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ANALYSIS OF READY QUEUE PROCESSING TIME UNDER PPS-LS AND SRS-LS SCHEME IN MULTIPROCESSING ENVIRONMENT

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Abstract
In operating system, process sequencing is an open problem and solved by many scientists/authors suggesting different scheduling schemes. Every process needs a time span to be processed by the CPU. Lottery scheduling is one such scheme where the process selection is purely on random basis. The ready queue is used for processes to wait there until selected for processor. This paper considers the environment of many processors, a ready queue, lottery scheduling and presents an efficient method to predict about total time needed to process the entire ready queue if only few are processed in a specified time. Confidence internals are calculated based on PPS-LS and compared with SRS-LS. The PPS-LS found better over SRS-LS.

Keywords*: *Scheduling, Probability Proportional to Size Lottery Scheduling (PPS-LS), Bias, Variance, Confidence interval, Simple Random Sampling Lottery Scheduling (SRS-LS), Estimator, Sampling, Ready Queue.

1. INTRODUCTION

In multiprocessor and multi-user environment, in a fraction of second, many job requests arrive at the ready queue. Scheduler's role is to decide which of the process should be assigned to which processor at an instant of time. There are many CPU scheduling schemes exist in literature {See [15], [17], [18]} and Lottery scheduling is one of them whose algorithm is as under:

i. Allot token number to each of the process entering into the ready queue.
ii. Pickup a random number and search matching process token number to random number.
iii. The process which is matched to both numbers shall be assigned to processor by scheduler.
iv. Continue steps (i) (ii) and (iii) unless ready queue is vacated.

A modification in the Lottery scheduling procedure for n processors environment is to choose n random numbers at a time and perform n matching of tokens of processes. After matching, select n processes at a time randomly.

Carl et al. [1] discussed the proportional share resource management technique in lottery scheduling. David et al. [3] presented the specialization matching methodology in context to lottery scheduling. Raz et al. [4] presented procedure of deciding priorities among jobs by maintaining fairness in selection procedure.

Shukla et.al [7] picked up multiprocessor environment and lottery scheduling and discussed a procedure to obtain ready queue time estimate. The kind of prediction is important for backup management when sudden failure of power supply, machine disorder occur. Shukla et al [8] discussed similar problem but in grouped setup of ready queue using lottery scheduling. Shukla and Jain [5], [6] tackled Markov Chain based study of transition behaviors of scheduler in multilevel queue scheduling. Some other contributions are [9], [10], [11], [12], [13] and [14]. Sampling theory contains tools and techniques useful to estimate the unknown population parameter. The basis for this is information contained in a small sample which is a part of the whole {See [2] and [16]}.

One can think of utilizing additional information for ready queue processing time estimation. Suppose the size of each process is available in terms of bytes at the time of entering into the ready queue. This information could be a source of efficient estimation. Aim of present content is to

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utilize this in the estimation of ready queue processing time under PPS-LS setup and multiprocessor environment by using size measure of the process.

2. PROBLEM DEFINITION

Let the size of coming i^{th} process in the ready queue be X_i (i=1, 2,…., N) in terms of bytes, the total size being $X = \sum_i^{} X_i$. We associate the random numbers 1to X with the first unit, the unit with which this number is associated is selected. This gives the surety of selection of i^{th} unit in the ready queue or pool of processes with probability proportional to its size X_i. This procedure is repeated n times with replacement of the processes. The X_i is a size measure of processes based on bytes.

3. ESTIMATION OF READY QUEUE PROCESSING TIME

(A)PPS-LS scheme with replacement

Consider a pool of N processes and let X_i be size value of the process Pi where (i=1….N). Suppose ($c_i = X_i/X$) be the chance that i^{th} process the process c_i is selected in processor such that $\sum_i^N c_i = 1$.

The Y be processing time as main variable .Let n independent choice be made with replacement method and the value of y_i for each selected process is observed. Take y_i (time), c_i (chance) be the size and chance of selection of the i^{th} process in the sample. It can be seen that random variate $\left(\frac{y_i}{c_i}\right)$ (i=1...N) are independent and identically distributed. If $c_i=1/N$ it gives rise to a simple random sample. Consider estimator $\hat{Y}_{pps} = \frac{1}{n}\sum_i^n \left(\frac{y_i}{c_i}\right)$ which is unbiased estimator of the ready queue processing time total Y .

Sampling variance

We define $Z_i=Y_i/Nc_i$ and $z_i=y_i/Nc_i$. The Z_i denotes values of processes in ready queue and z_i relates to value in sample n assigned to n processors (n<N).

$$= \frac{1}{n}\sum_i^N c_i \left(\frac{y_i}{c_i} - Y\right)^2$$

$$cov\left(\frac{y_i}{c_i}, \frac{y_j}{c_j}\right)$$

The variance of estimator is inversely proportional to the sample size n as in simple random sampling, wr. An unbiased estimator of population mean is, $\bar{Y}$ is given by

$$\hat{\bar{Y}}_{pps} = \frac{1}{nN}\sum_i^N \left(\frac{y_i}{c_i}\right) \text{ with its sampling variance.}$$

In PPS-LS sampling wr,

$$v\left(\hat{Y}_{pps}\right) = \frac{1}{n(n-1)}\sum_i^n \left(\frac{y_i}{c_i} - \hat{Y}_{pps}\right)^2$$

$$z_i \left(= \frac{y_i}{c_i}\right), \; i = 1,2.............n \,,$$

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independent unbiased estimator of Y having the same variance. In PPS-LS sampling, wr an unbiased estimator of $V\left(\hat{\bar{Y}}_{pps}\right)$ is given by

$$s^2 = \sum_{i}^{n} \left(\frac{z_i - \bar{z}}{n-1}\right)^2,$$

where is unbiased estimator of with the usual meaning.

$$V\left(\hat{Y}_{pps}\right) = \frac{1}{n}\sum_{i}^{N} c_i \left(\frac{y_i}{Nc_i} - \bar{Y}\right)^2$$

$$V\left(\hat{Y}_{pps}\right) = V(\bar{z}) = \frac{1}{n^2}\sum_{i}^{n} V(z_i)$$

$$\because E\left(\hat{Y}_{pps}\right) = E(\bar{z}) = \sum_{i}^{n} \frac{1}{n} E(z_i) = Y$$

$$V\left(\hat{Y}_{pps}\right) = \frac{1}{n}\sum_{i}^{n} c_i \left(\frac{y_i}{c_i} - Y\right)^2$$

$$= \frac{1}{n(n-1)}\left[\sum_{i}^{n}\left(\frac{y_i}{c_i}\right)^2 - n\hat{Y}_{pps}^2\right]$$

So, an unbiased estimator of $V\left(\hat{\bar{Y}}_{pps}\right)$ is given by

$$v\left(\hat{Y}_{pps}\right) = \frac{1}{n(n-1)}\sum_{i}^{n}\left(\frac{y_i}{Nc_i} - \hat{Y}_{pps}\right)^2$$

$$= \frac{1}{n(n-1)N}\left[\sum_{i}^{n}\left(\frac{y_i}{c_i}\right)^2 - n\hat{Y}_{pps}\right]$$

The confidence interval for mean in PPS-LS is

$$\frac{\hat{Y}_{pps}}{N} - \frac{s}{N}\sqrt{V(\hat{Y}_p}, \quad \frac{\hat{Y}_{pps}}{N} + \frac{s}{N}\sqrt{V(\hat{Y}_p}$$

(B) SRS-LS scheme

Consider c_i = for all then we get SRS-LS set-up as Z_i = and z_i = with process sample mean

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \text{ Also whole ready queue mean a square is } S^2$$

$$= \frac{1}{n-1}\sum_{i=1}^{N} (y_i - \bar{y})^2.$$

The $\bar{y}$ denotes mean time of sample processes in the n processors at a time.This generates confidence interval for SRS-LS for mean $\left[\bar{y} - 3\sqrt{V(\bar{y})}, \bar{y} + 3\sqrt{V(\bar{y}}\right.$ where $V(\bar{y}) = \frac{N-n}{Nn}$.

The 99% confidence interval for any mean time is $\left[\bar{t} - 3\sqrt{V(\bar{t})}, \bar{t} + 3\sqrt{V(\bar{t})}\right] = 0$.

Note that when confidence interval length is high, the estimation procedure is less efficient. This comparative methodology is adopted here in this content.

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4. NUMERICAL DATA

Consider 30 processes in ready queue at a time whose size measure X is also given in terms of bytes. If we assume that all the processes are processed completely in the ready queue, the CPU burst time Y is mentioned against them. The table 1 presents computation of size measure probability.

Table 1: Processes parameters in ready queue.

Process Number	Process		$c_i = X_i/X$	PPS-LS	SRS-LS
	Size(X_i) Parameter	CPU Burst Time (Y_i)		(Y_i/Nc_i)	$Y_i/(Nc_i)$
1	210	30	0.01974	50.66	30.03
2	897	20	0.08434	7.9	20.02
3	312	112	0.02933	127.29	112.11
4	171	40	0.01608	82.92	40.04
5	461	59	0.04334	45.38	59.06
6	290	60	0.02727	73.34	60.06
7	379	30	0.03563	28.07	30.03
8	220	43	0.02068	69.31	43.04
9	470	101	0.04419	76.19	101.1
10	636	69	0.0598	38.46	69.07
11	455	138	0.04278	107.53	138.14
12	682	43	0.06412	22.35	43.04
13	952	109	0.08951	40.59	109.11
14	574	26	0.05397	16.06	26.03
15	536	74	0.05039	48.95	74.07
16	416	89	0.03911	75.85	89.09
17	788	123	0.07409	55.34	123.12
18	902	67	0.08481	26.33	67.07
19	623	58	0.05857	33.01	58.06
20	563	84	0.05293	52.9	84.08
21	111	143	0.01044	44.7	14.01
22	341	29	0.03206	30.15	29.03
23	775	147	0.07287	21.5	47.05
24	913	94	0.08584	36.5	94.09
25	745	131	0.07005	62.34	131.13
26	130	79	0.01222	215.49	79.08
27	877	46	0.08246	18.59	46.05
28	927	59	0.08716	22.56	59.06
29	424	72	0.03986	60.21	72.07
30	356	22	0.03347	21.91	22.02

The table 2 presents the allotment of range of random numbers and table 3, 4, 5 and 6 are for sample information in terms of size measure based probability. Note the true value of total is 1968 and entire mean is 65.6.

Table 2: Interval Random Number Association

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Process Number	Size(x_i) Parameter	Cumulative Size Totals	Random Numbers Associated
1	210	210	0-210
2	897	1107	210-1107
3	312	1419	1107-1419
4	171	1590	1419-1590
5	461	2051	1590-2051
6	290	2341	2051-2341
7	379	2720	2341-2720
8	220	2940	2720-2940
9	470	3410	2940-3410
10	636	4046	3410-4046
11	455	4501	4046-4501
12	682	5183	4501-5183
13	952	6135	5183-6135
14	574	6709	6135-6709
15	536	7245	6709-7245
16	416	7661	7245-7661
17	788	8449	7661-8449
18	902	9351	8449-9351
19	623	9974	9351-9974
20	563	10537	9974-10537
21	111	10648	10537-10648
22	341	10989	10648-10989
23	775	11764	10989-11764
24	913	12677	11764-12677
25	745	13422	12677-13422
26	130	13552	13422-13552
27	877	14429	13552-14429
28	927	15356	14429-15356
29	424	15780	15356-15780
30	356	16136	15780-16136

Table 3: Sampled processes (n=8)

Sample No.	Sampled Processes				
1	P_{30}	P_{17}	P_6	P_{25}	P_{15}
2	P_8	P_4	P_{18}	P_{25}	P_{28}
3	P_{20}	P_4	P_{11}	P_1	P_{22}
4	P_{12}	P_{22}	P_4	P_{16}	P_{24}
5	P_3	P_6	P_7	P_{18}	P_{12}
6	P_{27}	P_{19}	P_{13}	P_2	P_6
7	P_{24}	P_{16}	P_8	P_5	P_{19}
8	P_4	P_{12}	P_{15}	P_{16}	P_{29}

Table 4: CPU burst time for sample (n=8)

Y_i	Sampled Processes CPU Burst Time

	Factor				
1	22	123	60	131	74
2	43	40	67	131	59
3	84	40	138	30	29
4	43	29	40	89	94
5	112	60	33	67	43
6	46	58	109	20	60
7	94	89	43	59	58
8	40	43	74	89	72

Table 5: Size measure of sampled process (n=8)

X_i	Sampled Processes Weight Factor				
1	356	788	290	745	536
2	220	902	745	171	927
3	563	171	455	210	341
4	682	171	341	913	416
5	312	290	379	902	682
6	877	623	952	879	290
7	913	416	220	561	623
8	171	682	536	416	424

Table 6: The selection probability based on size measure

c_i	Selection Chances of Sampled Processes				
1	0.03347	0.07409	0.02727	0.07005	0.05039
2	0.02068	0.01608	0.08481	0.07005	0.08716
3	0.05293	0.01608	0.04278	0.01974	0.03206
4	0.06412	0.03206	0.01608	0.03911	0.08584
5	0.02933	0.02727	0.03563	0.08481	0.06412
6	0.08246	0.05857	0.08951	0.08434	0.02727
7	0.08584	0.03911	0.02068	0.04334	0.05857
8	0.01608	0.06412	0.05039	0.03911	0.03986

5. RESULT AND DISCUSSION

In light of table 7 the mean, variance, confidence interval show that PPS-LS means are closer to true value than SRS-LS. The confidence intervals generated by PPS-LS are smaller than generated by SRS-LS. The estimator efficiently estimates the ready queue processing time.

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Table 7: Computation of Sample Mean and Confidence Interval for ULS and PPS Scheduling Scheme

Random Samples	Sampled Process (k=5)	Mean Variance		Confidence Intervals	
		PPS-LS	SRS-LS	PPS-LS	SRS-LS
1	$P_{30}, P_{17}, P_6, P_{25}, P_{15}$	52.37	82.08	(30.44-74.31)	(21.16-143)
2	$P_8, P_4, P_{18}, P_{25}, P_{28}$	61.02	65.26	(49.16-72.88)	(115.53-109.98)
3	$P_{20}, P_4, P_{11}, P_1, P_{22}$	61.15	64.26	(47.43-74.87)	(1.16-127.36)
4	$P_{12}, P_{22}, P_4, P_{16}, P_{24}$	85.34	56.05	(50.68-120.0)	(20.7-91.4)
5	$P_3, P_6, P_7, P_{18}, P_{12}$	55.47	62.46	(35.25-75.68)	(20.42-104.42)
6	$P_{27}, P_{19}, P_{13}, P_2, P_6$	34.69	58.6	(1.09-68.29)	(15.13-102.07)
7	$P_{24}, P_{16}, P_8, P_5, P_{19}$	52	68.66	(25.91-78.09)	(39.23-98.09)
8	$P_4, P_{12}, P_{15}, P_{16}, P_{29}$	58.05	63	(59.51-66.48)	(53.53-73.46)

6. CONCLUSION

The content of this paper suggests an estimation technique for obtaining sampled based estimate of total time required for processing for the ready queue. When we consider size measure of processes as additional information we get better estimate of processing time. This estimate is useful when sudden breakdown of system occurs and system manager needs time valuation to vacate the entire ready holding the ready processes. The estimate helps for disaster and backup management of CPU system. The proposed methodology PPS-LS is efficient than SRS-LS due to incorporation of additional information in the form of size measure of processes in ready queue.

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