**Hwk1 Solution 2014**

1. (5 points) The feasible interval of each job in the precedence graph (shown below) is given next to its name. The execution time of all jobs is equal to 1.

   a. Find the effective release times and effective deadlines of the jobs in the precedence graph. Recall that run time is not used in computing effective release times and effective deadlines.

Job	Effective Release Time	Effective Deadline
J_1	1	4
J_2	2	4
J_3	2	9
J_4	2	4
J_5	2	8
J_6	2	10
J_7	2	5
J_8	6	8
J_9	6	8

   b. Find a feasible schedule of the jobs on a single processor using their effective release times and effective deadlines. To find a feasible schedule, use the fact that each job runs for 1 time unit and adjust the effective times to compute possible release times and deadlines; e.g., the effective release time of job J_2 is 2, but the earliest possible release time of job J_2 is 3 because job J_4 will run for 1 unit of time; if it is released at time 2, it won't finish until time 3.

   J_1 (1, 7] J_2 (0, 4] J_3 (0, 9]

   J_4 (2, 8]

   J_5 (1, 9] J_6 (0, 10]

   J_7 (1, 5] J_8 (6, 9] J_9 (1, 8]
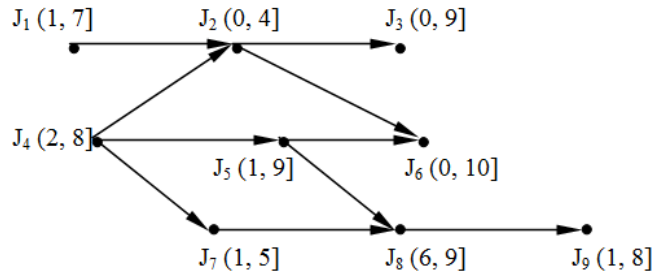
Job	Feasible Release Time	Feasible Deadline	
J_1	1	3	
J_2	2	4	=> J4 in (2,3) => J1 in (1,2)
J_3	2	9	
J_4	2	3	=> J2 in (3,4)
J_5	3	6	
J_6	4	10	
J_7	3	5	+ J2 in (3,4) => J7 in (4,5)
J_8	6	7	
J_9	7	8	

   Schedule: J1 -> J4 -> J2 -> J7 -> J5 -> J8 -> J9 -> J3 -> J6

2. (10 pts.) Consider the task set consisting of the following three preemptive, periodic tasks (denoted using the notation $\tau_i = (p_i, e_i, D_i)$):

   $$\tau_1 = (8, 2, 8)$$
   $$\tau_2 = (16, 3, 16)$$

$$\tau_3 = (16, 5, 8)$$

The system is to be scheduled and executed using a fixed cyclic schedule.

a) Using a frame size of 8, define a network flow graph that can be used to find a fixed (static) cyclic schedule of the tasks using a maximum network flow algorithm. Hint: Remember to indicate maximum allowable flows on all edges in the graph used as input. Upload as hwk1.inp.

```
p max 8 11
n 1 s
n 8 t
a 1 2 2
a 1 3 2
a 1 4 3
a 1 5 5
a 2 6 8
a 3 7 8
a 4 6 8
a 4 7 8
a 5 6 8
a 6 8 8
a 7 8 8

Other inputs are equivalent, for example, they could have an edge
with zero flow from 5 to 7.
```

b) Use hwk1.inp as input the hi_pr to determine the maximum network flow on each edge using the command: hi_pr < hwk1.inp > hwk1.out. Upload the output as hwk1.out.

```
c hi_pr version 3.7
c Copyright C by IG Systems, igsys@eclipse.net
c
c nodes:                8
c arcs:                11
c
c flow:              12.0
c time:              0.00
c cut tm:            0.00
c
c Solution checks (feasible and optimal)
c
c pushes:              12
c relabels:             4
c updates:              1
c gaps:                 0
c gap nodes:            0
c
c flow values
f         1        2             2
f         1        4             3
f         1        3             2
f         1        5             5
f         2        6             2
f         3        7             2
f         4        7             3
f         4        6             0
f         5        6             5
f         6        8             7
```

```
f       7       8               5
c
```

c) Convert the output to graphics format using the custom convert code: convert 4 2 hw1.out hwk1.gr
    and then to graphics using the GraphViz command: dot -Tpng -o hwk1.png hwk1.gr, or the editor
    Gvedit available online at http://www.graphviz.org.
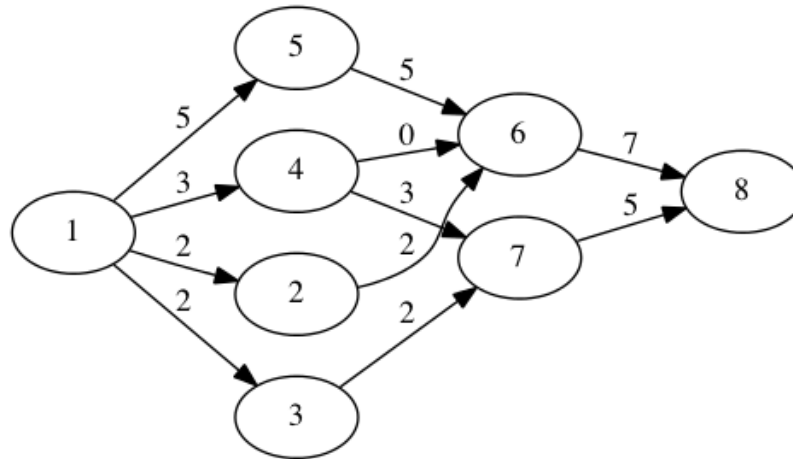
3. (10 points) Consider the synchronous task set shown in Table 1 (on the next page). This task set
    comes from an embedded signal processing application for an anti-submarine warfare (ASW) system.
    More specifically, the task set is a modified subset of the tasks that implement the Directed Low
    Frequency Analysis and Recording (DIFAR) acoustic signal processing application from the Airborne
    Low Frequency Sonar (ALFS) system of the U.S. Navy's SH-60B LAMPS MK III anti-submarine
    helicopter. The ALFS system processes low frequency signals received by sono-buoys in the water. Its
    primary function is to detect and track submarines and to calculate range and bearing estimates to each
    target. The task set shown in Table 1 represents an implementation of a portion of the DIFAR
    application on a Mercury PowerPC 6U VME board with a 200MHz 603e processor. This portion of
    the DIFAR application processes five bands of Constant Resolution (CR) data from each of five sono-
    buoys. In this assignment, we will assume all tasks are independent.

Task ID	Phase in ms	Period in ms	Time/Exec in ms	Relative Deadline	Processing Primitive
1	0	250	6.4545	250	FLW
2	0	250	30.1303	250	BDFC
3	0	250	0.3437	250	MASTERMCS
4	0	250	0.1022	250	SLAVEMCS
5	0	250	5.7349	250	DIFARDAD
6	0	250	5.7557	250	DIFARDAD
7	0	250	5.7974	250	DIFARDAD
8	0	250	5.8807	250	DIFARDAD
9	0	250	6.0472	250	DIFARDAD
10	0	250	4.3071	250	DIFARDAD
11	0	250	7.7672	250	DIFARDAD
12	0	250	14.6875	250	DIFARDAD
13	0	250	7.183	250	CRFIL
14	0	250	7.3999	250	CRFIL
15	0	250	7.8337	250	CRFIL
16	0	250	8.7012	250	CRFIL
17	0	250	8.7012	250	CRFIL
18	0	250	8.1264	250	CRSPECANAL
19	0	250	8.1264	250	CRSPECANAL
20	0	250	8.4815	250	CRSPECANAL

21	0	250	9.1918	250	CRSPECANAL
22	0	250	9.1918	250	CRSPECANAL
23	0	250	3.217	250	ALLBANDMERGE
24	0	250	3.5179	250	SAD
25	0	250	3.6363	250	GRM
26	0	250	5.1914	250	BBC
27	0	250	0.1496	250	GRAMMERGE
28	0	500	3.3671	500	CRDETECT
29	0	500	3.3671	500	CRDETECT
30	0	500	3.3671	500	CRDETECT
31	0	500	3.3671	500	CRDETECT
32	0	500	3.3671	500	CRDETECT
33	0	2000	3.1913	2000	ALI
34	0	2000	5.1122	2000	BRG
35	0	2000	0.5047	2000	ALIMERGE
36	0	2000	0.5906	2000	BEARMERGE
37	0	6000	2.4799	6000	AUTODETECT
38	0	6000	0.199	6000	BINMERGE
39	0	6000	0.6898	6000	AUTODETMERGE
40	0	6000	40.823	6000	EXTRAMERGE

Table1: Synchronous signal processing task set for a 200MHz 603e PowerPC.

a. For all i, $1 \le i \le 40$, what is the utilization of task T_i? What is the total system utilization?

Total utilization: 0.8123656833333334 = 81.2365%

Hyperperiod: 6000, Total utilization: 0.8123656833333334 = 81.2365%

Task id	phi	p	e	D	u
1	0	250	6.4545	250	0.025818
2	0	250	30.1303	250	0.1205212
3	0	250	0.3437	250	0.0013748
4	0	250	0.1022	250	4.088E-4
5	0	250	5.7349	250	0.022939599999999997
6	0	250	5.7557	250	0.0230228
7	0	250	5.7974	250	0.023189599999999998
8	0	250	5.8807	250	0.0235228
9	0	250	6.0472	250	0.0241888
10	0	250	4.3071	250	0.0172284
11	0	250	7.7672	250	0.0310688
12	0	250	14.6875	250	0.05875
13	0	250	7.183	250	0.028732
14	0	250	7.3999	250	0.0295996
15	0	250	7.8337	250	0.0313348
16	0	250	8.7012	250	0.0348048
17	0	250	8.7012	250	0.0348048
18	0	250	8.1264	250	0.0325056
19	0	250	8.1264	250	0.0325056
20	0	250	8.4815	250	0.033926000000000005
21	0	250	9.1918	250	0.0367672
22	0	250	9.1918	250	0.0367672
23	0	250	3.217	250	0.012868000000000001
24	0	250	3.5179	250	0.0140716
25	0	250	3.6363	250	0.0145452
26	0	250	5.1914	250	0.0207656
27	0	250	0.1496	250	5.984E-4
28	0	500	3.3671	500	0.0067342
29	0	500	3.3671	500	0.0067342
30	0	500	3.3671	500	0.0067342
31	0	500	3.3671	500	0.0067342
32	0	500	3.3671	500	0.0067342
33	0	2000	3.1913	2000	0.00159565
34	0	2000	5.1122	2000	0.0025561
35	0	2000	0.5047	2000	2.5235000000000004E-4
36	0	2000	0.5906	2000	2.953E-4
37	0	6000	2.4799	6000	4.133166666666667E-4
38	0	6000	0.199	6000	3.316666666666667E-5

| 39 | 0 | 6000 | 0.6898 | 6000 | 1.1496666666666666E-4 |
| 40 | 0 | 6000 | 40.823 | 6000 | 0.006803833333333334 |

    b.   What is the Hyperiod (H) of the task set? 6000

    c.   What are the possible frame sizes that could be used to create a static cyclic schedule for this task set?

        (i) f >= 40.823, the deadline of task 40.
        (ii) f divides evenly into the hyperperiod, so starting with those that satisfy (i), we have 50, 60, 75, 100, 125, 150, 200, 250, 300, etc…
        (iii) There must be at least one frame between the release and deadline of each task. Note that all of these tasks have periods equal to their deadlines, and all are multiples of 250, so this condition is satisfied for frames sizes 50, 100, 125, 150, 200, and 250.

        I chose to use the largest possible frame size which is 250.

    d.   Create a static cyclic schedule for the task set (you may want to create a program to do this using a Maximum Network Flow algorithm). Turn in the scheduled created. If you wrote a program to generate the schedule or the input to a maximum network flow algorithm, please turn it in as well. You can retrieve a text file containing the task parameters in 4-tuple form from: http://www.cis.ksu.edu/~neilsen/cis721/HW1table1.txt.

        Using the generator from http://www.cis.ksu.edu/~neilsen/cis721/generator.c, I produced the input data set http://www.cis.ksu.edu/~neilsen/cis721/data.inp.
        All input is scaled by 10000 to generate integral input to hi_pr.
gcc –o myGen generator.c
./myGen
➔ max flow = 4874.1941 sec. = 48741941 units.
./hi_pr < data.inp > data.out

        Source = node 1
        Sink = node 750
        Jobs = nodes 2 to 725 = 724 jobs
        Frames = nodes 726 to 749 = 24 frames

```
c
c hi_pr version 3.6
c Copyright C by IG Systems, igsys@eclipse.net
c
c nodes:              750
c arcs:              1708
c
c flow:         48741941.0   ← all possible flow accounted for
c time:              0.00
c cut tm:            0.00
c
c Solution checks (feasible and optimal)
c
c pushes:            2172
c relabels:           724
c updates:              1
c gaps:                 0
c gap nodes:            0
c
c flow values
f       1       2          64545
f       1     183          58807
f       1     341          78337
f       1     605          51914
f       1       3          64545
f       1     385          87012
f       1     392          87012
```

f	1	395	87012
f	1	4	64545
f	1	184	58807
f	1	274	146875
f	1	429	81264
f	1	5	64545
f	1	319	73999
f	1	459	84815
f	1	525	91918
f	1	6	64545
f	1	185	58807
f	1	358	78337
f	1	646	1496
f	1	7	64545
f	1	668	33671
f	1	561	35179
f	1	510	91918
f	1	8	64545
f	1	186	58807
f	1	275	146875
f	1	661	33671
f	1	9	64545
f	1	636	1496
f	1	414	81264
f	1	442	81264
f	1	10	64545
f	1	187	58807
f	1	437	81264
f	1	675	33671
f	1	11	64545
f	1	447	81264
f	1	419	81264
f	1	682	33671
f	1	12	64545
f	1	188	58807
f	1	276	146875
f	1	505	91918
f	1	13	64545
f	1	320	73999
f	1	721	5906
f	1	541	32170
f	1	14	64545
f	1	189	58807
f	1	342	78337
f	1	702	33671
f	1	15	64545
f	1	546	32170
f	1	579	36363
f	1	709	33671
f	1	16	64545
f	1	190	58807
f	1	277	146875
f	1	712	31913
f	1	17	64545
f	1	353	78337
f	1	500	91918
f	1	413	81264
f	1	18	64545
f	1	191	58807
f	1	373	87012
f	1	387	87012
f	1	19	64545
f	1	408	87012
f	1	592	36363
f	1	570	35179
f	1	20	64545
f	1	192	58807
f	1	278	146875
f	1	577	35179
f	1	21	64545
f	1	321	73999
f	1	424	81264

```
f       1       377        87012
f       1        22        64545
f       1       193        58807
f       1       361        78337
f       1       399        87012
f       1        23        64545
f       1       455        81264
f       1       382        87012
f       1       531        32170
f       1        24        64545
f       1       194        60472
f       1       279       146875
f       1       478        84815
f       1        25        64545
f       1       689        33671
f       1       647         1496
f       1       598        36363
f       1        26       301303
f       1       195        60472
f       1       460        84815
f       1       432        81264
f       1        27       301303
f       1       481        84815
f       1       421        81264
f       1       616        51914
f       1        28       301303
f       1       196        60472
f       1       280       146875
f       1       626         1496
f       1        29       301303
f       1       322        73999
f       1       495        91918
f       1       450        81264
f       1        30       301303
f       1       197        60472
f       1       343        78337
f       1       606        51914
f       1        31       301303
f       1       380        87012
f       1       637         1496
f       1       655        33671
f       1        32       301303
f       1       198        60472
f       1       281       146875
f       1       398        87012
f       1        33       301303
f       1       526        91918
f       1       566        35179
f       1       521        91918
f       1        34       301303
f       1       199        60472
f       1       485        91918
f       1       445        81264
f       1        35       301303
f       1       648         1496
f       1       511        91918
f       1       374        87012
f       1        36       301303
f       1       200        60472
f       1       282       146875
f       1       407        87012
f       1        37       301303
f       1       323        73999
f       1       725       408230
f       1       696        33671
f       1        38       301303
f       1       201        60472
f       1       417        81264
f       1       375        87012
f       1        39       301303
f       1       465        84815
f       1       393        87012
```

```
f       1       710       31913
f       1        40      301303
f       1       202       60472
f       1       283      146875
f       1       627        1496
f       1        41      301303
f       1       557       35179
f       1       467       84815
f       1       669       33671
f       1        42      301303
f       1       203       60472
f       1       552       32170
f       1       389       87012
f       1        43      301303
f       1       599       36363
f       1       719        5906
f       1       468       84815
f       1        44      301303
f       1       204       60472
f       1       284      146875
f       1       683       33671
f       1        45      301303
f       1       324       73999
f       1       662       33671
f       1       490       91918
f       1        46      301303
f       1       205       60472
f       1       344       78337
f       1       586       36363
f       1        47      301303
f       1       427       81264
f       1       458       84815
f       1       412       81264
f       1        48      301303
f       1       206       60472
f       1       285      146875
f       1       703       33671
f       1        49      301303
f       1       354       78337
f       1       403       87012
f       1       394       87012
f       1        50        3437
f       1       207       60472
f       1       676       33671
f       1       506       91918
f       1        51        3437
f       1       384       87012
f       1       607       51914
f       1       617       51914
f       1        52        3437
f       1       208       60472
f       1       286      146875
f       1       580       36363
f       1        53        3437
f       1       325       73999
f       1       411       81264
f       1       542       32170
f       1        54        3437
f       1       209       60472
f       1       359       78337
f       1       435       81264
f       1        55        3437
f       1       475       84815
f       1       547       32170
f       1       416       81264
f       1        56        3437
f       1       210       60472
f       1       287      146875
f       1       516       91918
f       1        57        3437
f       1       440       81264
f       1       717        5047
```

f	1	562	35179
f	1	58	3437
f	1	211	60472
f	1	697	33671
f	1	690	33671
f	1	59	3437
f	1	593	36363
f	1	638	1496
f	1	532	32170
f	1	60	3437
f	1	212	60472
f	1	288	146875
f	1	537	32170
f	1	61	3437
f	1	326	73999
f	1	578	36363
f	1	453	81264
f	1	62	3437
f	1	213	60472
f	1	345	78337
f	1	364	87012
f	1	63	3437
f	1	600	36363
f	1	472	84815
f	1	378	87012
f	1	64	3437
f	1	214	60472
f	1	289	146875
f	1	367	87012
f	1	65	3437
f	1	363	87012
f	1	386	87012
f	1	482	91918
f	1	66	3437
f	1	215	60472
f	1	527	91918
f	1	568	35179
f	1	67	3437
f	1	423	81264
f	1	463	84815
f	1	369	87012
f	1	68	3437
f	1	216	60472
f	1	290	71830
f	1	471	84815
f	1	69	3437
f	1	327	73999
f	1	501	91918
f	1	418	81264
f	1	70	3437
f	1	217	60472
f	1	656	33671
f	1	587	36363
f	1	71	3437
f	1	381	87012
f	1	608	51914
f	1	558	35179
f	1	72	3437
f	1	218	43071
f	1	291	71830
f	1	601	36363
f	1	73	3437
f	1	376	87012
f	1	486	91918
f	1	704	33671
f	1	74	1022
f	1	219	43071
f	1	553	32170
f	1	425	81264
f	1	75	1022
f	1	715	51122
f	1	618	51914

```
f      1      491      91918
f      1       76       1022
f      1      220      43071
f      1      292      71830
f      1      628       1496
f      1       77       1022
f      1      328      73999
f      1      496      91918
f      1      639       1496
f      1       78       1022
f      1      221      43071
f      1      346      78337
f      1      649       1496
f      1       79       1022
f      1      430      81264
f      1      670      33671
f      1      448      81264
f      1       80       1022
f      1      222      43071
f      1      293      71830
f      1      402      87012
f      1       81       1022
f      1      355      78337
f      1      368      87012
f      1      522      91918
f      1       82       1022
f      1      223      43071
f      1      461      84815
f      1      677      33671
f      1       83       1022
f      1      512      91918
f      1      365      87012
f      1      629       1496
f      1       84       1022
f      1      224      43071
f      1      294      71830
f      1      371      87012
f      1       85       1022
f      1      329      73999
f      1      466      84815
f      1      548      32170
f      1       86       1022
f      1      225      43071
f      1      619      51914
f      1      663      33671
f      1       87       1022
f      1      609      51914
f      1      443      81264
f      1      657      33671
f      1       88       1022
f      1      226      43071
f      1      295      71830
f      1      573      35179
f      1       89       1022
f      1      397      87012
f      1      684      33671
f      1      388      87012
f      1       90       1022
f      1      227      43071
f      1      438      81264
f      1      415      81264
f      1       91       1022
f      1      401      87012
f      1      406      87012
f      1      640       1496
f      1       92       1022
f      1      228      43071
f      1      296      71830
f      1      379      87012
f      1       93       1022
f      1      330      73999
f      1      502      91918
```

```
f       1       650     33671
f       1        94      1022
f       1       229     43071
f       1       347     78337
f       1       594     36363
f       1        95      1022
f       1       517     91918
f       1       698     33671
f       1       705     33671
f       1        96      1022
f       1       230     43071
f       1       297     71830
f       1       507     91918
f       1        97      1022
f       1       479     84815
f       1       456     81264
f       1       691     33671
f       1        98     57349
f       1       231     43071
f       1       713     51122
f       1       543     32170
f       1        99     57349
f       1       366     87012
f       1       630      1496
f       1       390     87012
f       1       100     57349
f       1       232     43071
f       1       298     71830
f       1       497     91918
f       1       101     57349
f       1       331     73999
f       1       554     35179
f       1       433     81264
f       1       102     57349
f       1       233     43071
f       1       559     35179
f       1       610     51914
f       1       103     57349
f       1       671     33671
f       1       533     32170
f       1       487     91918
f       1       104     57349
f       1       234     43071
f       1       299     71830
f       1       383     87012
f       1       105     57349
f       1       569     35179
f       1       410     81264
f       1       370     87012
f       1       106     57349
f       1       235     43071
f       1       685     33671
f       1       678     33671
f       1       107     57349
f       1       372     87012
f       1       581     36363
f       1       641      1496
f       1       108     57349
f       1       236     43071
f       1       300     71830
f       1       538     32170
f       1       109     57349
f       1       332     73999
f       1       620     51914
f       1       528     91918
f       1       110     57349
f       1       237     43071
f       1       348     78337
f       1       722     24799
f       1       111     57349
f       1       451     81264
f       1       391     87012
```

```
f       1       523      91918
f       1       112      57349
f       1       238      43071
f       1       301      71830
f       1       574      35179
f       1       113      57349
f       1       356      78337
f       1       651      33671
f       1       664      33671
f       1       114      57349
f       1       239      43071
f       1       564      35179
f       1       711      31913
f       1       115      57349
f       1       492      91918
f       1       699      33671
f       1       469      84815
f       1       116      57349
f       1       240      43071
f       1       302      71830
f       1       446      81264
f       1       117      57349
f       1       333      73999
f       1       582      36363
f       1       631       1496
f       1       118      57349
f       1       241      43071
f       1       360      78337
f       1       602      51914
f       1       119      57349
f       1       464      84815
f       1       473      84815
f       1       692      33671
f       1       120      57349
f       1       242      77672
f       1       303      71830
f       1       658      33671
f       1       121      57349
f       1       720       5906
f       1       405      87012
f       1       428      81264
f       1       122      57557
f       1       243      77672
f       1       642       1496
f       1       611      51914
f       1       123      57557
f       1       621      51914
f       1       396      87012
f       1       503      91918
f       1       124      57557
f       1       244      77672
f       1       304      71830
f       1       518      91918
f       1       125      57557
f       1       334      73999
f       1       560      35179
f       1       706      33671
f       1       126      57557
f       1       245      77672
f       1       349      78337
f       1       508      91918
f       1       127      57557
f       1       513      91918
f       1       588      36363
f       1       549      32170
f       1       128      57557
f       1       246      77672
f       1       305      71830
f       1       436      81264
f       1       129      57557
f       1       362      87012
f       1       643       1496
```

```
f       1       652     33671
f       1       130     57557
f       1       247     77672
f       1       476     84815
f       1       679     33671
f       1       131     57557
f       1       565     35179
f       1       483     91918
f       1       686     33671
f       1       132     57557
f       1       248     77672
f       1       306     71830
f       1       539     32170
f       1       133     57557
f       1       335     73999
f       1       665     33671
f       1       529     91918
f       1       134     57557
f       1       249     77672
f       1       400     87012
f       1       555     35179
f       1       135     57557
f       1       718      5047
f       1       672     33671
f       1       534     32170
f       1       136     57557
f       1       250     77672
f       1       307     71830
f       1       462     84815
f       1       137     57557
f       1       544     32170
f       1       659     33671
f       1       441     81264
f       1       138     57557
f       1       251     77672
f       1       595     36363
f       1       449     81264
f       1       139     57557
f       1       420     81264
f       1       632      1496
f       1       575     35179
f       1       140     57557
f       1       252     77672
f       1       308     71830
f       1       583     36363
f       1       141     57557
f       1       336     73999
f       1       693     33671
f       1       680     33671
f       1       142     57557
f       1       253     77672
f       1       350     78337
f       1       454     81264
f       1       143     57557
f       1       612     51914
f       1       622     51914
f       1       498     91918
f       1       144     57557
f       1       254     77672
f       1       309     71830
f       1       571     35179
f       1       145     57557
f       1       357     78337
f       1       603     51914
f       1       723      1990
f       1       146     57974
f       1       255     77672
f       1       700     33671
f       1       488     91918
f       1       147     57974
f       1       589     36363
f       1       409     87012
```

```
f       1       493     91918
f       1       148     57974
f       1       256     77672
f       1       310     71830
f       1       431     81264
f       1       149     57974
f       1       337     73999
f       1       524     91918
f       1       644      1496
f       1       150     57974
f       1       257     77672
f       1       633      1496
f       1       707     33671
f       1       151     57974
f       1       514     91918
f       1       716      5047
f       1       439     81264
f       1       152     57974
f       1       258     77672
f       1       311     71830
f       1       666     33671
f       1       153     57974
f       1       519     91918
f       1       509     91918
f       1       673     33671
f       1       154     57974
f       1       259     77672
f       1       545     32170
f       1       687     33671
f       1       155     57974
f       1       623     51914
f       1       550     32170
f       1       660     33671
f       1       156     57974
f       1       260     77672
f       1       312     71830
f       1       535     32170
f       1       157     57974
f       1       338     78337
f       1       584     36363
f       1       457     81264
f       1       158     57974
f       1       261     77672
f       1       351     78337
f       1       590     36363
f       1       159     57974
f       1       567     35179
f       1       596     36363
f       1       701     33671
f       1       160     57974
f       1       262     77672
f       1       313     71830
f       1       474     84815
f       1       161     57974
f       1       426     81264
f       1       694     33671
f       1       653     33671
f       1       162     57974
f       1       263     77672
f       1       613     51914
f       1       477     84815
f       1       163     57974
f       1       530     32170
f       1       480     84815
f       1       576     35179
f       1       164     57974
f       1       264     77672
f       1       314     73999
f       1       540     32170
f       1       165     57974
f       1       339     78337
f       1       504     91918
```

```
f       1       624         51914
f       1       166         57974
f       1       265         77672
f       1       708         33671
f       1       724          6898
f       1       167         57974
f       1       444         81264
f       1       452         81264
f       1       422         81264
f       1       168         57974
f       1       266        146875
f       1       315         73999
f       1       604         51914
f       1       169         57974
f       1       404         87012
f       1       614         51914
f       1       556         35179
f       1       170         58807
f       1       267        146875
f       1       494         91918
f       1       489         91918
f       1       171         58807
f       1       470         84815
f       1       484         91918
f       1       625         51914
f       1       172         58807
f       1       268        146875
f       1       316         73999
f       1       434         81264
f       1       173         58807
f       1       340         78337
f       1       634          1496
f       1       645          1496
f       1       174         58807
f       1       269        146875
f       1       352         78337
f       1       499         91918
f       1       175         58807
f       1       667         33671
f       1       591         36363
f       1       515         91918
f       1       176         58807
f       1       270        146875
f       1       317         73999
f       1       714         51122
f       1       177         58807
f       1       597         36363
f       1       520         91918
f       1       674         33671
f       1       178         58807
f       1       271        146875
f       1       681         33671
f       1       585         36363
f       1       179         58807
f       1       688         33671
f       1       635          1496
f       1       536         32170
f       1       180         58807
f       1       272        146875
f       1       318         73999
f       1       695         33671
f       1       181         58807
f       1       563         35179
f       1       572         35179
f       1       615         51914
f       1       182         58807
f       1       273        146875
f       1       654         33671
f       1       551         32170
f       2       726         64545   ← all of job 1 (node 2) is assigned to the first frame
f       3       727         64545
f       4       728         64545
```

```
f       5       729         64545
f       6       730         64545
f       7       731         64545
f       8       732         64545
f       9       733         64545
f      10       734         64545
f      11       735         64545
f      12       736         64545
f      13       737         64545
f      14       738         64545
f      15       739         64545
f      16       740         64545
f      17       741         64545
f      18       742         64545
f      19       743         64545
f      20       744         64545
f      21       745         64545
f      22       746         64545
f      23       747         64545
f      24       748         64545
f      25       749         64545  ← ditto for all jobs in task 1; each assigned to a unique
frame
f      26       726        301303
f      27       727        301303
f      28       728        301303
f      29       729        301303
f      30       730        301303
f      31       731        301303
f      32       732        301303
f      33       733        301303
f      34       734        301303
f      35       735        301303
f      36       736        301303
f      37       737        301303
f      38       738        301303
f      39       739        301303
f      40       740        301303
f      41       741        301303
f      42       742        301303
f      43       743        301303
f      44       744        301303
f      45       745        301303
f      46       746        301303
f      47       747        301303
f      48       748        301303
f      49       749        301303
f      50       726          3437
f      51       727          3437
f      52       728          3437
f      53       729          3437
f      54       730          3437
f      55       731          3437
f      56       732          3437
f      57       733          3437
f      58       734          3437
f      59       735          3437
f      60       736          3437
f      61       737          3437
f      62       738          3437
f      63       739          3437
f      64       740          3437
f      65       741          3437
f      66       742          3437
f      67       743          3437
f      68       744          3437
f      69       745          3437
f      70       746          3437
f      71       747          3437
f      72       748          3437
f      73       749          3437
f      74       726          1022
f      75       727          1022
```

```
f     76     728        1022
f     77     729        1022
f     78     730        1022
f     79     731        1022
f     80     732        1022
f     81     733        1022
f     82     734        1022
f     83     735        1022
f     84     736        1022
f     85     737        1022
f     86     738        1022
f     87     739        1022
f     88     740        1022
f     89     741        1022
f     90     742        1022
f     91     743        1022
f     92     744        1022
f     93     745        1022
f     94     746        1022
f     95     747        1022
f     96     748        1022
f     97     749        1022
f     98     726       57349
f     99     727       57349
f    100     728       57349
f    101     729       57349
f    102     730       57349
f    103     731       57349
f    104     732       57349
f    105     733       57349
f    106     734       57349
f    107     735       57349
f    108     736       57349
f    109     737       57349
f    110     738       57349
f    111     739       57349
f    112     740       57349
f    113     741       57349
f    114     742       57349
f    115     743       57349
f    116     744       57349
f    117     745       57349
f    118     746       57349
f    119     747       57349
f    120     748       57349
f    121     749       57349
f    122     726       57557
f    123     727       57557
f    124     728       57557
f    125     729       57557
f    126     730       57557
f    127     731       57557
f    128     732       57557
f    129     733       57557
f    130     734       57557
f    131     735       57557
f    132     736       57557
f    133     737       57557
f    134     738       57557
f    135     739       57557
f    136     740       57557
f    137     741       57557
f    138     742       57557
f    139     743       57557
f    140     744       57557
f    141     745       57557
f    142     746       57557
f    143     747       57557
f    144     748       57557
f    145     749       57557
f    146     726       57974
f    147     727       57974
```

f	148	728	57974
f	149	729	57974
f	150	730	57974
f	151	731	57974
f	152	732	57974
f	153	733	57974
f	154	734	57974
f	155	735	57974
f	156	736	57974
f	157	737	57974
f	158	738	57974
f	159	739	57974
f	160	740	57974
f	161	741	57974
f	162	742	57974
f	163	743	57974
f	164	744	57974
f	165	745	57974
f	166	746	57974
f	167	747	57974
f	168	748	57974
f	169	749	57974
f	170	726	58807
f	171	727	58807
f	172	728	58807
f	173	729	58807
f	174	730	58807
f	175	731	58807
f	176	732	58807
f	177	733	58807
f	178	734	58807
f	179	735	58807
f	180	736	58807
f	181	737	58807
f	182	738	58807
f	183	739	58807
f	184	740	58807
f	185	741	58807
f	186	742	58807
f	187	743	58807
f	188	744	58807
f	189	745	58807
f	190	746	58807
f	191	747	58807
f	192	748	58807
f	193	749	58807
f	194	726	60472
f	195	727	60472
f	196	728	60472
f	197	729	60472
f	198	730	60472
f	199	731	60472
f	200	732	60472
f	201	733	60472
f	202	734	60472
f	203	735	60472
f	204	736	60472
f	205	737	60472
f	206	738	60472
f	207	739	60472
f	208	740	60472
f	209	741	60472
f	210	742	60472
f	211	743	60472
f	212	744	60472
f	213	745	60472
f	214	746	60472
f	215	747	60472
f	216	748	60472
f	217	749	60472
f	218	726	43071
f	219	727	43071

```
f    220    728       43071
f    221    729       43071
f    222    730       43071
f    223    731       43071
f    224    732       43071
f    225    733       43071
f    226    734       43071
f    227    735       43071
f    228    736       43071
f    229    737       43071
f    230    738       43071
f    231    739       43071
f    232    740       43071
f    233    741       43071
f    234    742       43071
f    235    743       43071
f    236    744       43071
f    237    745       43071
f    238    746       43071
f    239    747       43071
f    240    748       43071
f    241    749       43071
f    242    726       77672
f    243    727       77672
f    244    728       77672
f    245    729       77672
f    246    730       77672
f    247    731       77672
f    248    732       77672
f    249    733       77672
f    250    734       77672
f    251    735       77672
f    252    736       77672
f    253    737       77672
f    254    738       77672
f    255    739       77672
f    256    740       77672
f    257    741       77672
f    258    742       77672
f    259    743       77672
f    260    744       77672
f    261    745       77672
f    262    746       77672
f    263    747       77672
f    264    748       77672
f    265    749       77672
f    266    726      146875
f    267    727      146875
f    268    728      146875
f    269    729      146875
f    270    730      146875
f    271    731      146875
f    272    732      146875
f    273    733      146875
f    274    734      146875
f    275    735      146875
f    276    736      146875
f    277    737      146875
f    278    738      146875
f    279    739      146875
f    280    740      146875
f    281    741      146875
f    282    742      146875
f    283    743      146875
f    284    744      146875
f    285    745      146875
f    286    746      146875
f    287    747      146875
f    288    748      146875
f    289    749      146875
f    290    726       71830
f    291    727       71830
```

f	292	728	71830
f	293	729	71830
f	294	730	71830
f	295	731	71830
f	296	732	71830
f	297	733	71830
f	298	734	71830
f	299	735	71830
f	300	736	71830
f	301	737	71830
f	302	738	71830
f	303	739	71830
f	304	740	71830
f	305	741	71830
f	306	742	71830
f	307	743	71830
f	308	744	71830
f	309	745	71830
f	310	746	71830
f	311	747	71830
f	312	748	71830
f	313	749	71830
f	314	726	73999
f	315	727	73999
f	316	728	73999
f	317	729	73999
f	318	730	73999
f	319	731	73999
f	320	732	73999
f	321	733	73999
f	322	734	73999
f	323	735	73999
f	324	736	73999
f	325	737	73999
f	326	738	73999
f	327	739	73999
f	328	740	73999
f	329	741	73999
f	330	742	73999
f	331	743	73999
f	332	744	73999
f	333	745	73999
f	334	746	73999
f	335	747	73999
f	336	748	73999
f	337	749	73999
f	338	726	78337
f	339	727	78337
f	340	728	78337
f	341	729	78337
f	342	730	78337
f	343	731	78337
f	344	732	78337
f	345	733	78337
f	346	734	78337
f	347	735	78337
f	348	736	78337
f	349	737	78337
f	350	738	78337
f	351	739	78337
f	352	740	78337
f	353	741	78337
f	354	742	78337
f	355	743	78337
f	356	744	78337
f	357	745	78337
f	358	746	78337
f	359	747	78337
f	360	748	78337
f	361	749	78337
f	362	726	87012
f	363	727	87012

f	364	728	87012
f	365	729	87012
f	366	730	87012
f	367	731	87012
f	368	732	87012
f	369	733	87012
f	370	734	87012
f	371	735	87012
f	372	736	87012
f	373	737	87012
f	374	738	87012
f	375	739	87012
f	376	740	87012
f	377	741	87012
f	378	742	87012
f	379	743	87012
f	380	744	87012
f	381	745	87012
f	382	746	87012
f	383	747	87012
f	384	748	87012
f	385	749	87012
f	386	726	87012
f	387	727	87012
f	388	728	87012
f	389	729	87012
f	390	730	87012
f	391	731	87012
f	392	732	87012
f	393	733	87012
f	394	734	87012
f	395	735	87012
f	396	736	87012
f	397	737	87012
f	398	738	87012
f	399	739	87012
f	400	740	87012
f	401	741	87012
f	402	742	87012
f	403	743	87012
f	404	744	87012
f	405	745	87012
f	406	746	87012
f	407	747	87012
f	408	748	87012
f	409	749	87012
f	410	726	81264
f	411	727	81264
f	412	728	81264
f	413	729	81264
f	414	730	81264
f	415	731	81264
f	416	732	81264
f	417	733	81264
f	418	734	81264
f	419	735	81264
f	420	736	81264
f	421	737	81264
f	422	738	81264
f	423	739	81264
f	424	740	81264
f	425	741	81264
f	426	742	81264
f	427	743	81264
f	428	744	81264
f	429	745	81264
f	430	746	81264
f	431	747	81264
f	432	748	81264
f	433	749	81264
f	434	726	81264
f	435	727	81264

f	436	728	81264
f	437	729	81264
f	438	730	81264
f	439	731	81264
f	440	732	81264
f	441	733	81264
f	442	734	81264
f	443	735	81264
f	444	736	81264
f	445	737	81264
f	446	738	81264
f	447	739	81264
f	448	740	81264
f	449	741	81264
f	450	742	81264
f	451	743	81264
f	452	744	81264
f	453	745	81264
f	454	746	81264
f	455	747	81264
f	456	748	81264
f	457	749	81264
f	458	726	84815
f	459	727	84815
f	460	728	84815
f	461	729	84815
f	462	730	84815
f	463	731	84815
f	464	732	84815
f	465	733	84815
f	466	734	84815
f	467	735	84815
f	468	736	84815
f	469	737	84815
f	470	738	84815
f	471	739	84815
f	472	740	84815
f	473	741	84815
f	474	742	84815
f	475	743	84815
f	476	744	84815
f	477	745	84815
f	478	746	84815
f	479	747	84815
f	480	748	84815
f	481	749	84815
f	482	726	91918
f	483	727	91918
f	484	728	91918
f	485	729	91918
f	486	730	91918
f	487	731	91918
f	488	732	91918
f	489	733	91918
f	490	734	91918
f	491	735	91918
f	492	736	91918
f	493	737	91918
f	494	738	91918
f	495	739	91918
f	496	740	91918
f	497	741	91918
f	498	742	91918
f	499	743	91918
f	500	744	91918
f	501	745	91918
f	502	746	91918
f	503	747	91918
f	504	748	91918
f	505	749	91918
f	506	726	91918
f	507	727	91918

f	508	728	91918
f	509	729	91918
f	510	730	91918
f	511	731	91918
f	512	732	91918
f	513	733	91918
f	514	734	91918
f	515	735	91918
f	516	736	91918
f	517	737	91918
f	518	738	91918
f	519	739	91918
f	520	740	91918
f	521	741	91918
f	522	742	91918
f	523	743	91918
f	524	744	91918
f	525	745	91918
f	526	746	91918
f	527	747	91918
f	528	748	91918
f	529	749	91918
f	530	726	32170
f	531	727	32170
f	532	728	32170
f	533	729	32170
f	534	730	32170
f	535	731	32170
f	536	732	32170
f	537	733	32170
f	538	734	32170
f	539	735	32170
f	540	736	32170
f	541	737	32170
f	542	738	32170
f	543	739	32170
f	544	740	32170
f	545	741	32170
f	546	742	32170
f	547	743	32170
f	548	744	32170
f	549	745	32170
f	550	746	32170
f	551	747	32170
f	552	748	32170
f	553	749	32170
f	554	726	35179
f	555	727	35179
f	556	728	35179
f	557	729	35179
f	558	730	35179
f	559	731	35179
f	560	732	35179
f	561	733	35179
f	562	734	35179
f	563	735	35179
f	564	736	35179
f	565	737	35179
f	566	738	35179
f	567	739	35179
f	568	740	35179
f	569	741	35179
f	570	742	35179
f	571	743	35179
f	572	744	35179
f	573	745	35179
f	574	746	35179
f	575	747	35179
f	576	748	35179
f	577	749	35179
f	578	726	36363
f	579	727	36363

```
f    580    728    36363
f    581    729    36363
f    582    730    36363
f    583    731    36363
f    584    732    36363
f    585    733    36363
f    586    734    36363
f    587    735    36363
f    588    736    36363
f    589    737    36363
f    590    738    36363
f    591    739    36363
f    592    740    36363
f    593    741    36363
f    594    742    36363
f    595    743    36363
f    596    744    36363
f    597    745    36363
f    598    746    36363
f    599    747    36363
f    600    748    36363
f    601    749    36363
f    602    726    51914
f    603    727    51914
f    604    728    51914
f    605    729    51914
f    606    730    51914
f    607    731    51914
f    608    732    51914
f    609    733    51914
f    610    734    51914
f    611    735    51914
f    612    736    51914
f    613    737    51914
f    614    738    51914
f    615    739    51914
f    616    740    51914
f    617    741    51914
f    618    742    51914
f    619    743    51914
f    620    744    51914
f    621    745    51914
f    622    746    51914
f    623    747    51914
f    624    748    51914
f    625    749    51914
f    626    726     1496
f    627    727     1496
f    628    728     1496
f    629    729     1496
f    630    730     1496
f    631    731     1496
f    632    732     1496
f    633    733     1496
f    634    734     1496
f    635    735     1496
f    636    736     1496
f    637    737     1496
f    638    738     1496
f    639    739     1496
f    640    740     1496
f    641    741     1496
f    642    742     1496
f    643    743     1496
f    644    744     1496
f    645    745     1496
f    646    746     1496
f    647    747     1496
f    648    748     1496
f    649    749     1496
f    650    726    33671
f    650    727        0
```

```
f     651     728        33671
f     651     729            0
f     652     730        33671
f     652     731            0
f     653     732        33671
f     653     733            0
f     654     734        33671
f     654     735            0
f     655     736        33671
f     655     737            0
f     656     738        33671
f     656     739            0
f     657     740        33671
f     657     741            0
f     658     742        33671
f     658     743            0
f     659     744        33671
f     659     745            0
f     660     746        33671
f     660     747            0
f     661     748        33671
f     661     749            0
f     662     726        33671
f     662     727            0
f     663     728        33671
f     663     729            0
f     664     730        33671
f     664     731            0
f     665     732        33671
f     665     733            0
f     666     734        33671
f     666     735            0
f     667     736        33671
f     667     737            0
f     668     738        33671
f     668     739            0
f     669     740        33671
f     669     741            0
f     670     742        33671
f     670     743            0
f     671     744        33671
f     671     745            0
f     672     746        33671
f     672     747            0
f     673     748        33671
f     673     749            0
f     674     727        33671
f     674     726            0
f     675     728        33671
f     675     729            0
f     676     730        33671
f     676     731            0
f     677     732        33671
f     677     733            0
f     678     734        33671
f     678     735            0
f     679     736        33671
f     679     737            0
f     680     738        33671
f     680     739            0
f     681     741        33671
f     681     740            0
f     682     742        33671
f     682     743            0
f     683     744        33671
f     683     745            0
f     684     746        33671
f     684     747            0
f     685     748        33671
f     685     749            0
f     686     726        33671
f     686     727            0
```

f	687	728	33671
f	687	729	0
f	688	730	33671
f	688	731	0
f	689	732	33671
f	689	733	0
f	690	734	33671
f	690	735	0
f	691	736	33671
f	691	737	0
f	692	738	33671
f	692	739	0
f	693	740	33671
f	693	741	0
f	694	742	33671
f	694	743	0
f	695	744	33671
f	695	745	0
f	696	746	33671
f	696	747	0
f	697	748	33671
f	697	749	0
f	698	726	33671
f	698	727	0
f	699	728	33671
f	699	729	0
f	700	730	33671
f	700	731	0
f	701	732	33671
f	701	733	0
f	702	734	33671
f	702	735	0
f	703	736	33671
f	703	737	0
f	704	738	33671
f	704	739	0
f	705	740	33671
f	705	741	0
f	706	742	33671
f	706	743	0
f	707	744	33671
f	707	745	0
f	708	746	33671
f	708	747	0
f	709	748	33671
f	709	749	0
f	710	726	31913
f	710	727	0
f	710	728	0
f	710	729	0
f	710	730	0
f	710	731	0
f	710	732	0
f	710	733	0
f	711	741	31913
f	711	734	0
f	711	735	0
f	711	736	0
f	711	737	0
f	711	738	0
f	711	739	0
f	711	740	0
f	712	742	31913
f	712	743	0
f	712	744	0
f	712	745	0
f	712	746	0
f	712	747	0
f	712	748	0
f	712	749	0
f	713	726	51122
f	713	727	0

f	713	728	0
f	713	729	0
f	713	730	0
f	713	731	0
f	713	732	0
f	713	733	0
f	714	735	51122
f	714	736	0
f	714	737	0
f	714	738	0
f	714	739	0
f	714	740	0
f	714	741	0
f	714	734	0
f	715	742	51122
f	715	743	0
f	715	744	0
f	715	745	0
f	715	746	0
f	715	747	0
f	715	748	0
f	715	749	0
f	716	729	5047
f	716	730	0
f	716	731	0
f	716	732	0
f	716	733	0
f	716	726	0
f	716	727	0
f	716	728	0
f	717	734	5047
f	717	735	0
f	717	736	0
f	717	737	0
f	717	738	0
f	717	739	0
f	717	740	0
f	717	741	0
f	718	748	5047
f	718	749	0
f	718	742	0
f	718	743	0
f	718	744	0
f	718	745	0
f	718	746	0
f	718	747	0
f	719	726	5906
f	719	727	0
f	719	728	0
f	719	729	0
f	719	730	0
f	719	731	0
f	719	732	0
f	719	733	0
f	720	734	5906
f	720	735	0
f	720	736	0
f	720	737	0
f	720	738	0
f	720	739	0
f	720	740	0
f	720	741	0
f	721	742	5906
f	721	743	0
f	721	744	0
f	721	745	0
f	721	746	0
f	721	747	0
f	721	748	0
f	721	749	0
f	722	737	24799
f	722	736	0

```
f    722    735         0
f    722    734         0
f    722    733         0
f    722    732         0
f    722    731         0
f    722    730         0
f    722    729         0
f    722    728         0
f    722    748         0
f    722    747         0
f    722    727         0
f    722    726         0
f    722    746         0
f    722    745         0
f    722    725         0
f    722    744         0
f    722    743         0
f    722    742         0
f    722    741         0
f    722    740         0
f    722    739         0
f    722    738         0
f    723    742      1990
f    723    741         0
f    723    740         0
f    723    739         0
f    723    738         0
f    723    737         0
f    723    736         0
f    723    735         0
f    723    734         0
f    723    733         0
f    723    732         0
f    723    731         0
f    723    730         0
f    723    729         0
f    723    728         0
f    723    727         0
f    723    748         0
f    723    726         0
f    723    747         0
f    723    746         0
f    723    725         0
f    723    745         0
f    723    744         0
f    723    743         0
f    724    746      6898
f    724    726         0
f    724    745         0
f    724    725         0
f    724    744         0
f    724    743         0
f    724    742         0
f    724    741         0
f    724    740         0
f    724    739         0
f    724    738         0
f    724    737         0
f    724    736         0
f    724    735         0
f    724    734         0
f    724    733         0
f    724    732         0
f    724    731         0
f    724    730         0
f    724    729         0
f    724    728         0
f    724    748         0
f    724    727         0
f    724    747         0
f    725    730    408230  ← last task has its job assigned to frame 5 = (730-725)
f    725    729         0
```

```
f     725     728              0
f     725     727              0
f     725     748              0
f     725     726              0
f     725     725              0
f     725     747              0
f     725     746              0
f     725     745              0
f     725     744              0
f     725     743              0
f     725     742              0
f     725     741              0
f     725     740              0
f     725     739              0
f     725     738              0
f     725     737              0
f     725     736              0
f     725     735              0
f     725     734              0
f     725     733              0
f     725     732              0
f     725     731              0
f     726     750        2140200  ← all frames have less than 250s. (2500000 units) assigned
f     727     750        1950246
f     728     750        2084930
f     729     750        1921622
f     730     750        2493160
f     731     750        1916575
f     732     750        2084930
f     733     750        1916575
f     734     750        2095883
f     735     750        1967697
f     736     750        2084930
f     737     750        1941374
f     738     750        2084930
f     739     750        1916575
f     740     750        2051259
f     741     750        1982159
f     742     750        2175861
f     743     750        1916575
f     744     750        2084930
f     745     750        1916575
f     746     750        2091828
f     747     750        1916575
f     748     750        2089977
f     749     750        1916575
c
```

e. What is the frame size *f* of your schedule? How many minor cycles are there in your major
    cycle? With frame size 250, there are 6000/250 = 24 minor cycles.