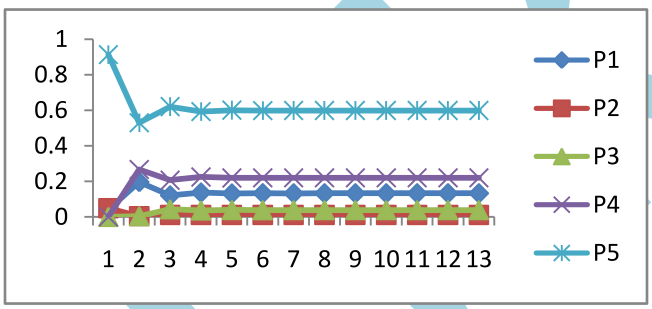


(a = 0.016, d = 0.008)

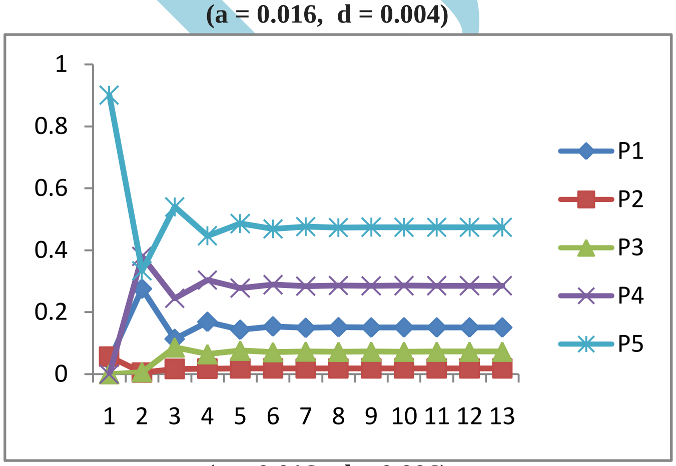
Case 4: when a = 0.016



(a = 0.016, d = 0.002)

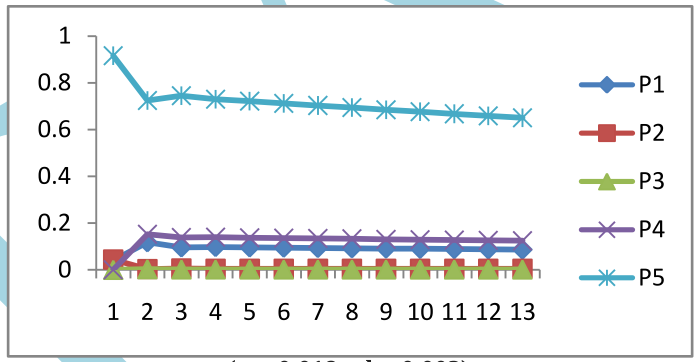


(a = 0.016, d = 0.004)

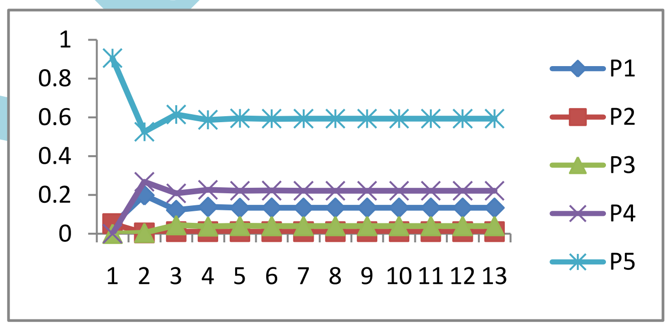


(a = 0.016, d = 0.006)

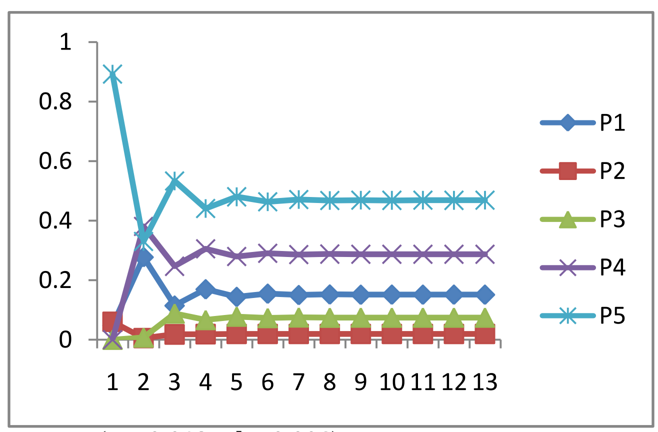
Case 5: when a = 0.018



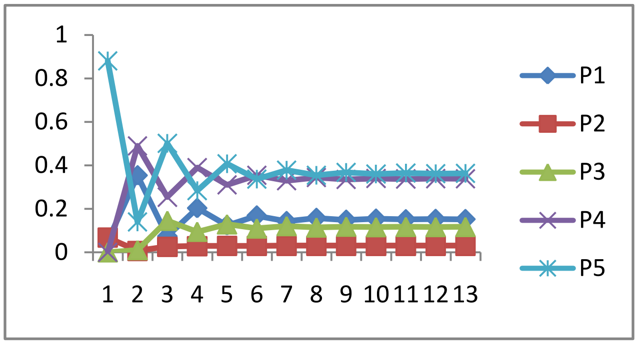
(a = 0.018, d = 0.002)



(a = 0.018, d = 0.004)



(a = 0.018, d = 0.006)



(a = 0.018, d = 0.008)

VI. DISCUSSION ON SIMULATION STUDY

For unrestricted scheme, transition probability of processes increases in linear order, but if scale goes at higher end, probability of rest state suddenly going down up to some quantum and then follow a steady pattern. During same time, probability of other states also increases steadily but in sluggish mode.

Overall the pattern of transition over states is linear. Initially rest state has highest probability which represents that scheduler will spend more time in rest state as compare to other process states. Hence unrestricted transition of scheduler with random movement may leads to decrease in efficiency of CPU. Although at higher ends of origin as well as scale, state probabilities of P1, P2, P3 and P4 get increase.

In restricted scheme,the variability pattern over different time quantum shows that although initially P5 has highest probability over all, but if scale is increased then there is increase in order of probability of P1,P3 and P4 while decrease in P5. Hence in this scheme there is indication of increase in efficiency of scheduler for higher end scale. It provides a platform to scheduler for job processing rather than going towards rest state. But here there is less chance of transition of state P2 as its probability becomes steady. In this scheme the pattern of probabilities for variance of states is increasing consistently.

VII. CONCLUSION

For unrestricted transition although probability of rest state decreases at higher end of scale but still remains more than that of other state probabilities, which may cause less system efficiency and seems as not precise operative.

In restricted scheme, the pattern of probabilities for each state is in increasing order and overall the probability of process states moves forward with increase in quantum which gives better scheduling scenario as compared to unrestricted transition.

Concluding towards analysis by considering Markov chain probability model, it can be stated that restricted scheduling over extensive round robin schemecanbe more beneficial for job processing than unrestricted scheduling scheme as its effectiveness seems to be more.

VIII. FUTURE ENHANCEMENT

Proposed scheduling schemes are beneficial for job processing in proficient manner but these can be further investigated for providing more task oriented results. In restricted scheme, transition probability of state P2 is lowest and steady, hence there is less chance scheduling of P2. This can be topic of future analysis along with developing some adaptive algorithms so that scheduler usage can be optimum in multifaceted complex working of operating system.

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