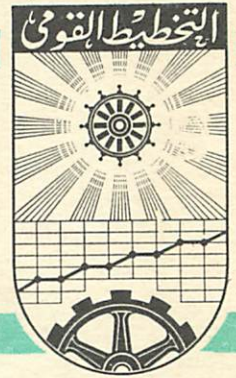


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ON THE MACHINE INTERFERENCE PROBLEM

BY

ALWALID ELSHAFEI
OPERATIONS RESEARCH GROUP

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"Opinions Expressed and Positions Taken by Authors
are Entirely Their Own and do not Necessarily Reflect the
Views of the Institute of National Planning".

1. THE PROBLEM:

In one of the Job-shops, there are about 20-30 machines in operation. Due to fatigue and aging, those machines are subject to breakdown. Some repairmen are maintained on the regular payroll in order to restore the machines to operation.

THE PROBLEM is how many repairmen should be kept

THE OBJECTIVE is minimum cost

THE STRATEGIES are the various number of repairmen who might be hired

THE STATES OF NATURE are:

- The various rates at which the machines may breakdown
- The various rates at which repair takes place.

2. COST ANALYSIS

Concerning cost elements, there are two conflicting elements. One which increases as the number of repairmen increases, which is the cost of their idle time; while the other decreases as their number increases, which is the cost of idle machines due to the unavailability of repairmen for service.

As an example, suppose that we have a shop with the following characteristics:

- 20 machines are in operation
- The cost of one machine being out of operation for one hour is estimated to be £ 60.
- Repairmen capable for this job are paid £ 7 per hour.
- The probability distribution for the breakdown (on an hourly basis) is as follows:

BREAKDOWNS PER HOUR	PROBABILITY	CUMULATIVE PROBABILITY
0	0.613	0.613
1	0.281	0.894
2	0.106	1.000

TABLE 1

In which case the mean of the distribution of machine breakdown is calculated by:

$$0(0.613) + 1(0.281) + 2(0.106) = 0.493 \quad \text{machines / hour}$$

In other words, on the average, one machine breaks down every 2.029 hours (1/0.493 = 2.029)

- The probability distribution for the repair time is as follows:

HOURS TO REPAIR	PROBABILITY	CUMULATIVE PROBABILITY
1	0.491	0.391
2	0.217	0.708
3	0.194	0.902
4	0.062	0.964
5	0.036	1.000

TABLE II

The average repair time is calculated as follows:

$$1(0.491) + 2(0.217) + 3(0.194) + 4(0.062) + 5(0.036) = 1.915$$

3. NEED FOR OPTIMIZATION:

It might appear that there is really no problem here at all. On the basis of the available information we have been given it seems that, on the average, a machine will break down every 2.029 hours and it will take the repairman, again on the average, 1.915 hour to repair it. Thus, one repairman can easily handle the necessary repairs and remain idle for a period of, on the average) 0.114 hour between consecutive repairs. Associated with each breakdown there is a loss of $1.915 \times 60 = \text{£}114.90$. Considering four breakdowns during an 8-hours day, the loss will be $\text{£}459.60$.

This analysis, unfortunately, is too aggressive because it completely overlooks the outstanding characteristic of this kind of problem. We have based the fallacious argument of the analysis on the assumption that we can calculate the cost of the machine's being out of operation by simply multiplying the average time during which the machine remains idle by the cost of an idle hour. This is based on the assumption that there is a repairman available to start work once the breakdown takes place, but what happens if he is not. Suppose that he is busy repairing another machine. In such event the machine will have to wait, and the time it has to wait costs $\text{£} 60$ per hour. We have to study the characteristics of such idle time. There is a possibility that more than one machine are idle and waiting for service. Those machines have to QUEUE UP for service forming what is called a QUEUE or a WAITING LINE.

Unfortunately, the mathematics involved in the analysis of waiting lines and waiting times is too complex and behind the scope of this article. Instead, Monte Carlo Simulation Techniques" can help us to get some insight into the problem.

4. USE OF SIMULATION :

The idea behind simulation is the use of RANDOM SAMPLING to construct a version to simulate the process being analyzed. By this means we can actually see what happens rather than having to calculate it from mathematical equations.

In the present cases we want to see what happens if we have machines that break down according to the given pattern and a single repairman who repairs the breakdowns according to another given pattern (refer to tables I&II)

4-1- STEPS OF SIMULATION PROCEDURE :

- 1- Decide upon the number of hours to be simulated (length of experiment, or sample size)
- 2- Calculate failures in each simulated hour as follows:
 - a- Generate a 3 - digit uniform random number, transfer it to a deviate (between 0-----1)
 - b- Compare it with the numbers in the last column in Table I, ascendingly till we arrive at a stage where the generated deviate is found to be less than or equal to the corresponding cumulative probability figure. The corresponding no. of breakdowns per hour are read as well (either 0 or 1 or 2)
- 3- For each failure, calculate the repair time, using 3 - digits uniform random numbers in conjunction with table II. It is obvious that hours with no failure (or 0 failure) are excluded from our analysis heretoeafter.
- 4- Proceed with the analysis to determine :
TERMINATION TIME (or time to terminate repair). If at the hour the breakdown occurs, the repairman is vacant; he can handle the error right at once. In this case the terminating time is simply the product of adding the repair time (as found in step 3) to the hour of failure.

In another case, the repairman might be busy repairing another machine. The machine has to wait, idle, till he finishes the one he is dealing with

* This procedure of "RANDOM PICKING" is well documented in Memo 842 of the NPIC.

Then the terminating time would be the repair time of this machine added to the terminating time of the one that has been repaired immediately before it.

WAITING TIME : In the previous case, one machine had to WAIT till the repairman sets another one to the working conditions. The waiting time is the result of subtracting the time of the i th failure from the time of terminating the repair of the $(i-1)$ th failure.

IDLE TIME : If the repairman remains idle between two repairs this time is to be recorded. It is the product of subtracting the terminating time of the repair of the $(i-1)$ th failure from the occurrence of the i th failure. One important restriction is that this product is positive.

QUEUE LENGTH : Whenever a failure arrives we investigate the no. of machines waiting (or queuing up) for repair.

This procedure is to be followed for each failure. Also comparisons and accumulations are to be setup for NECESSARY STATISTICS such as :

Maximum queue length

Cumulative service time

Cumulative queue length

Cumulative waiting time (idle time for machine)

Cumulative inactive time

Machines' idleness factor

Worker's idleness factor

4-2- PROGRAMMING FOR THE IBM-1620 :

The same steps, as mentioned before, were translated into a FORTRAN II coded program. It has to be noticed that :

- 1- Read statements were included to allow for :
 - Setting up characteristics of Random Number Generator
 - Reading Failure Pattern
 - Reading Repair Time
- 2- There are three SUBROUTINES
 - SUBROUTINE to generate Random Numbers *
 - SUBROUTINE to calculate Queue Length
 - SUBROUTINE to calculate Necessary Statistics and Terminating Conditions.
- 3- There is a part of the program for the case of 2 - REPAIRMEN for further analysis and comparative analysis (as will be shown later on). The program is applicable for either case (one or two repairmen) using Sense Switch 2

* I apologize for not being able to include this subroutine.

- 4- Due to IBM-1620 limited storage capacity. The program can be used to simulate 100 hours (at a maximum) as it can be seen from the DIMENSION statement. In such simulation experiments, we should be able to simulate a much longer period (in the order of 2000-3000 hours). Unfortunately we are completely disabled to do this. The least we can do is show the methodology and don't rely much on the simulated values. In the near future, if I can perform a longer run on a bigger computer, I will publish results in a Part II of this memo.
The results of the 100 simulated hours period are also included.

4-3 ANALYSIS OF OBTAINED RESULTS :

Examining the results, we can see that :

- Cumulative waiting time (m/c's idle time) = 119 hours
- There were 45 breakdowns in 100 hours. This compares well with the mean of the distribution of machine breakdowns (as found in section 2) as found to be 0.493. In other words our sample, though very small in size, is very much representing original population.
- Cumulative service time is 81 hours to prepare 45 breakdowns. On the average of $81/45 = 1.80$ hour/breakdown. In section 2, the average repair time was calculated to 1.915 hour/breakdown. This is another evidence that our sample is quite representative of the original data.
- The total waiting time, as found to be 119 hours, can be averaged as $119/100 = 1.19$ hours for each of the 100 hours represented in the sample. At the stated cost of £ 60 per hour for a machine out of order, this will cause £ 71.4 loss due to waiting time per hour.
Since an additional repairman would cost only £ 7 per hour, it appears worth investigating whether an additional repairman would save more than £ 7 in waiting time. This is why I have included the part of TWO REPAIRMAN in the program. Results for the simulation experiment in this case are also shown.

5- COMPARATIVE ANALYSIS FOR TWO REPAIRMEN :

- The total waiting time in this case = 9 hours
This represents an average waiting time of 0.09 hours /hour
At a £ 60 cost of an idle machine per hour, the cost of idleness in this case = £ 5,4
 - ∴ The additional repairman has decreased the average hourly cost of idleness by an amount = $71,4 - 5,4 = £ 66$
 - This decrease has been achieved at the cost of an additional repairman's salary of £ 7.
 - ∴ The net saving = $66 - 7 = £ 59$
 - ∴ An additional repairman should be definitely added.
- This conclusion is surprising because it seems that the idle time for the case of one repairman (being 30.61%) should preclude the idea of adding another repairman. However, results from minimizing total costs show the contrary.

6- DISCUSSIONS AND CONCLUSION :

From the results previously obtained, an obvious conflict between the results obtained and the ones we should normally expect. This is due to the fact that the obvious averages are not good measures of effectiveness in a process like this.

We have proceeded in the following terms :

ON THE AVERAGE , a machine breaks down every 2.029 hours

ON THE AVERAGE , 1.915 hours are needed to prepare the machine

So : ON THE AVERAGE , the repairman will be able to repair breakdowns

So : ON THE AVERAGE , why should we need another repairman ?

The fault in this reasoning is that it does not take account of another kind of average, which is :

ON THE AVERAGE , machines will not break down in intervals nicely spread to allow the repairman to handle them all. Rather , the breakdowns will cluster in the way they have done in the simulation experiment. This clustering of breakdowns accounts for the waiting time which is not considered in the ON THE AVERAGE reasoning traced above.

List of Abbreviations,

EPS	=	Precision Factor For Comparison
NO	=	Full Length For Random Number Generator
MO	=	Characteristic For Random Number Generator
M3	=	Number of Simulated Hours
IHB(I)	=	Intervals For Failure Pattern
IBP(I)	=	Frequencies For Intervals Of Failure Pattern (Three Digits)
IDT(I)	=	Intervals For Repair Pattern
ICT(I)	=	Frequencies For Intervals Of Repair (Three Digits)
NR	=	Generated Random Uniform Number (three Digits)
IA(K)	=	Arrival Time For Event K
IRT(I1)	=	Repair Time For Event I1
TW(I2)	=	Waiting Time For Event I2
TINA(I2)	=	Inactive Time For Worker Associated With Arrival Of I2
STW	=	Cumulative Waiting Time
STINA	=	Cumulative Inactive Time
ITER(I2)	=	Terminating Time For Repair Of Failure I2
IQL(I2)	=	Queue Length When Event I2 Arrives
IQLL	=	Maximum Queue Length
ISTS	=	Cumulative Service Time
ISQL	=	Cumulative Queue Length
PINAM	=	Machines Idleness Factor
PINAW	=	Worker's Idleness Factor

```
*0608 DIMENSION NRC(100),NRI(100),ENB(100),Th(100),TINA1(100)
DIMENSION IA(100),IHB(5),IBP(5),IDT(15),ICT(15),E(20)
DIMENSION ITER(100),IRI(100),IZ(100),ICL(100),IX(100)
1000 READ11,EPS
C READ R.N. GENERATOR CHARACTERS AND NUMBER OF ARRIVALS
READ21,NC,MC,M2
C
C READ FAILURE PATTERN
READ21,MM
500 CO5I=1,MM
5 READ2,IHB(I),IBP(I)
C
C READ REPAIR PATTERN
READ21,NN
CO1CI=1,NN
10 READ2,ICT(I),ICT(I)
C
MM=0
NN=0
C
C PREPARATION OF R.N. GENERATOR DATA
CO15I=1,NC
15 E(I)=1
I=0
J=0
K=0
18 PRINT1
1 FORMAT(47+SENSE SWITCH 1 CN FOR REPAIR TIME , FRESS START)
PAUSE
C
20 CALL RNGEN(B,NC,MC,RN)
C
IF(SENSE SWITCH 1)105,390
C CALCULATE FAILURE TIME
C
390 IF(J-M3)40,45,45
40 NRC(I)=NR
GOTO20
45 NRC(I)=NR
C
K=0
M=0
MM=0
50 CO72I=1,M2
NRI=NRC(I)
CO60J1=1,2
J2=J1
IF(NRI-IBP(J1))65,65,60
60 CONTINUE
65 ENB(I)=IHB(J2)
IF(ENB(I)-EPS)72,72,70
70 MM=MM+1
IZ(MM)=I
72 CONTINUE
CO85IL=1,MM
K=K+1
L=K+1
IK=IZ(IL)
IF(ENB(IK)-2.)75,80,80
75 IA(K)=IK
M=K
GOTO85
80 IA(L)=IK
M=L
```

```
      K=L
      85 CONTINUE
      C DETERMINATION OF REPAIR TIME
      I=C
      J=0
      GOTO 18
      105 IF(J-M)110,112,115
      110 NRT(I)=NR
      GO TO 20
      112 NRT(I)=NR
      115 CO13CL=1,M
      NRJ=NR1(L1)
      CO12CI2=1,15
      I3=I2
      IF(NRJ-IC1(I2))125,125,120
      120 CONTINUE
      125 IRT(L1)=IC1(I3)
      130 CONTINUE
      555 PRINT3
      PAUSE
      3 FORMAT(40F5SENSE SWITCH 2 ON FOR TWO REPAIRMEN, PRESS START)
      IF(SENSE SWITCH 2)444,233
C
C     CASE OF ONE REPAIRMAN
C
C     CALCULATION OF TERMINATING TIME , WAITING TIME , ICLE TIME
      233 ITER(1)=IA(1)+IRT(1)
      TW(1)=C
      TINA1(1)=IA(1)
      STINA=C
      STW=0
      STINA=STINA+TINA1(1)
      IK2=1
      DO 145 I2=2,M
      IK2=IK2+1
      C=IA(I2)-ITER(I2-1)
      IF(C)140,135,135
      135 TW(I2)=C
      ITER(I2)=IA(I2)+IRT(I2)
      STW=STW+TW(I2)
      TINA1(I2)=C
      STINA=STINA+TINA1(I2)
      GOTO 145
      140 TW(I2)=-D
      STW=STW+TW(I2)
      TINA1(I2)=C
      ITER(I2)=ITER(I2-1)+IRT(I2)
      STINA=STINA+TINA1(I2)
      145 CONTINUE
      AA=IA(M)
      PINAM=(STW/AA)*100.
      PINAW=(STINA/AA)*100.
C
C     CALCULATE QUEUE LENGTH
      CALL QLEN(IA,ITER,ICL,M)
C
C     PUNCH SIMULATION TABLE
      PUNCH4
      PUNCH6
      PUNCH7
      PUNCH8
      DO 180 I2=1,M
      180 PUNCH2,I2,IA(I2),IRT(I2),ITER(I2),TW(I2),TINA1(I2),ICL(I2)
      PUNCH8
C
C     END OF SIMULATION TABLE
```

C CALCULATE NECESSARY STATISTICS
CALL TERM(IRT,IQL,IQL1,ISTS,ISCL,M)

C DOCUMENT NECESSARY STATISTICS
PUNCH31
PUNCH32,IQL1
PUNCH33,ISTS
PUNCH34,ISCL
PUNCH36,STINA
PUNCH38,STH
PUNCH39,PINAM
PUNCH42,PINAM
PUNCH43

C PAUSE
GOTO555

C CASE OF TWO REPAIRMEN

C CALCULATION OF TERMINATING TIME , WAITING TIME

444 STW=0
CO200L=1,M
ITER(L)=C
TW(L)=C
200 IQL(L)=C
TW(1)=C
TW(2)=C
ITER(1)=IA(1)+IRT(1)
ITER(2)=IA(2)+IRT(2)
CO290 I2=3,M
II=I2-2
L=0
K=0
CO215J=1,II
I3=I2-J
I4=I2-J-1
IC=ITER(I3)-ITER(I4)
IF(IC-IRT(I3))21C,205,210
205 L=L+1
IX(L)=I2-J+1
GOTO215
210 K=K+1
215 CONTINUE
IF(K-11)22C,25C,22C
220 IF(L-2)24C,225,225
225 CO235IL=2,L
IL1=IL-1
X1=IX(IL)-IX(IL1)
IF(X1-1.)235,23C,235
230 J1=I2-IX(IL)+1
GO TO 245
235 CONTINUE
GO TO 245
240 J1=I2-IX(L)+1
245 TW(I2)=IA(I2)-ITER(J1)
ITER(I2)=ITER(J1)+IRT(I2)
250 C1=IA(I2)-ITER(I2-2)
IF(D1)26C,255,255
255 TW(I2)=C
ITER(I2)=IA(I2)+IRT(I2)
GO TO 29C
260 C2=IA(I2)-ITER(I2-1)
IF(D2)27C,265,265
265 TW(I2)=C
ITER(I2)=IA(I2)+IRT(I2)

```
      GO TO 250
270 IF(C1-C2)275,280,280
275 TW(I2)=-C2
      ITER(I2)=ITER(I2-1)+IRT(I2)
      GO TO 285
280 TW(I2)=-C1
      ITER(I2)=ITER(I2-2)+IRT(I2)
285 STW=STW+TW(I2)
290 CONTINUE
      AA=IA(M)
      PINAM=(STW/AA)*ICC.
      PINAW=(STINA/AA)*ICC.
      PAUSE
C
C      CALCULATE QLELE LENGTH
      CALL QLEN(IA,ITER,IQL,M)
C
C      PUNCH SIMULATION TABLE
      PUNCH41
      PUNCH6
      PUNCH7
      PUNCH8
      DO295 I2=1,M
295 PUNCH I2, I2, IA(I2), IRT(I2), ITER(I2), TW(I2), ICL(I2)
      PUNCH8
      END OF SIMULATION TABLE
C
C      CALCULATE NECESSARY STATISTICS
      CALL TERM(IRT,IQL,IQL1,IS1S,ISQL,M)
C
C      DOCUMENT NECESSARY STATISTICS
      PUNCH31
      PUNCH32,IQL1
      PUNCH33,IS1S
      PUNCH34,ISQL
      PUNCH38,STW
      PUNCH39,PINAM
      PUNCH42,PINAW
      PUNCH43
C
      GOTO1000
2  FORMAT(10X,4(I5,5X),2(F7.2,3X),I5)
4  FORMAT(EX,64HRESULTS FOR THE M/C INTERFERENCE PROBLEM , CASE OF ON
   XE REPAIRMAN)
6  FORMAT(80F-----)
   X-----)
7  FORMAT(12X,6CHARIVAL,2X,10H ARIV TME ,10H SERV TME ,10H TERM TME ,1
   X0H WAIT TME ,10H INAC TME ,4H C.L)
8  FORMAT(80F-----)
   X-----)
21 FORMAT(10X,2I4)
11 FORMAT(F5.2)
12 FORMAT(10X,4(I5,5X),F7.2,13X,I5)
22 FORMAT(10X,3(I5,5X),2(F7.2,3X))
31 FORMAT(10X,21HNECESSARY STATISTICS,)
32 FORMAT(20X,25HMAXIMUM QLELE LENGTH      =,I6)
33 FORMAT(20X,25HCUMLLATIVE SERVICE TIME  =,I6)
34 FORMAT(20X,25HCUMLLATIVE QLELE LENGTH  =,I6)
36 FORMAT(20X,25HCUMLLATIVE INACTIV TIME  =,F9.2)
38 FORMAT(20X,25HCUMLLATIVE WAITING TIME  =,F9.2)
39 FORMAT(20X,25HM/C IDLENESS FACTOR      =,F9.2)
42 FORMAT(20X,25HMAN IDLENESS FACTOR      =,F9.2)
43 FORMAT(/)
41 FORMAT(EX,64HRESULTS FOR THE M/C INTERFERENCE PROBLEM , CASE OF TW
   XO REPAIRMEN)
      END
```

```
*0608 SUBROUTINE QLEN(IA,ITER,IQL,M)
      DIMENSION IA(100),ITER(100),IQL(100)
      C CALCULATION OF QLELE LENGTH
      IQL(1)=C
      DO170 K=2,M
      JK=0
      ITAK=IA(K)
      DO165 IK=2,K
      K1=K-IK+1
      IF(ITER(K1)-ITAK)160,155,150
150 JK=JK+1
      GOTO165
155 JK=JK+1
160 IQL(K)=JK
      GOTO170
165 CONTINUE
      IQL(K)=JK
170 CONTINUE
      RETURN
      END
```

```
*0608 SUBROUTINE TERM(IRT,IQL,IQL1,ISTS,ISQL,M)
      DIMENSIONIRT(100),IQL(100)
      C CALCULATION OF QL1 , STS , SCL
      ISQL=0
      ISTS=IRT(1)
      IQL1=IQL(1)
      DO 195 I=1,M
      IF(IQL1-IQL(I))185,19C,19C
185 IQL1=IQL(I)
190 ISTS=ISTS+IRT(I)
195 ISQL=ISQL+IQL(I)
      RETURN
      END
```


RESULTS FOR THE M/C INTERFERENCE PROBLEM, CASE OF ONE REPAIRMAN

ARRIVAL	ARRIV TME	SERV TME	TERM TME	WAIT TME	INAC TME	C.L
1	11	2	13	0.00	11.00	0
2	12	1	14	1.00	0.00	1
3	13	2	16	1.00	0.00	2
4	18	3	21	0.00	2.00	0
5	19	1	22	2.00	0.00	1
6	20	1	23	2.00	0.00	2
7	23	1	24	0.00	0.00	1
8	24	2	26	0.00	0.00	1
9	31	1	32	0.00	5.00	0
10	34	1	35	0.00	2.00	0
11	35	3	38	0.00	0.00	1
12	43	2	45	0.00	5.00	0
13	45	2	47	0.00	0.00	1
14	45	2	49	2.00	0.00	2
15	46	1	50	3.00	0.00	2
16	46	2	52	4.00	0.00	2
17	47	1	53	5.00	0.00	4
18	47	2	55	6.00	0.00	5
19	53	2	57	2.00	0.00	2
20	55	2	61	0.00	2.00	0
21	60	3	64	1.00	0.00	1
22	62	3	67	2.00	0.00	1
23	67	3	70	0.00	0.00	1
24	67	3	73	3.00	0.00	2
25	69	1	74	4.00	0.00	2
26	70	1	75	4.00	0.00	2
28	78	1	79	0.00	1.00	0
29	79	1	80	0.00	0.00	1
27	74	2	77	1.00	0.00	2
30	82	2	84	0.00	2.00	0
31	82	1	85	2.00	0.00	1
32	85	2	87	0.00	0.00	1
33	86	2	89	1.00	0.00	1
34	87	3	92	2.00	0.00	2
35	87	1	93	5.00	0.00	2
36	88	2	95	5.00	0.00	2
37	88	2	97	7.00	0.00	4
38	92	1	98	5.00	0.00	4
39	92	2	100	5.00	0.00	4
40	96	3	103	4.00	0.00	2
41	96	1	104	7.00	0.00	4
42	97	1	105	7.00	0.00	5
43	97	1	106	8.00	0.00	6
44	98	2	108	8.00	0.00	6
45	98	1	109	10.00	0.00	7

NECESSARY STATISTICS,
 MAXIMUM QUEUE LENGTH = 7
 CUMULATIVE SERVICE TIME = 81
 CUMULATIVE QUEUE LENGTH = 95
 CUMULATIVE INACTIV TIME = 30.00
 CUMULATIVE WAITING TIME = 119.00
 M/C IDLENESS FACTOR = 121.42
 MAN IDLENESS FACTOR = 30.61

RESULTS FOR THE M/C INTERFERENCE PROBLEM , CASE OF TWO REPAIRMEN

ARRIVAL	ARRIV TIME	SERV TIME	TERM TIME	WAIT TIME	INAC TIME	C.L
1	11	2	13	0.00		C
2	12	1	13	0.00		1
3	13	2	15	0.00		1
4	18	3	21	0.00		C
5	19	1	20	0.00		1
6	20	1	21	0.00		1
7	23	1	24	0.00		C
8	24	2	26	0.00		1
9	31	1	32	0.00		C
10	34	1	35	0.00		C
11	35	3	38	0.00		1
12	43	2	45	0.00		C
13	45	2	47	0.00		1
14	45	2	47	0.00		2
15	46	1	48	1.00		2
16	46	2	49	1.00		2
17	47	1	49	1.00		2
18	47	2	51	2.00		4
19	53	2	55	0.00		C
20	59	2	61	0.00		C
21	60	3	63	0.00		1
22	62	3	65	0.00		1
23	67	3	70	0.00		C
24	67	3	70	0.00		1
25	69	1	71	1.00		2
26	70	1	71	0.00		2
27	74	2	76	0.00		C
28	78	1	79	0.00		C
29	79	1	80	0.00		1
30	82	2	84	0.00		C
31	82	1	83	0.00		1
32	85	2	87	0.00		C
33	86	2	88	0.00		1
34	87	3	90	0.00		2
35	87	1	89	1.00		2
36	88	2	91	1.00		2
37	88	2	91	1.00		4
38	92	1	93	0.00		C
39	93	2	95	0.00		1
40	96	3	99	0.00		C
41	96	1	97	0.00		1
42	97	1	98	0.00		1
43	97	1	98	0.00		2
44	98	2	100	0.00		1
45	98	1	99	0.00		2

NECESSARY STATISTICS,

MAXIMUM QUEUE LENGTH	=	4
CUMULATIVE SERVICE TIME	=	81
CUMULATIVE QUEUE LENGTH	=	51
CUMULATIVE WAITING TIME	=	9.00
M/C IDLENESS FACTOR	=	9.18
MAN IDLENESS FACTOR	=	30.61