Bolt Beranek and Newman Inc.

Report No. 5423

IMP Performance Measurements
Preliminary Results

John G. Zornig

October 1983

BBN Communications

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1. INTRODUCTION

This is the final report provided under the provisions of Job Order 83-001 of Maryland Procurement Office Contract MDA-83-C-0959. It reports the current status of an investigation of the performance properties of the BBNCC C/30 Interface Message Processor (IMP). This investigation is incomplete and therefore this report will be as succinct as possible. The results of the study will be reported in more detail when it is complete and the author is in a position to make recommendations.

2. BASELINE MEASUREMENTS

During the period of the Job Order a three part measurement experiment was designed and conducted on a trial basis. The experiment consisted of simultaneous collection of frequency of occurrence data on C/30 NMFS microcode instructions and 4320 process execution together with BBN CUMSTATS traffic measurements as a normalization. It was expected that these data would reveal that a large portion of the MBB processor bandwidth was being used for input/output, indicating a potential for improvement by implementation of more efficient I/O hardware and firmware.

For these measurements, two systems had to be designed and implemented. These were (1) an automated system for collection and analysis of logic analyser records of micro-program counter activity, and (2) a process timing system for measurement of

macrocode process activity. Both systems were built, tested, and used to collect the data enclosed with this report.

Time constraints have not permitted detailed analysis of the results of this experiment. However, preliminary inspection of the data have indicated that:

a. There is no reason based on the data to believe that more than 20% of the processor bandwidth is used for I/O under even heavy load conditions.

b. A minimum of about 10% of the processor bandwidth is used for I/O, presumably synchronous idling, under no load conditions.

c. The relationship between traffic and I/O process activity is linear in both trunk and host interface cases. The slope is, however, different. Trunk load is about 0.2%/packet/sec. not including RFNMS, and host interface load is about 0.3%/packet/sec.

d. An appreciable amount of overhead (2-5%) involving spurious console I/O polling is present but would be avoidable with suitable microcode modification.

e. The current instrumentation does not reveal fraction of time spent idling in the macrocode background process.

3. ATTACHMENT OF 256kb TRUNKS

An attempt was made to find obstacles to connection of 256kb synchronous trunks to the current 4320 NMFS IMP. Microcode observations have revealed that there exist uninterruptable strips of instruction execution long enough to disturb such operation. Preliminary analyses of these observations indicates that these strips may be avoidable and that 256kb connection may therefore be possible. Modification and testing of the NMFS code would be necessary in order to verify this hypothesis.

3. INCREASE OF AGGREGATE THROUGHPUT

No determination of the feasibility of attaching a total of 3-256 kb trunks and 2-256kb hosts can be made until the physical attachment problem is solved and the excess processor capacity is determined. Based on the assumption that physical modification of the IMP would be necessary in order to handle the increase in load, a study of the feasibility of a number of alternatives was initiated. This study has resulted in the identification of a number of alternatives, but no firm analysis of cost and effectiveness has been made.

APPENDIX A: Measured Microengine Profiles

The following profiles were taken during a 12 hour period as indicated. They display the fraction of real time that the micro-program counter was observed to be in each part of the NMFS program, and a summary of that data by class of activity. Each measurement report is followed by the CUMSTATS report of IMP activity during the period of the measurement. These measurements are preliminary and should not be considered to be confirmed or reliable.

EXPERIMENT DURATION
FROM SEP 28, 1983   12:01:24.000   BBN-NMC TIME
  TO SEP 28, 1983   12:57:17.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

33 CUM STAT'S (100% OF MAX.)
TIME COVERED BY DATA =   3460.301 SECONDS

C30 IMP   (EXA)

MESSAGE AND PACKET SIZE STATISTICS

	HISTOGRAM OF MESSAGE LENGTH		LOG2 HISTOGRAM OF PACKET LENGTH		
PACKETS	FROM HOSTS	INTO HOSTS	16-BIT	HOSTS		CHAN
			DATA	FROM	INTO	OUT
1	95050	74085	WORDS			
2	1506	944				
3	216	143	0-1	12	3	971
4	10	50	2-3	32	27	73103
5	439	651	4-7	151	216	1391
6	4	5	8-15	8922	8452	9763
7	194	11	16-31	81698	48736	77203
8	158	25	32-63	12776	22730	14041

TOTALS	97577	75914		103591	80164	176472
MEAN/SEC (MSG)	28.20	21.94	(PKTS)	29.94	23.17	51.00
MEAN BITS/SEC	11897.42	10976.38				
MEAN PKTS/MSG	1.06	1.06				
MEAN BITS/MSG	421.91	500.32				
MEAN BITS/PKT	397.42	473.80				

H2I: PKTS/SEC=   29.9   MSGS/SEC=   28.2
I2H: PKTS/SEC=   23.2   MSGS/SEC=   21.9   PKTS & RFNMS =   51.4
M2I: PKTS/SEC=   50.5
I2M: PKTS/SEC=   51.0
TSK: PKTS/SEC=   102.4

HOST MSG TOTALS	CSNET -CIC	BBN-N OC	DIV6- TAC	FIBER -GW
TOTAL FROM	12551	2776	14836	67414
CONTROL TO	12551	2776	14836	67414

FAKE HOST MSG TOTALS	TTY	DEBUG	PC/TR	DS/ST
TOTAL FROM	0	0	0	0
CONTROL TO	0	0	0	0

CHANNEL ACTIVITY

NEIGHBOR	PKTS OUT	BITS OUT	BITS/SEC
UCC4	75258	1.71E+07	4950.30
UCC8	48756	1.28E+07	3685.86
UCC2	52458	1.16E+07	3345.71
TOTAL	176472	4.15E+07	11981.87

MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   234.94

```
# OF ROUND-TRIPS & MEAN RT TIME, TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
   UCC2      17555,      46  /  UCC4     19325,     98  /  DB5          1,     90
   UCC6       3930,      76  /  UCC7       487,     91  /  UCC8     23586,     63
   NCLB9      1155,     127  /  MLB10    10381,     81  /  UCC14    21271,     46
   TEST5         2,     102  /

      97693 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY =  66.42 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =    1.01
          PER LINE:
              TO   UCC4     0.34  (    60.79 BITS)  PER SECOND
              TO   UCC8     0.34  (    60.79 BITS)  PER SECOND
              TO   UCC2     0.34  (    60.79 BITS)  PER SECOND

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.74

TOTAL NULLS PER SECOND (ALL LINES) =    44.64
          PER LINE:
              TO   UCC4    15.94  (  2422.48 BITS)  PER SECOND
              TO   UCC8    16.14  (  2453.75 BITS)  PER SECOND
              TO   UCC2    12.56  (  1909.24 BITS)  PER SECOND

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983 13:00:50.000   BBN-NMC TIME
  TO SEP 28, 1983 13:56:45.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

       33 CUM STAT'S (100% OF MAX.)
         TIME COVERED BY DATA =   3460.301 SECONDS

       C30 IMP   (EXA)

              MESSAGE AND PACKET SIZE STATISTICS
        HISTOGRAM OF MESSAGE LENGTH   LOG2 HISTOGRAM OF PACKET LENGTH
     PACKETS   FROM HOSTS   INTO HOSTS   16-BIT   HOSTS   CHAN
        1   100899   80686   DATA   FROM   INTO   OUT
        2   1432   1111   WORDS
        3   377   201   0-1   19   17   1071
        4   259   80   2-3   34   28   79470
        5   317   377   4-7   160   188   1526
        6   14   7   8-15   9570   9321   10109
        7   34   31   16-31   87097   55905   80525
        8   68   86   32-63   11501   21204   15773

TOTALS   103400   82579   108381   86663   188474
MEAN/SEC (MSG)   29.88   23.86   (PKTS)   31.32   25.04   54.47
MEAN BITS/SEC 12214.66   11557.25
MEAN PKTS/MSG   1.05   1 05
MEAN BITS/MSG 408.77   484.28
MEAN BITS/PKT 389.98   461.46

H2I: PKTS/SEC=   31.3   MSGS/SEC=   29.9
I2H: PKTS/SEC=   25.0   MSGS/SEC=   23.9   PKTS & RFNMS =   54.9
M2I: PKTS/SEC=   54.2
I2M: PKTS/SEC=   54.5
TSK: PKTS/SEC= 109.4

HOST MSG TOTALS   CSNET   BBN-N   DIV6-   FIBER
                     -CIC   OC   TAC   -GW
TOTAL   FROM   11275   6453   16404   69268
CONTROL TO   11275   6453   16404   69268

FAKE HOST MSG TOTALS   TTY   DEBUG   PC/TR   DS/ST
TOTAL   FROM   0   0   0   0
CONTROL TO   0   0   0   0

                CHANNEL ACTIVITY
       NEIGHBOR   PKTS OUT   BITS OUT   BITS/SEC
         UCC4   60056   1.35E+07   3901.77
         UCC8   75821   1.87E+07   5407.50
         UCC2   52597   1.20E+07   3461.04
        TOTAL   188474   4.42E+07   12770.21
MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   234.46

```
# OF ROUND-TRIPS & MEAN RT TIME, TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
   UCC2      16670       64   /   UCC4    15329,    101   /   DB5        878,    146
   UCC6       6253,     112   /   UCC7     2030,    130   /   UCC8     34395,    118
   NCLB9      2620,     135   /   MLB10    2118,    109   /   UCC14    23224,     70
   TEST5         1,      96   /

     103518 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY =  96.41 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =   1.09
          PER LINE:
            TO  UCC4      0.36  (   65.99 BITS)  PER SECOND
            TO  UCC8      0.36  (   65.99 BITS)  PER SECOND
            TO  UCC2      0.36  (   65.99 BITS)  PER SECOND

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.83

TOTAL NULLS PER SECOND (ALL LINES) =   47.02
          PER LINE:
            TO  UCC4     14.11  ( 2144.33 BITS)  PER SECOND
            TO  UCC8     19.82  ( 3012.55 BITS)  PER SECOND
            TO  UCC2     13.10  ( 1990.50 BITS)  PER SECOND

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983   14:00:17.000   BBN-NMC TIME
  TO SEP 28, 1983   14:58:05.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

         34 CUM STAT'S (100% OF MAX.)
            TIME COVERED BY DATA =   3565.158 SECONDS

            C30 IMP   (EXA)

                  MESSAGE AND PACKET SIZE STATISTICS
             HISTOGRAM OF MESSAGE LENGTH   LOG2 HISTOGRAM OF PACKET LENGTH
          PACKETS   FROM HOSTS INTO HOSTS   16-BIT   HOSTS   CHAN
             1   138597   96580   DATA   FROM   INTO   OUT
             2   2310   2175   WORDS
             3   106   529   0-1   32   41   2389
             4   9   152   2-3   82   50   111659
             5   20   1037   4-7   174   658   3258
             6   0   58   8-15   11052   11160   12596
             7   0   27   16-31   123080   67648   124311
             8   0   146   32-63   9251   30458   22108

TOTALS   141042   100704   143671   110015   276321
MEAN/SEC (MSG)   30.56   28.25   (PKTS)   40.30   30.86   77.51
MEAN BITS/SEC 14807.70   14895.31
MEAN PKTS/MSG   1.02   1.09
MEAN BITS/MSG   374.30   527.33
MEAN BITS/PKT   367.45   482.70

H2I: PKTS/SEC=   40.3   MSGS/SEC=   39.6
I2H: PKTS/SEC=   30.9   MSGS/SEC=   28.2   PKTS & RFNMS =   70.4
M2I: PKTS/SEC=   79.4
I2M: PKTS/SEC=   77.5
TSK: PKTS/SEC= 147.9

HOST MSG TOTALS   CSNET   BBN-N   DIV6-   FIBER
                     -CIC   OC   TAC   -GW
TOTAL   FROM   13307   3349   19127   105262
CONTROL TO   13307   3349   19127   105265

FAKE HOST MSG TOTALS   TTY   DEBUG   PC/TR   DS/ST
TOTAL   FROM   0   0   0   0
CONTROL TO   0   0   0   0

              CHANNEL ACTIVITY
    NEIGHBOR   PKTS OUT   BITS OUT   BITS/SEC
       UCC4   80210   1.70E+07   4776.43
       UCC8   93479   2.21E+07   6202.99
       UCC2   102632   2.79E+07   7833.36
      TOTAL   276321   6.71E+07   18812.79
MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   242.73

```
# OF ROUND-TRIPS & MEAN RT TIME,  TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
   UCC2    40975,    135  /  UCC4   18033,   190  /  DB5        49,    94
   UCC6    10231,    149  /  UCC7     978.   241  /  UCC8    35588,   115
   NCLB9    2110,    309  /  MLB10   5729,   242  /  UCC14   27478,   146

   141171 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY = 147.84 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =    1.36
        PER LINE:
                TO  UCC4     0.45  (   82.71 BITS)  PER SECOND
                TO  UCC8     0.45  (   82.71 BITS)  PER SECOND
                TO  UCC2     0.45  (   82.71 BITS)  PER SECOND

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.93

TOTAL NULLS PER SECOND (ALL LINES) =    63.03
        PER LINE:
                TO  UCC4    18.21  ( 2768.15 BITS)  PER SECOND
                TO  UCC8    21.84  ( 3319.29 BITS)  PER SECOND
                TO  UCC2    22.98  ( 3492.95 BITS)  PER SECOND

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983 15:01:34.000   BBN-NMC TIME
  TO SEP 28, 1983 15:57:33.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

          33 CUM STAT'S (100% OF MAX.)
             TIME COVERED BY DATA =   3460.301 SECONDS

          C30 IMP   (EXA)

                    MESSAGE AND PACKET SIZE STATISTICS
          HISTOGRAM OF MESSAGE LENGTH   LOG2 HISTOGRAM OF PACKET LENGTH
          PACKETS   FROM HOSTS INTO HOSTS   16-BIT   HOSTS   CHAN
            1   124325   82821   DATA   FROM   INTO   OUT
            2   2027   2840   WORDS
            3   103   462   0-1   10   9   986
            4   7   27   2-3   17   17   78194
            5   20   179   4-7   101   817   1504
            6   13   3   8-15   10295   9871   10512
            7   10   2   16-31 108242   56170   98386
            8   20   10   32-63   10459   24118   9470

TOTALS   126525   86344   129124   91002   199052
MEAN/SEC (MSG)   36.56   24.95   (PKTS)   37.32   26.30   57.52
MEAN BITS/SEC   13884.17   12160.01
MEAN PKTS/MSG   1.02   1.05
MEAN BITS/MSG   379.71   487.32
MEAN BITS/PKT   372.07   462.38

H2T: PKTS/SEC=   37.3   MSGS/SEC=   36.6
I2H: PKTS/SEC=   26.3   MSGS/SEC=   25.0   PKTS & RFNMS =   62.9
M2I: PKTS/SEC=   58.1
I2M: PKTS/SEC=   57.5
TSK: PKTS/SEC=   120.4

HOST MSG TOTALS   CSNET   BBN-N   DIV6-   FIBER
                       -CIC   OC   TAC   -GW
TOTAL   FROM   13571   4385   23197   85372
CONTROL TO   13571   4385   23198   85372

FAKE HOST MSG TOTALS   TTY   DEBUG   PC/TR   DS/ST
TOTAL   FROM   0   0   0   0
CONTROL TO   0   0   0   0

                    CHANNEL ACTIVITY
        NEIGHBOR   PKTS OUT   BITS OUT   BITS/SEC
          UCC4   67058   1.39E+07   4005.21
          UCC8   73725   1.89E+07   5449.09
          UCC2   58269   1.20E+07   3470.53
          TOTAL   199052   4.47E+07   12924.83
MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   224.68

```
#  OF ROUND-TRIPS & MEAN RT TIME,  TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
    UCC2      22466,      44   /   UCC4      18252,      90   /   DB5          3,    100
    UCC6       7207,      75   /   UCC7         80,      80   /   UCC8      42917.     75
    NCLB9      3034,     107   /   MLB10      5561,      99 . /   UCC14     27117,     80
    TEST5         2,     115   /

        126639 ROUND-TRIPS TO ALL DESTINATIONS

    TOTAL MEAN ROUND-TRIP DELAY =   74.54 MSEC.

    TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =    0.86
            PER LINE:
                    TO  UCC4       0.29  (    51.78 BITS)  PER SECOND
                    TO  UCC8       0.29  (    51.78 BITS)  PER SECOND
                    TO  UCC2       0.29  (    51.78 BITS)  PER SECOND

    AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.7"

    TOTAL NULLS PER SECOND (ALL LINES) =    51.71
            PER LINE:
                    TO  UCC4      15.86  (  2411.45 BITS)  PER SECOND
                    TO  UCC8      21.68  (  3295.61 BITS)  PER SECOND
                    TO  UCC2      14.16  (  2152.41 BITS)  PER SECOND

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983   16:01:02.000   BBN-NMC TIME
  TO SEP 28, 1983   16:58:46.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

34 CUM STAT'S (100% OF MAX.)
TIME COVERED BY DATA =   3565.158 SECONDS

C30 IMP   (EXA)

MESSAGE AND PACKET SIZE STATISTICS

HISTOGRAM OF MESSAGE LENGTH			LOG2 HISTOGRAM OF PACKET LENGTH			
PACKETS	FROM HOSTS	INTO HOSTS	16-BIT		HOSTS	CHAN
			DATA	FROM	INTO	OUT
			WORDS			
1	114536	72908				
2	1125	4039				
3	8	623	0-1	14	20	763
4	2	26	2-3	13	18	78552
5	2	528	4-7	182	1367	1238
6	0	0	8-15	9936	9938	10009
7	0	0	16-31	101527	45758	96704
8	0	2	32-63	5156	28514	10934

TOTALS	115673	78126		116828	85615	198200
MEAN/SEC (MSG)	32.45	21.91	(PKTS)	32.77	24.01	55.59
MEAN BITS/SEC	11626.10	11956.41				
MEAN PKTS/MSG	1.01	1.10				
MEAN BITS/MSG	358.33	545.61				
MEAN BITS/PKT	354.79	497.89				

H2I: PKTS/SEC=   32.8   MSGS/SEC=   32.4
I2H: PKTS/SEC=   24.0   MSGS/SEC=   21.9   PKTS & RFNMS =   56.5
M2I: PKTS/SEC=   57.4
I2M: PKTS/SEC=   55.6
TSK: PKTS/SEC= 112.1

HOST MSG TOTALS	CSNET -CIC	BBN-N OC	DIV6- TAC	FIBER -GW
TOTAL FROM	8750	2557	24630	79735
CONTROL TO	8750	2557	24632	79734

FAKE HOST MSG TOTALS	TTY	DEBUG	PC/TR	DS/ST
TOTAL FROM	0	0	0	0
CONTROL TO	0	0	0	0

CHANNEL ACTIVITY

NEIGHBOR	PKTS OUT	BITS OUT	BITS/SEC
UCC4	74994	1.60E+07	4493.03
UCC8	62883	1.60E+07	4478.66
UCC2	60323	1.36E+07	3809.66
TOTAL	198200	4.56E+07	12781.35

MEAN (DATA ONLY) BITS/PKT OUT CHANNELS = 229.91

```
# OF ROUND-TRIPS & MEAN RT TIME, TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
  UCC2    20961,      45 /  UCC4    23498,    83 /  DB5         1,     96
  UCC6    10914,      79 /  UCC7      697,    75 /  UCC8     34622,     53
  NCLB9    1382,     128 /  MLB10    3297,    93 /  UCC14    20418,     45

     115790 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY =  60.91 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =   0.96
          PER LINE:
               TO  UCC4      0.32  (    57.75 BITS)  PER SECOND
               TO  UCC8      0.32  (    57.75 BITS)  PER SECOND
               TO  UCC2      0.32  (    57.75 BITS)  PER SECOND

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.82

TOTAL NULLS PER SECOND (ALL LINES) =    51.12
          PER LINE:
               TO  UCC4     16.01  ( 2433.04 BITS)  PER SECOND
               TO  UCC8     20.20  ( 3070.82 BITS)  PER SECOND
               TO  UCC2     14.91  ( 2265.74 BITS)  PER SECOND

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983   19:01:04.000   BBN-NMC TIME
  TO SEP 28, 1983   19:56:58.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

      33 CUM STAT'S (100% OF MAX.)
         TIME COVERED BY DATA =   3460.301 SECONDS

         C30 IMP   (EXA)

                MESSAGE AND PACKET SIZE STATISTICS
         HISTOGRAM OF MESSAGE LENGTH   LOG2 HISTOGRAM OF PACKET LENGTH
     PACKETS   FROM HOSTS INTO HOSTS   16-BIT   HOSTS   CHAN
        1   29738   24994   DATA   FROM   INTO   OUT
        2   219   186   WORDS
        3   16   13   0-1   1   2   756
        4   0   2   2-3   12   3   32570
        5   3   2   4-7   20   61   990
        6   66   0   8-15   4747   4696   6667
        7   42   0   16-31   22505   14653   25193
        8   2   0   32-63   3660   6008   12019

TOTALS   30086   25197   30945   25423   78195
MEAN/SEC (MSG)   8.69   7.28   (PKTS)   8.94   7.35   22.60
MEAN BITS/SEC   3510.71   3205.75
MEAN PKTS/MSG   1.03   1.01
MEAN BITS/MSG   403.78   440 25
MEAN BITS/PKT   392.57   436.33

H2I: PKTS/SEC=   8.9   MSGS/SEC=   8.7
I2H: PKTS/SEC=   7.3   MSGS/SEC=   7.3   PKTS & RFNMS =   16.0
M2I: PKTS/SEC=   22.4
I2M: PKTS/SEC=   22.6
TSK: PKTS/SEC=   38.6

HOST MSG TOTALS   CSNET   BBN-N   DIV6-   FIBER
                     -CIC   OC   TAC   -GW
TOTAL   FROM   5205   628   635   23618
CONTROL TO   5205   628   635   23618

FAKE HOST MSG TOTALS   TTY   DEBUG   PC/TR   DS/ST
TOTAL   FROM   0   0   0   0
CONTROL TO   0   0   0   0

              CHANNEL ACTIVITY
    NEIGHBOR   PKTS OUT   BITS OUT   BITS/SEC
    . UCC4   28301   7.03E+06   2031 53
      UCC8   28985   1.06E+07   3065.18
      UCC2   20909   4.09E+06   1181.86
     TOTAL   78195   2.17E+07   6278.57
MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   277.84

```
# OF ROUND-TRIPS & MEAN RT TIME, TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
  UCC2      4840,     39  /  UCC4      6381,     48  /  UCC6      1297,      96
  UCC7      2096,     61  /  UCC8     12717.     79  /  MLB10     1668,      63
  UCC14     1332,     12  /

    30331 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY =  61.48 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =   1.01
        PER LINE:
             TO   UCC4     0.34  (    60.75 BITS)  PER SECOND
             TO   UCC8     0.34  (    60.75 BITS)  PER SECOND
             TO   UCC2     0.34  (    60.75 BITS)  PER SECOND

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.80

TOTAL NULLS PER SECOND (ALL LINES) =    20.03
        PER LINE:
             TO   UCC4     7.28  ( 1106.17 BITS)  PER SECOND
             TO   UCC8     7.22  ( 1097.42 BITS)  PER SECOND
             TO   UCC2     5.54  (  841.55 BITS)  PER SECOND

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983   20:00:27.000   BBN-NMC TIME
  TO SEP 28, 1983   20:59:52.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

35 CUM STAT'S (100% OF MAX.)
TIME COVERED BY DATA =   3670.016 SECONDS

C30 IMP   (EXA)

MESSAGE AND PACKET SIZE STATISTICS

HISTOGRAM OF MESSAGE LENGTH			LOG2 HISTOGRAM OF PACKET LENGTH		
PACKETS	FROM HOSTS	INTO HOSTS	16-BIT	HOSTS		CHAN
				FROM	INTO	OUT
1	20535	17860	DATA			
2	327	91	WORDS			
3	44	15	0-1	0	0	385
4	0	2	2-3	17	1	20477
5	2	0	4-7	39	21	502
6	0	0	8-15	4615	4606	6317
7	0	1	16-31	15246	11784	15473
8	0	2	32-63	1414	1706	3545

TOTALS	20908	17971		21331	18118	46699
MEAN/SEC (MSG)	5.70	4.90	(PKTS)	5.81	4.94	12.72
MEAN BITS/SEC	2058.50	1788.47				
MEAN PKTS/MSG	1.02	1.01				
MEAN BITS/MSG	361.33	365.24				
MEAN BITS/PKT	354.17	362.27				

H2I:	PKTS/SEC=	5.8	MSGS/SEC=	5.7	
I2H:	PKTS/SEC=	4.9	MSGS/SEC=	4.9	PKTS & RFNMS = 10.6
M2I:	PKTS/SEC=	12.6			
I2M:	PKTS/SEC=	12.7			
TSK:	PKTS/SEC=	23.4			

HOST MSG TOTALS	CSNET -CIC	BBN-N OC	DIV6- TAC	FIBER -GW
TOTAL FROM	2717	230	3114	14847
CONTROL TO	2717	230	3114	14847

FAKE HOST MSG TOTALS	TTY	DEBUG	PC/TR	DS/ST
TOTAL FROM	0	0	0	0
CONTROL TO	0	0	0	0

CHANNEL ACTIVITY

NEIGHBOR	PKTS OUT	BITS OUT	BITS/SEC
UCC4	19315	3.49E+06	951.56
UCC8	18679	4.84E+06	1319.32
UCC2	8705	1.69E+06	460.73
TOTAL	46699	1.00E+07	2731.61

MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   214.67

```
# OF ROUND-TRIPS & MEAN RT TIME, TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
   UCC4      3146,      33  /  UCC6      3235,      57  /  UCC7      2275,      53
   UCC8      7415,      33  /  MLB10     3289,      57  /  UCC14     1671,       8

   21031 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY =   40.42 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =    0.84
        PER LINE:
            TO  UCC4      0.28  (    50.49 BITS)  PER SECOND
            TO  UCC8      0.28  (    50.49 BITS)  PER SECOND
            TO  UCC2      0.28  (    50.49 BITS)  PER SECOND

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.72

TOTAL NULLS PER SECOND (ALL LINES) =    12.30
        PER LINE:
            TO  UCC4      5.81  (   883.21 BITS)  PER SECOND
            TO  UCC8      5.05  (   768.24 BITS)  PER SECOND
            TO  UCC2      1.44  (   218.89 BITS)  PER SECOND

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983 21:01:36.000   BBN-NMC TIME
  TO SEP 28, 1983 21:59:15.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

        34 CUM STAT'S (100% OF MAX.)
          TIME COVERED BY DATA =   3565.158 SECONDS

        C30 IMP   (EXA)

              MESSAGE AND PACKET SIZE STATISTICS
        HISTOGRAM OF MESSAGE LENGTH   LOG2 HISTOGRAM OF PACKET LENGTH
    PACKETS   FROM HOSTS INTO HOSTS   16-BIT   HOSTS   CHAN
       1   20610   21920   DATA   FROM   INTO   OUT
       2   189   1   WORDS
       3   46   2   0-1   4   0   410
       4   0   17   2-3   12   1   30162
       5   0   51   4-7   29   0   527
       6   0   0   8-15   4945   4915   6616
       7   0   0   16-31   14849   15513   19636
       8   0   0   32-63   1287   1822   2568

    TOTALS   20845   21991   21126   22251   59919
    MEAN/SEC (MSG) 5.85   6.17   (PKTS)   5.93   6.24   16.81
    MEAN BITS/SEC 2071.48   2236.90
    MEAN PKTS/MSG   1.01   1.01
    MEAN BITS/MSG 354.29   362.64
    MEAN BITS/PKT 349.58   358.41

    H2I: PKTS/SEC=   5.9   MSGS/SEC=   5.8
    I2H: PKTS/SEC=   6.2   MSGS/SEC=   6.2   PKTS & RFNMS =   12.1
    M2I: PKTS/SEC=   16.8
    I2M: PKTS/SEC=   16.8
    TSK: PKTS/SEC=   28.9

    HOST MSG TOTALS   CSNET   BBN-N   DIV6-   FIBER
                        -CIC   OC   TAC   -GW
    TOTAL   FROM   1732   2049   19   17045
    CONTROL TO   1732   2049   19   17045

    FAKE HOST MSG TOTALS   TTY   DEBUG   PC/TR   DS/ST
    TOTAL   FROM   0   0   0   0
    CONTROL TO   0   0   0   0

                  CHANNEL ACTIVITY
       NEIGHBOR   PKTS OUT   BITS OUT   BITS/SEC
         UCC4   19477   3.19E+06   895.93
         UCC8   18576   3.60E+06   1010.25
         UCC2   21866   3.79E+06   1063.04
        TOTAL   59919   1.06E+07   2969.22
    MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   176.67

```
# OF ROUND-TRIPS & MEAN RT TIME, TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
   CC3          1,     45  /   UCC4      1214,     30  /   UCC6     1079,     60
   UCC7      5892,     51  /   UCC8      7548,     32  /   NCLB9     750,     78
   MLB10     4124,     52  /   UCC14      356.     11  /

      20964 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY =  44.17 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =    0.83
         PER LINE:
                 TO  UCC4      0.28  (    49.80 BITS)  PER SECOND
                 TO  UCC8      0.28  (    49.80 BITS)  PER SECOND
                 TO  UCC2      0.28  (    49.80 BITS)  PER SECOND

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.72

TOTAL NULLS PER SECOND (ALL LINES) =    16.47
         PER LINE:
                 TO  UCC4      5.15  (   783.20 BITS)  PER SECOND
                 TO  UCC8      7.28  (  1106.89 BITS)  PER SECOND
                 TO  UCC2      4.03  (   613.13 BITS)  PER SECOND

--14---UCC14-----14---UCC14-----14---UCC14-----14---UCC14-----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983 22:01:00.000   BBN-NMC TIME
  TO SEP 28, 1983 22:58:39.000   BBN-NMC TIME

--14---UCC14-----14---UCC14-----14---UCC14-----14---UCC14-----14---UCC14--

             34 CUM STAT'S (100% OF MAX.)
               TIME COVERED BY DATA =   3565.158 SECONDS

               C30 IMP   (EXA)

                 MESSAGE AND PACKET SIZE STATISTICS
        HISTOGRAM OF MESSAGE LENGTH   LOG2 HISTOGRAM OF PACKET LENGTH
   PACKETS   FROM HOSTS INTO HOSTS   16-BIT   HOSTS   CHAN
      1   17030   13712   DATA   FROM   INTO   OUT
      2   816   5   WORDS
      3   44   2   0-1   10   0   599
      4   0   0   2-3   24   4   18363
      5   0   2   4-7   62   1   764
      6   0   0   8-15   4860   4808   6615
      7   0   1   16-31   11813   8323   14101
      8   0   0   32-63   2025   609   4401

TOTALS   17890   13722   18794   13745   44843
MEAN/SEC (MSG)   5.02   3.85   (PKTS)   5.27   3.86   12.58
MEAN BITS/SEC 1958.93   1263.23
MEAN PKTS/MSG   1.05   1.00
MEAN BITS/MSG 390.38   328.21
MEAN BITS/PKT 371.60   327.66

H2I: PKTS/SEC=   5.3   MSGS/SEC=   5.0
I2H: PKTS/SEC=   3.9   MSGS/SEC=   3.8   PKTS & RFNMS =   8.9
M2I: PKTS/SEC=   12.3
I2M: PKTS/SEC=   12.6
TSK: PKTS/SEC=   21.5

HOST MSG TOTALS   CSNET   BBN-N   DIV6-   FIBER
                     -CIC   OC   TAC   -GW
TOTAL   FROM   1260   305   20   16305
CONTROL TO   1260   305   20   16305

FAKE HOST MSG TOTALS   TTY   DEBUG   PC/TR   DS/ST
TOTAL   FROM   0   0   0   0
CONTROL TO   0   0   0   0

              CHANNEL ACTIVITY
   NEIGHBOR   PKTS OUT   BITS OUT   BITS/SEC
     UCC4   18516   5.07E+06   1421.24
     UCC8   12023   2.47E+06   692.85
     UCC2   14304   2.92E+06   819.01
     TOTAL   44843   1.05E+07   2933.09
MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   233.19

```
# OF ROUND-TRIPS & MEAN RT TIME, TO FOLLOWING IMPS /SITE #TRIPS,#ᴹSEC/
  CC3          2,      45  /  UCC4       1491,      31  /  UCC6      1098,      60
  UCC7      5653,      57  /  UCC8       3693,      31  /  NCLB9     1653,      78
  MLB10     4106,      55  /  UCC14       305,       6  /

      18001 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY =   50.46 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =    0.85
          PER LINE:
              TO   UCC4      0.28  (    51.08 BITS)  PER SECOND
              TO   UCC8      0.28  (    51.08 BITS)  PER SECOND
              TO   UCC2      0.28  (    51.08 BITS)  PER SECOND

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.75

TOTAL NULLS PER SECOND (ALL LINES) =    12.02
          PER LINE:
              TO   UCC4      4.48  (   681.01 BITS)  PER SECOND
              TO   UCC8      3.79  (   575.91 BITS)  PER SECOND
              TO   UCC2      3.75  (   569.43 BITS)  PER SECOND

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--
```

EXPERIMENT DURATION
FROM SEP 28, 1983 23:00:24.000   BBN-NMC TIME
  TO SEP 28, 1983 23:59:48.000   BBN-NMC TIME

--14---UCC14----14---UCC14----14---UCC14----14---UCC14----14---UCC14--

        35 CUM STAT'S (100% OF MAX.)
          TIME COVERED BY DATA =   3670.016 SECONDS

        C30 IMP   (EXA)

              MESSAGE AND PACKET SIZE STATISTICS
        HISTOGRAM OF MESSAGE LENGTH   LOG2 HISTOGRAM OF PACKET LENGTH
    PACKETS   FROM HOSTS INTO HOSTS   16-BIT   HOSTS   CHAN
      1   9919   8932   DATA   FROM   INTO   OUT
      2   14   1   WORDS
      3   1   4   0-1   0   0   62
      4   0   0   2-3   1   1   11261
      5   0   2   4-7   1   0   146
      6   0   0   8-15   4009   4003   5652
      7   0   0   16-31   5378   4157   5809
      8   0   0   32-63   561   795   1119

    TOTALS   9934   8939   9950   8956   24049
    MEAN/SEC (MSG) 2.71   2.44   (PKTS)   2.71   2.44   6.55
    MEAN BITS/SEC 869.18   831.38
    MEAN PKTS/MSG 1.00   1.00
    MEAN BITS/MSG 321.11   341.33
    MEAN BITS/PKT 320.59   340.68

    H2I: PKTS/SEC=   2.7   MSGS/SEC=   2.7
    I2H: PKTS/SEC=   2.4   MSGS/SEC=   2.4   PKTS & RFNMS =   5.1
    M2I: PKTS/SEC=   6.6
    I2M: PKTS/SEC=   6.6
    TSK: PKTS/SEC= 11.7

    HOST MSG TOTALS   CSNET   BBN-N   DTV6-   FIBER
                         -CIC   OC   TAC   -GW
    TOTAL   FROM   1136   4131   20   4647
    CONTROL TO   1136   4131   20   4647

    FAKE HOST MSG TOTALS   TTY   DEBUG   PC/TR   DS/ST
    TOTAL   FROM   0   0   0   0
    CONTROL TO   0   0   0   0

                 CHANNEL ACTIVITY
        NEIGHBOR   PKTS OUT   BITS OUT   BITS/SEC
          UCC4   12331   2.10E+06   573.05
          UCC8   8888   1.77E+06   481.24
          UCC2   2830   3.99E+05   108.71
          TOTAL   24049   4.27E+06   1163.01
    MEAN (DATA ONLY) BITS/PKT OUT CHANNELS =   177.48

```
# OF ROUND-TRIPS & MEAN RT TIME, TO FOLLOWING IMPS /SITE #TRIPS,#MSEC/
  UCC4      5585,     28  /  UCC6     1145,     58  /  UCC7       412,     47
  UCC8      2445,     29  /  NCLB9       1,     77  /  MLB10      162.     53
  UCC14      315,      6  /
```

10065 ROUND-TRIPS TO ALL DESTINATIONS

TOTAL MEAN ROUND-TRIP DELAY = 32.30 MSEC.

TOTAL ROUTING UPDATES TRANSMITTED PER SECOND =   0.82
```
        PER LINE:
                TO   UCC4      0.27  (    49.14 BITS)  PER SECOND
                TO   UCC8      0.27  (    49.14 BITS)  PER SECOND
                TO   UCC2      0.27  (    49.14 BITS)  PER SECOND
```

AVERAGE NEIGHBORS IN ROUTING UPDATE = 2.69

TOTAL NULLS PER SECOND (ALL LINES) =   6.41
```
        PER LINE:
                TO   UCC4      2.98  (   452.35 BITS)  PER SECOND
                TO   UCC8      2.56  (   388.94 BITS)  PER SECOND
                TO   UCC2      0.87  (   132.37 BITS)  PER SECOND
```

--14---UCC14----14---UCC14-----14---UCC14-----14---UCC14----14---UCC14--

```
 1.26%  [21250-21252]  CRA
  .77%  [21313-21317]  SZE
  .10%  [21325-21331]  SPL
  .92%  [21341-21345]  SNZ
  .10%  [21404-21411]  ARR
  .25%  [21442-21460]  SHFLUP
  .07%  [21461-21467]  SHFLUP1
  .04%  [21514-21515]  SHFROT
  .02%  [21516-21516]  SHFRR
  .02%  [21530-21530]  SHFLR
  .58%  [21531-21541]  SHFLR1
  .08%  [21575-21600]  SHFINT
  .06%  [21601-21603]  SHFRET
  .03%  [21632-21634]  JFFO
  .03%  [21635-21637]  JFFO.NZ
  .01%  [21640-21641]  JFFO.FIRST8
  .02%  [21666-21667]  JFFO.SECOND8
  .01%  [21670-21671]  JFFO.THIRD4
  .02%  [21702-21703]  JFFO.FOURTH4
  .01%  [21704-21707]  JFFO.SEVENTH2
  .04%  [21710-21713]  JFFO.EIGHTH2
  .33%  [21726-21765]  Q.ENQ
  .08%  [21766-21775]  Q.DEQ
  .51%  [21776-22026]  Q.DEQ.RMQ
  .19%  [22027-22052]  Q.RMQ
  .09%  [22073-22103]  Q316.DEQ
  .51%  [22275-22307]  SOFT
  .12%  [22310-22312]  SOFT.INSTR
  .03%  [22313-22315]  SOFT.SCAN
  .15%  [22325-22327]  INT.INSTR
  .20%  [22330-22333]  FAST.INSTR
  .14%  [22334-22342]  INT.SCAN
  .04%  [22343-22344]  EA0
 1.32%  [22345-22347]  EA0I
  .45%  [22350-22350]  MBR.MAR.LS
  .04%  [22351-22352]  EA0X
  .03%  [22356-22356]  MBR.X..LS
  .18%  [22357-22361]  EA1
  .04%  [22362-22365]  EA1I
  .25%  [22366-22371]  EA1X
  .12%  [22372-22375]  EA1IX
 2.94%  [22376-22403]  JMP1
 3.37%  [22413-22416]  STA0
  .56%  [22417-22423]  STA1
  .04%  [23233-23234]  DUMMY
  .12%  [23241-23246]  IO316.INH
  .39%  [23247-23262]  IO316.ENB
  .08%  [23366-23375]  IO316.SPK
  .13%  [23376-23412]  IO316.TDV
  .32%  [23413-23432]  IO316.RFI
  .01%  [23433-23436]  RFI.TO.READY
  .08%  [23443-23450]  RFI.TO.TIMING
  .04%  [23451-23454]  IO316.PCB
  .07%  [23455-23463]  IO.GOADSKIP
  .11%  [23464-23502]  IO.GOAD
  .33%  [23610-23627]  IO.ENQ.TIMING
```

```
 .25% [23630-23635] TI.TOP
3.13% [23636-23650] TI.LOOP
 .06% [23651-23652] TI.INT
 .26% [23653-23703] TI.HERE
 .45% [23704-23742] IO.RHQ.PENDING
 .13% [24022-24027] IO.FIND.PHEDR
 .22% [24030-24064] PM.SCAN
 .02% [24074-24075] SCAN.FROM.PENDIN
 .02% [24076-24077] SCAN.BOTTOM
 .02% [24100-24101] SCAN.DUMMY
 .06% [24102-24107] SCAN.SCAN
 .02% [24110-24111] SCAN.ATTN1
 .18% [24120-24131] SCAN.HAVE.PRIORI
 .06% [24304-24306] SCAN.SAME
 .06% [24311-24316] IO.CLOCK
 .07% [24317-24331] CLOCK.AGAIN
 .02% [24332-24333] CLOCK.EXIT
1.65% [24510-24512] IO.RET
3.24% [25476-25512] CM1I.INT
 .03% [25513-25517] CM1I.GOING
 .03% [25554-25556] CM1I.DATA
1.25% [25633-25642] CM1O.INT
2.14% [25643-25653] CM1O.IDLE
 .03% [25670-25674] CM1O.DATA
 .08% [25675-25704] CM1O.LOW
 .02% [25705-25706] CM1O.SEND
 .06% [25707-25714] CM1O.SEND1
 .06% [25751-25753] CM1.CRC, CM1.CRC.PATC
 .06% [25754-25756] CM1.CRC.PATB
 .10% [25757-25763] CM1.CRC.PATA
 .14% [25764-25772] CM1.CRC.PATD
```

```
  .69% Overhead
 4.00% General I/O
 3.52% Console I/O
74.28% Instruction Emulation
 2.74% Clock I/O
 5.91% Process Management
 8.87% ARPANET Trunk (MII) Driver
```