Advanced Topics in Embedded Computing (COL788)

Assignment - 2

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In this assignment we did scheduling of messages over the CAN bus. Different messages are getting invoked from various sources inside the system. We need to schedule them over the bandwidth limited CAN bus. We can observe that when the bandwidth is less most of the messages cant be scheduled and hence many message can't be reached to the destination within their required deadline.

Narrow bandwidth is the reason for poor scheduling of messages. But for already deployed systems we can't do any hardware related changes so it is feasible to do it using software. In this assignment we understood the potential reasons of poor scheduling and how piggybacking can help us in achieving it.

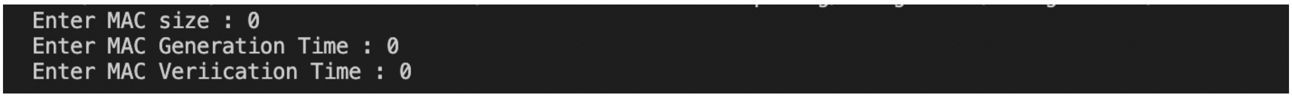
In piggybacking we collect the messages from same sources into same set and schedule the complete set at a time. This helps in reducing the delays for high priority messages and also improves bus utilisation factor.

Steps to Run the Code :

1. Keep the cpp file and 2 text files in the same folder.
2. Run the cpp file.
3. It will ask to insert the Mac size, Mac generation time and Mac verification time.
4. For 1st task all values should be 0.
5. For 2nd Task give values according to requirement.
6. At a time both normal scheduling and piggybacked scheduling results will be generated.

In the submission we included 2 text files. One (Normal.txt) representing the normal scheduling details while other (Piggybacked.txt) represents the piggybacked version of these message signals.

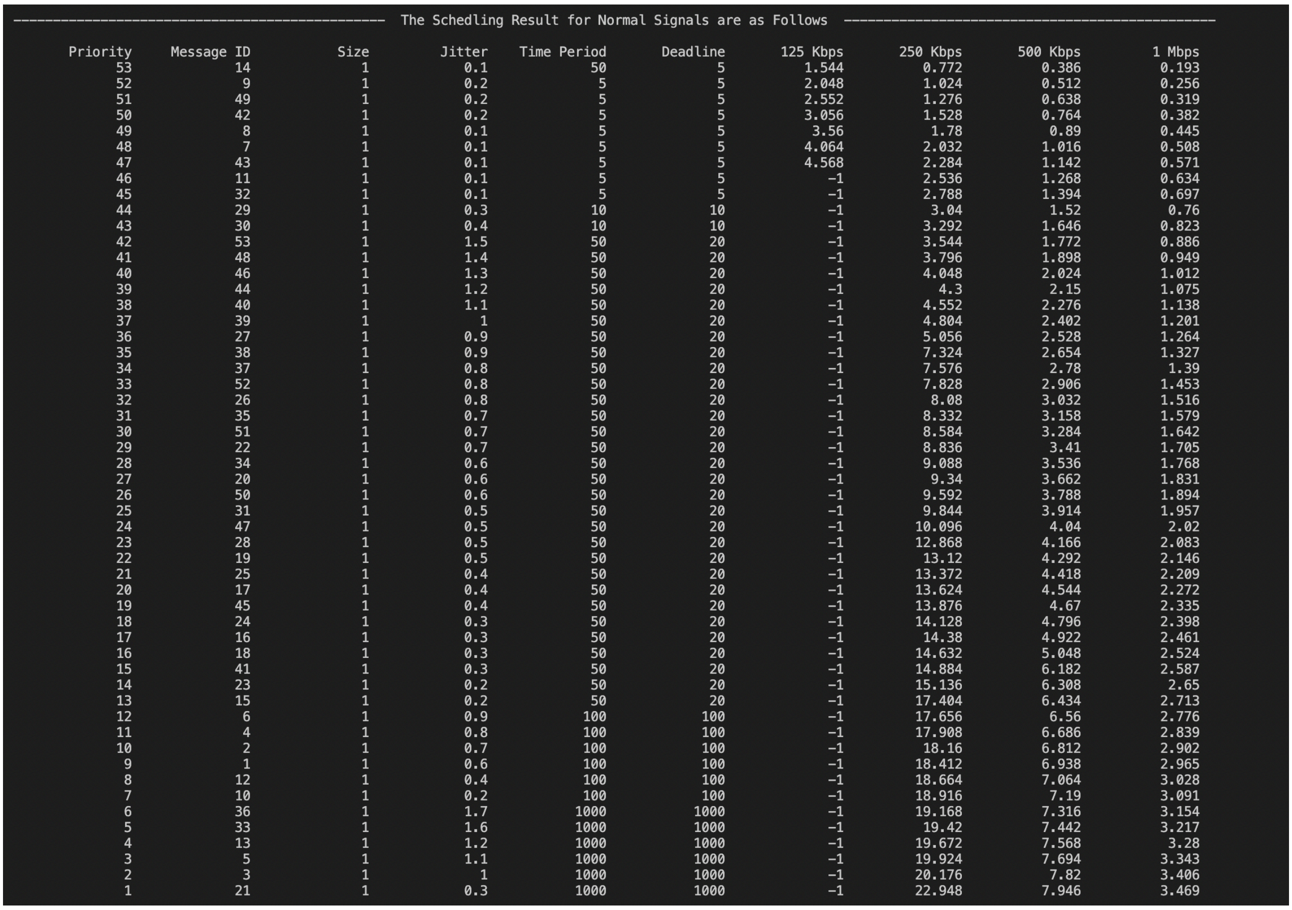
Task 1:
When we run the code using above steps, the interface looks something like this



```
Enter MAC size : 0
Enter MAC Generation Time : 0
Enter MAC Veriication Time : 0
```

In the above image it is asking for MAC size, MAC generation time and MAC verification time. For the 1st subproblem we need to input all these values as 0.

The scheduling results is as below. We can clearly see that all the timings are matching exactly with the ones in the reference paper. Here -1 indicates messages can't be scheduled.



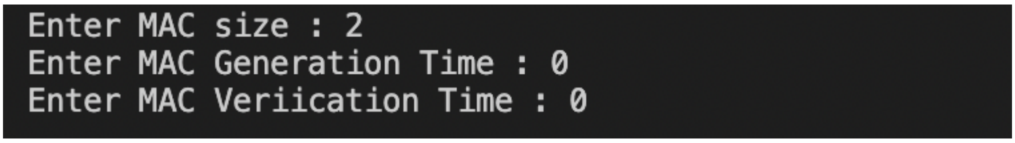
```
---------------------------------------------  The Schedling Result for Normal Signals are as Follows  ---------------------------------------------

       Priority     Message ID           Size         Jitter    Time Period       Deadline       125 Kbps       250 Kbps       500 Kbps         1 Mbps
             53             14              1            0.1             50              5          1.544          0.772          0.386          0.193
             52              9              1            0.2              5              5          2.048          1.024          0.512          0.256
             51             49              1            0.2              5              5          2.552          1.276          0.638          0.319
             50             42              1            0.2              5              5          3.056          1.528          0.764          0.382
             49              8              1            0.1              5              5           3.56           1.78           0.89          0.445
             48              7              1            0.1              5              5          4.064          2.032          1.016          0.508
             47             43              1            0.1              5              5          4.568          2.284          1.142          0.571
             46             11              1            0.1              5              5             -1          2.536          1.268          0.634
             45             32              1            0.1              5              5             -1          2.788          1.394          0.697
             44             29              1            0.3             10             10             -1           3.04           1.52           0.76
             43             30              1            0.4             10             10             -1          3.292          1.646          0.823
             42             53              1            1.5             50             20             -1          3.544          1.772          0.886
             41             48              1            1.4             50             20             -1          3.796          1.898          0.949
             40             46              1            1.3             50             20             -1          4.048          2.024          1.012
             39             44              1            1.2             50             20             -1            4.3           2.15          1.075
             38             40              1            1.1             50             20             -1          4.552          2.276          1.138
             37             39              1              1             50             20             -1          4.804          2.402          1.201
             36             27              1            0.9             50             20             -1          5.056          2.528          1.264
             35             38              1            0.9             50             20             -1          7.324          2.654          1.327
             34             37              1            0.8             50             20             -1          7.576           2.78           1.39
             33             52              1            0.8             50             20             -1          7.828          2.906          1.453
             32             26              1            0.8             50             20             -1           8.08          3.032          1.516
             31             35              1            0.7             50             20             -1          8.332          3.158          1.579
             30             51              1            0.7             50             20             -1          8.584          3.284          1.642
             29             22              1            0.7             50             20             -1          8.836           3.41          1.705
             28             34              1            0.6             50             20             -1          9.088          3.536          1.768
             27             20              1            0.6             50             20             -1           9.34          3.662          1.831
             26             50              1            0.6             50             20             -1          9.592          3.788          1.894
             25             31              1            0.5             50             20             -1          9.844          3.914          1.957
             24             47              1            0.5             50             20             -1         10.096           4.04           2.02
             23             28              1            0.5             50             20             -1         12.868          4.166          2.083
             22             19              1            0.5             50             20             -1          13.12          4.292          2.146
             21             25              1            0.4             50             20             -1         13.372          4.418          2.209
             20             17              1            0.4             50             20             -1         13.624          4.544          2.272
             19             45              1            0.4             50             20             -1         13.876           4.67          2.335
             18             24              1            0.3             50             20             -1         14.128          4.796          2.398
             17             16              1            0.3             50             20             -1          14.38          4.922          2.461
             16             18              1            0.3             50             20             -1         14.632          5.048          2.524
             15             41              1            0.3             50             20             -1         14.884          6.182          2.587
             14             23              1            0.2             50             20             -1         15.136          6.308           2.65
             13             15              1            0.2             50             20             -1         17.404          6.434          2.713
             12              6              1            0.9            100            100             -1         17.656           6.56          2.776
             11              4              1            0.8            100            100             -1         17.908          6.686          2.839
             10              2              1            0.7            100            100             -1          18.16          6.812          2.902
              9              1              1            0.6            100            100             -1         18.412          6.938          2.965
              8             12              1            0.4            100            100             -1         18.664          7.064          3.028
              7             10              1            0.2            100            100             -1         18.916           7.19          3.091
              6             36              1            1.7           1000           1000             -1         19.168          7.316          3.154
              5             33              1            1.6           1000           1000             -1          19.42          7.442          3.217
              4             13              1            1.2           1000           1000             -1         19.672          7.568           3.28
              3              5              1            1.1           1000           1000             -1         19.924          7.694          3.343
              2              3              1              1           1000           1000             -1         20.176           7.82          3.406
              1             21              1            0.3           1000           1000             -1         22.948          7.946          3.469
```

Fig : Task 1 Results

Task 2 :

(i) Only Communication Overhead:

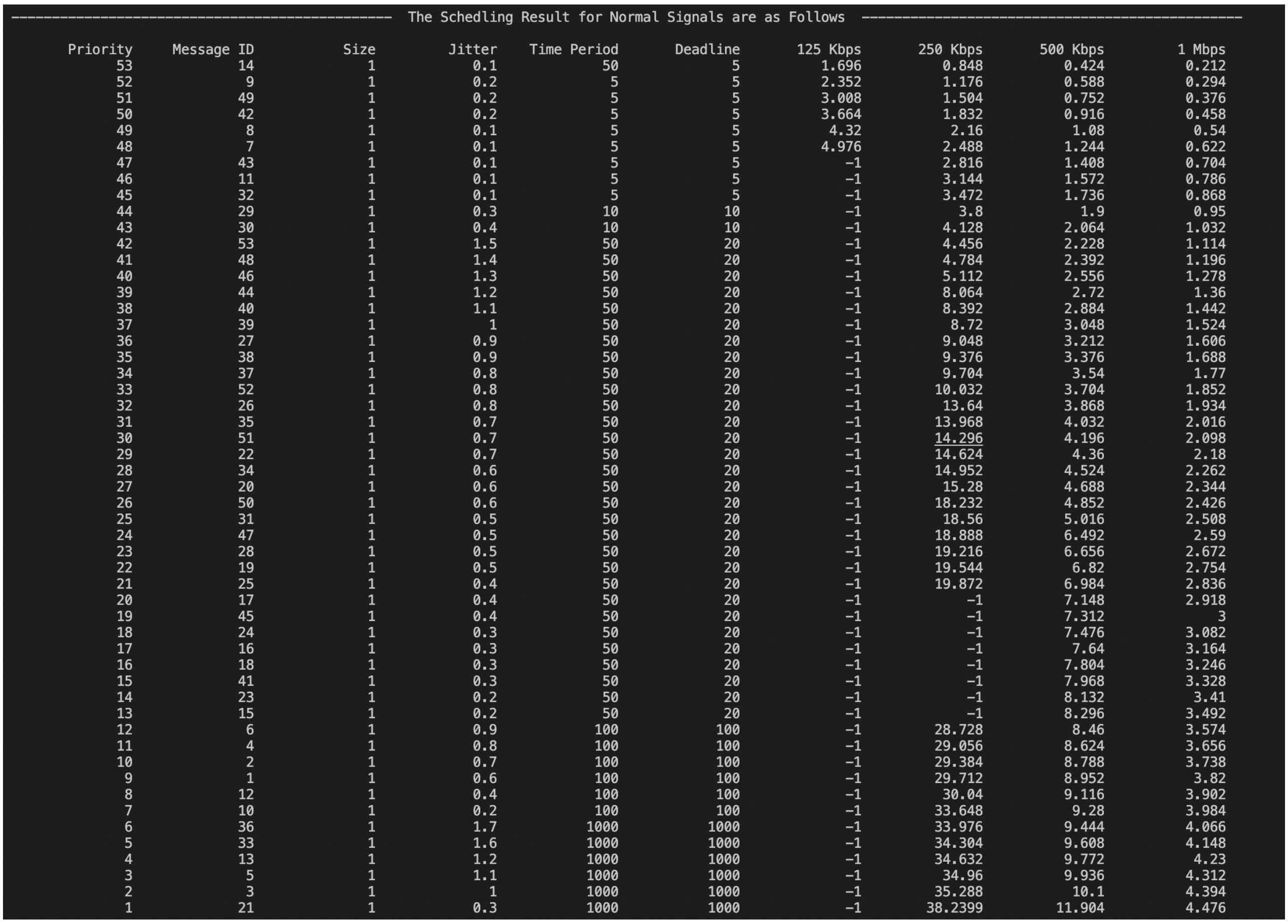
When we include MAC we know the MAC is going to have some size requirements. Hence this in turn increases the size of the messages to be communicated. Thus it leads to more delays and many messages can’t be scheduled in this scenario.



```
Enter MAC size : 2
Enter MAC Generation Time : 0
Enter MAC Veriication Time : 0
```

For this scenario inputs are shown above.

In the results image shown below we can see that at BW of 250kbps we cant schedule some of the messages when we include the extra 2 Bytes overhead of MAC in communication.

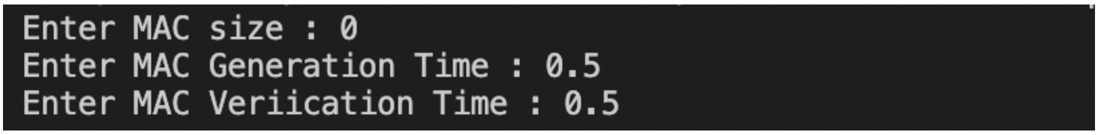


```
-------------------------------------------- The Schedling Result for Normal Signals are as Follows --------------------------------------------

      Priority     Message ID           Size         Jitter    Time Period       Deadline       125 Kbps       250 Kbps       500 Kbps         1 Mbps
            53             14              1            0.1             50              5          1.696          0.848          0.424          0.212
            52              9              1            0.2              5              5          2.352          1.176          0.588          0.294
            51             49              1            0.2              5              5          3.008          1.504          0.752          0.376
            50             42              1            0.2              5              5          3.664          1.832          0.916          0.458
            49              8              1            0.1              5              5           4.32           2.16           1.08           0.54
            48              7              1            0.1              5              5          4.976          2.488          1.244          0.622
            47             43              1            0.1              5              5             -1          2.816          1.408          0.704
            46             11              1            0.1              5              5             -1          3.144          1.572          0.786
            45             32              1            0.1              5              5             -1          3.472          1.736          0.868
            44             29              1            0.3             10             10             -1            3.8            1.9           0.95
            43             30              1            0.4             10             10             -1          4.128          2.064          1.032
            42             53              1            1.5             50             20             -1          4.456          2.228          1.114
            41             48              1            1.4             50             20             -1          4.784          2.392          1.196
            40             46              1            1.3             50             20             -1          5.112          2.556          1.278
            39             44              1            1.2             50             20             -1          8.064           2.72           1.36
            38             40              1            1.1             50             20             -1          8.392          2.884          1.442
            37             39              1              1             50             20             -1           8.72          3.048          1.524
            36             27              1            0.9             50             20             -1          9.048          3.212          1.606
            35             38              1            0.9             50             20             -1          9.376          3.376          1.688
            34             37              1            0.8             50             20             -1          9.704           3.54           1.77
            33             52              1            0.8             50             20             -1         10.032          3.704          1.852
            32             26              1            0.8             50             20             -1          13.64          3.868          1.934
            31             35              1            0.7             50             20             -1         13.968          4.032          2.016
            30             51              1            0.7             50             20             -1         14.296          4.196          2.098
            29             22              1            0.7             50             20             -1         14.624           4.36           2.18
            28             34              1            0.6             50             20             -1         14.952          4.524          2.262
            27             20              1            0.6             50             20             -1          15.28          4.688          2.344
            26             50              1            0.6             50             20             -1         18.232          4.852          2.426
            25             31              1            0.5             50             20             -1          18.56          5.016          2.508
            24             47              1            0.5             50             20             -1         18.888          6.492           2.59
            23             28              1            0.5             50             20             -1         19.216          6.656          2.672
            22             19              1            0.5             50             20             -1         19.544           6.82          2.754
            21             25              1            0.4             50             20             -1         19.872          6.984          2.836
            20             17              1            0.4             50             20             -1             -1          7.148          2.918
            19             45              1            0.4             50             20             -1             -1          7.312              3
            18             24              1            0.3             50             20             -1             -1          7.476          3.082
            17             16              1            0.3             50             20             -1             -1           7.64          3.164
            16             18              1            0.3             50             20             -1             -1          7.804          3.246
            15             41              1            0.3             50             20             -1             -1          7.968          3.328
            14             23              1            0.2             50             20             -1             -1          8.132           3.41
            13             15              1            0.2             50             20             -1             -1          8.296          3.492
            12              6              1            0.9            100            100             -1         28.728           8.46          3.574
            11              4              1            0.8            100            100             -1         29.056          8.624          3.656
            10              2              1            0.7            100            100             -1         29.384          8.788          3.738
             9              1              1            0.6            100            100             -1         29.712          8.952           3.82
             8             12              1            0.4            100            100             -1          30.04          9.116          3.902
             7             10              1            0.2            100            100             -1         33.648           9.28          3.984
             6             36              1            1.7           1000           1000             -1         33.976          9.444          4.066
             5             33              1            1.6           1000           1000             -1         34.304          9.608          4.148
             4             13              1            1.2           1000           1000             -1         34.632          9.772           4.23
             3              5              1            1.1           1000           1000             -1          34.96          9.936          4.312
             2              3              1              1           1000           1000             -1         35.288           10.1          4.394
             1             21              1            0.3           1000           1000             -1        38.2399         11.904          4.476
```

Fig : Task 2 (i) Results

(ii) Considering Only computational Overhead:

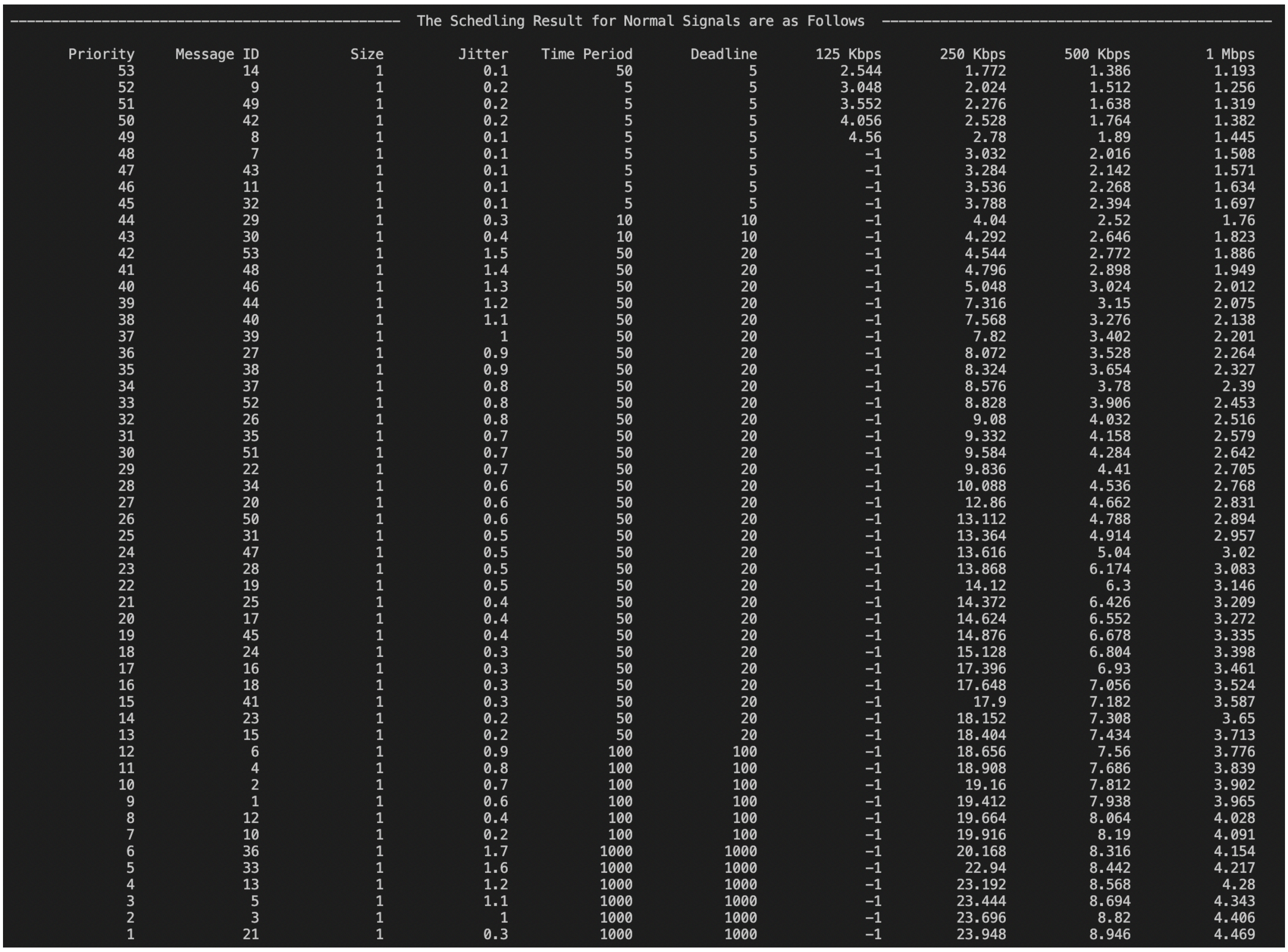
Considering computational overhead leads to extra delays in generation and verification of MAC. This delay will lead to delays in message scheduling and thus some of the messages can't be scheduled. Here we are considering computational overhead of 0.5ms. But while adding this overhead we are only considering it in the first message. Since we are considering before starting with high priority message we let the biggest size low priority message delivered. During this time only if it is more than the 0.5 then all the messages which got scheduled at time=0 will compute their MAC and hence the generation and verification time will be covered up by the previous message.



```
Enter MAC size : 0
Enter MAC Generation Time : 0.5
Enter MAC Veriication Time : 0.5
```

For this scenario inputs are shown above.

In the results shown below the message scheduling is similar to the scenario without MAC but the delays are more but not crossing the deadline.

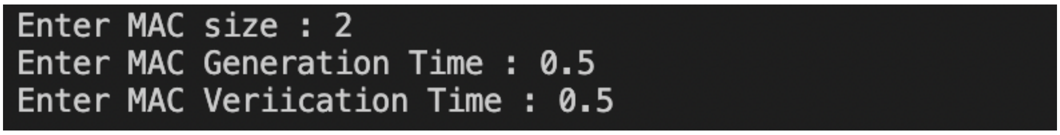


```
-----------------------------------------------  The Schedling Result for Normal Signals are as Follows  -----------------------------------------------

    Priority  Message ID        Size      Jitter Time Period    Deadline    125 Kbps    250 Kbps    500 Kbps      1 Mbps
          53          14           1         0.1          50           5       2.544       1.772       1.386       1.193
          52           9           1         0.2           5           5       3.048       2.024       1.512       1.256
          51          49           1         0.2           5           5       3.552       2.276       1.638       1.319
          50          42           1         0.2           5           5       4.056       2.528       1.764       1.382
          49           8           1         0.1           5           5        4.56        2.78        1.89       1.445
          48           7           1         0.1           5           5          -1       3.032       2.016       1.508
          47          43           1         0.1           5           5          -1       3.284       2.142       1.571
          46          11           1         0.1           5           5          -1       3.536       2.268       1.634
          45          32           1         0.1           5           5          -1       3.788       2.394       1.697
          44          29           1         0.3          10          10          -1        4.04        2.52        1.76
          43          30           1         0.4          10          10          -1       4.292       2.646       1.823
          42          53           1         1.5          50          20          -1       4.544       2.772       1.886
          41          48           1         1.4          50          20          -1       4.796       2.898       1.949
          40          46           1         1.3          50          20          -1       5.048       3.024       2.012
          39          44           1         1.2          50          20          -1       7.316        3.15       2.075
          38          40           1         1.1          50          20          -1       7.568       3.276       2.138
          37          39           1           1          50          20          -1        7.82       3.402       2.201
          36          27           1         0.9          50          20          -1       8.072       3.528       2.264
          35          38           1         0.9          50          20          -1       8.324       3.654       2.327
          34          37           1         0.8          50          20          -1       8.576        3.78        2.39
          33          52           1         0.8          50          20          -1       8.828       3.906       2.453
          32          26           1         0.8          50          20          -1        9.08       4.032       2.516
          31          35           1         0.7          50          20          -1       9.332       4.158       2.579
          30          51           1         0.7          50          20          -1       9.584       4.284       2.642
          29          22           1         0.7          50          20          -1       9.836        4.41       2.705
          28          34           1         0.6          50          20          -1      10.088       4.536       2.768
          27          20           1         0.6          50          20          -1       12.86       4.662       2.831
          26          50           1         0.6          50          20          -1      13.112       4.788       2.894
          25          31           1         0.5          50          20          -1      13.364       4.914       2.957
          24          47           1         0.5          50          20          -1      13.616        5.04        3.02
          23          28           1         0.5          50          20          -1      13.868       6.174       3.083
          22          19           1         0.5          50          20          -1       14.12         6.3       3.146
          21          25           1         0.4          50          20          -1      14.372       6.426       3.209
          20          17           1         0.4          50          20          -1      14.624       6.552       3.272
          19          45           1         0.4          50          20          -1      14.876       6.678       3.335
          18          24           1         0.3          50          20          -1      15.128       6.804       3.398
          17          16           1         0.3          50          20          -1      17.396        6.93       3.461
          16          18           1         0.3          50          20          -1      17.648       7.056       3.524
          15          41           1         0.3          50          20          -1        17.9       7.182       3.587
          14          23           1         0.2          50          20          -1      18.152       7.308        3.65
          13          15           1         0.2          50          20          -1      18.404       7.434       3.713
          12           6           1         0.9         100         100          -1      18.656        7.56       3.776
          11           4           1         0.8         100         100          -1      18.908       7.686       3.839
          10           2           1         0.7         100         100          -1       19.16       7.812       3.902
           9           1           1         0.6         100         100          -1      19.412       7.938       3.965
           8          12           1         0.4         100         100          -1      19.664       8.064       4.028
           7          10           1         0.2         100         100          -1      19.916        8.19       4.091
           6          36           1         1.7        1000        1000          -1      20.168       8.316       4.154
           5          33           1         1.6        1000        1000          -1       22.94       8.442       4.217
           4          13           1         1.2        1000        1000          -1      23.192       8.568        4.28
           3           5           1         1.1        1000        1000          -1      23.444       8.694       4.343
           2           3           1           1        1000        1000          -1      23.696        8.82       4.406
           1          21           1         0.3        1000        1000          -1      23.948       8.946       4.469
```

Fig : Task 2 (ii) Results

(iii) Considering both Computational and Communication Time:

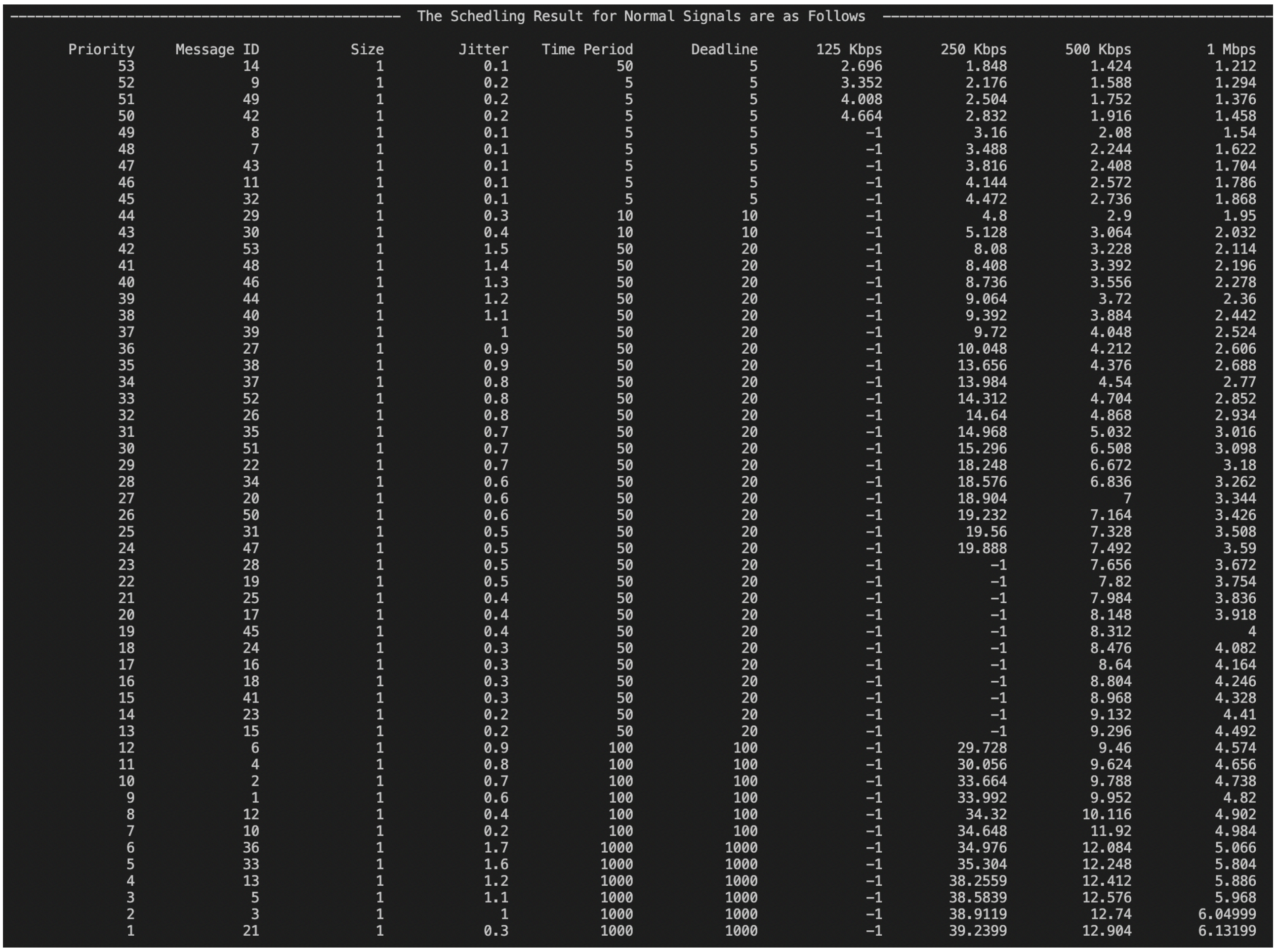
In this scenario we are going to consider both computation and communication time for the MAC. The inputs for this scenario are shown below:



```
Enter MAC size : 2
Enter MAC Generation Time : 0.5
Enter MAC Veriication Time : 0.5
```

The results for the above case are shown below:

From the below results we can see that when we add both computational and communication overhead on the CAN bus we can’t schedule some messages over 250kbps bus.



```
--------------------------------------------  The Schedling Result for Normal Signals are as Follows  --------------------------------------------

    Priority  Message ID        Size      Jitter Time Period    Deadline    125 Kbps    250 Kbps    500 Kbps      1 Mbps
          53          14           1         0.1          50           5       2.696       1.848       1.424       1.212
          52           9           1         0.2           5           5       3.352       2.176       1.588       1.294
          51          49           1         0.2           5           5       4.008       2.504       1.752       1.376
          50          42           1         0.2           5           5       4.664       2.832       1.916       1.458
          49           8           1         0.1           5           5          -1        3.16        2.08        1.54
          48           7           1         0.1           5           5          -1       3.488       2.244       1.622
          47          43           1         0.1           5           5          -1       3.816       2.408       1.704
          46          11           1         0.1           5           5          -1       4.144       2.572       1.786
          45          32           1         0.1           5           5          -1       4.472       2.736       1.868
          44          29           1         0.3          10          10          -1         4.8         2.9        1.95
          43          30           1         0.4          10          10          -1       5.128       3.064       2.032
          42          53           1         1.5          50          20          -1        8.08       3.228       2.114
          41          48           1         1.4          50          20          -1       8.408       3.392       2.196
          40          46           1         1.3          50          20          -1       8.736       3.556       2.278
          39          44           1         1.2          50          20          -1       9.064        3.72        2.36
          38          40           1         1.1          50          20          -1       9.392       3.884       2.442
          37          39           1           1          50          20          -1        9.72       4.048       2.524
          36          27           1         0.9          50          20          -1      10.048       4.212       2.606
          35          38           1         0.9          50          20          -1      13.656       4.376       2.688
          34          37           1         0.8          50          20          -1      13.984        4.54        2.77
          33          52           1         0.8          50          20          -1      14.312       4.704       2.852
          32          26           1         0.8          50          20          -1       14.64       4.868       2.934
          31          35           1         0.7          50          20          -1      14.968       5.032       3.016
          30          51           1         0.7          50          20          -1      15.296       6.508       3.098
          29          22           1         0.7          50          20          -1      18.248       6.672        3.18
          28          34           1         0.6          50          20          -1      18.576       6.836       3.262
          27          20           1         0.6          50          20          -1      18.904           7       3.344
          26          50           1         0.6          50          20          -1      19.232       7.164       3.426
          25          31           1         0.5          50          20          -1       19.56       7.328       3.508
          24          47           1         0.5          50          20          -1      19.888       7.492        3.59
          23          28           1         0.5          50          20          -1          -1       7.656       3.672
          22          19           1         0.5          50          20          -1          -1        7.82       3.754
          21          25           1         0.4          50          20          -1          -1       7.984       3.836
          20          17           1         0.4          50          20          -1          -1       8.148       3.918
          19          45           1         0.4          50          20          -1          -1       8.312           4
          18          24           1         0.3          50          20          -1          -1       8.476       4.082
          17          16           1         0.3          50          20          -1          -1        8.64       4.164
          16          18           1         0.3          50          20          -1          -1       8.804       4.246
          15          41           1         0.3          50          20          -1          -1       8.968       4.328
          14          23           1         0.2          50          20          -1          -1       9.132        4.41
          13          15           1         0.2          50          20          -1          -1       9.296       4.492
          12           6           1         0.9         100         100          -1      29.728        9.46       4.574
          11           4           1         0.8         100         100          -1      30.056       9.624       4.656
          10           2           1         0.7         100         100          -1      33.664       9.788       4.738
           9           1           1         0.6         100         100          -1      33.992       9.952        4.82
           8          12           1         0.4         100         100          -1       34.32      10.116       4.902
           7          10           1         0.2         100         100          -1      34.648       11.92       4.984
           6          36           1         1.7        1000        1000          -1      34.976      12.084       5.066
           5          33           1         1.6        1000        1000          -1      35.304      12.248       5.804
           4          13           1         1.2        1000        1000          -1     38.2559      12.412       5.886
           3           5           1         1.1        1000        1000          -1     38.5839      12.576       5.968
           2           3           1           1        1000        1000          -1     38.9119       12.74     6.04999
           1          21           1         0.3        1000        1000          -1     39.2399      12.904     6.13199
```

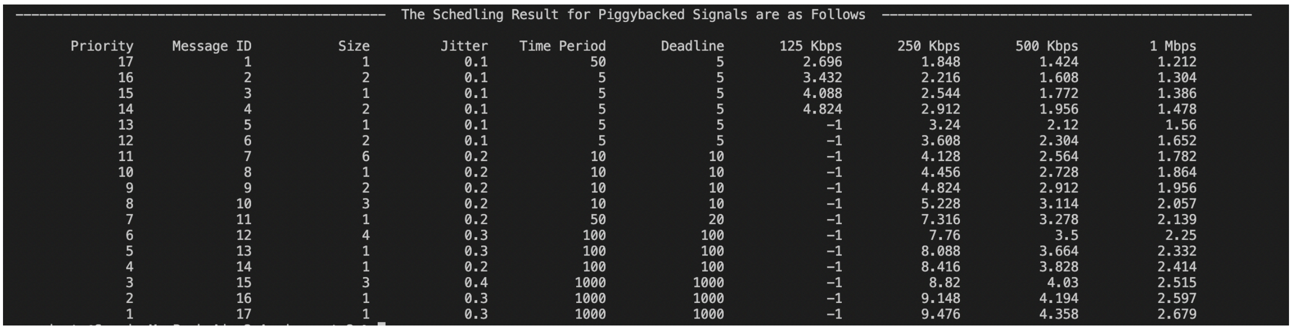
Fig : Task 2 (iii) Results

Task 3 :

Yes, we can see that there are several messages which can't be scheduled over the CAN bus in presence of MAC overhead. Both computational and communication overhead contributes to this. Here it is also observed that communication overhead imparts bigger harm to scheduling since it has direct correspondence to utilisation of CAN bus.

The effective technique of removing this is using piggybacking where we cluster messages coming from same sources and schedule them over the bus. Due to this we have more bus utilisation and lesser end to end delays.

For the last scenario the results of scheduling piggybacked signals are as follows:

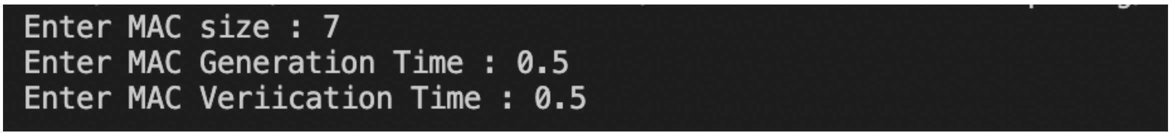


```
--------------------------------------------  The Schedling Result for Piggybacked Signals are as Follows  --------------------------------------------

    Priority  Message ID        Size      Jitter Time Period    Deadline    125 Kbps    250 Kbps    500 Kbps      1 Mbps
          17           1           1         0.1          50           5       2.696       1.848       1.424       1.212
          16           2           2         0.1           5           5       3.432       2.216       1.608       1.304
          15           3           1         0.1           5           5       4.088       2.544       1.772       1.386
          14           4           2         0.1           5           5       4.824       2.912       1.956       1.478
          13           5           1         0.1           5           5          -1        3.24        2.12        1.56
          12           6           2         0.1           5           5          -1       3.608       2.304       1.652
          11           7           6         0.2          10          10          -1       4.128       2.564       1.782
          10           8           1         0.2          10          10          -1       4.456       2.728       1.864
           9           9           2         0.2          10          10          -1       4.824       2.912       1.956
           8          10           3         0.2          10          10          -1       5.228       3.114       2.057
           7          11           1         0.2          50          20          -1       7.316       3.278       2.139
           6          12           4         0.3         100         100          -1        7.76         3.5        2.25
           5          13           1         0.3         100         100          -1       8.088       3.664       2.332
           4          14           1         0.2         100         100          -1       8.416       3.828       2.414
           3          15           3         0.4        1000        1000          -1        8.82        4.03       2.515
           2          16           1         0.3        1000        1000          -1       9.148       4.194       2.597
           1          17           1         0.3        1000        1000          -1       9.476       4.358       2.679
```

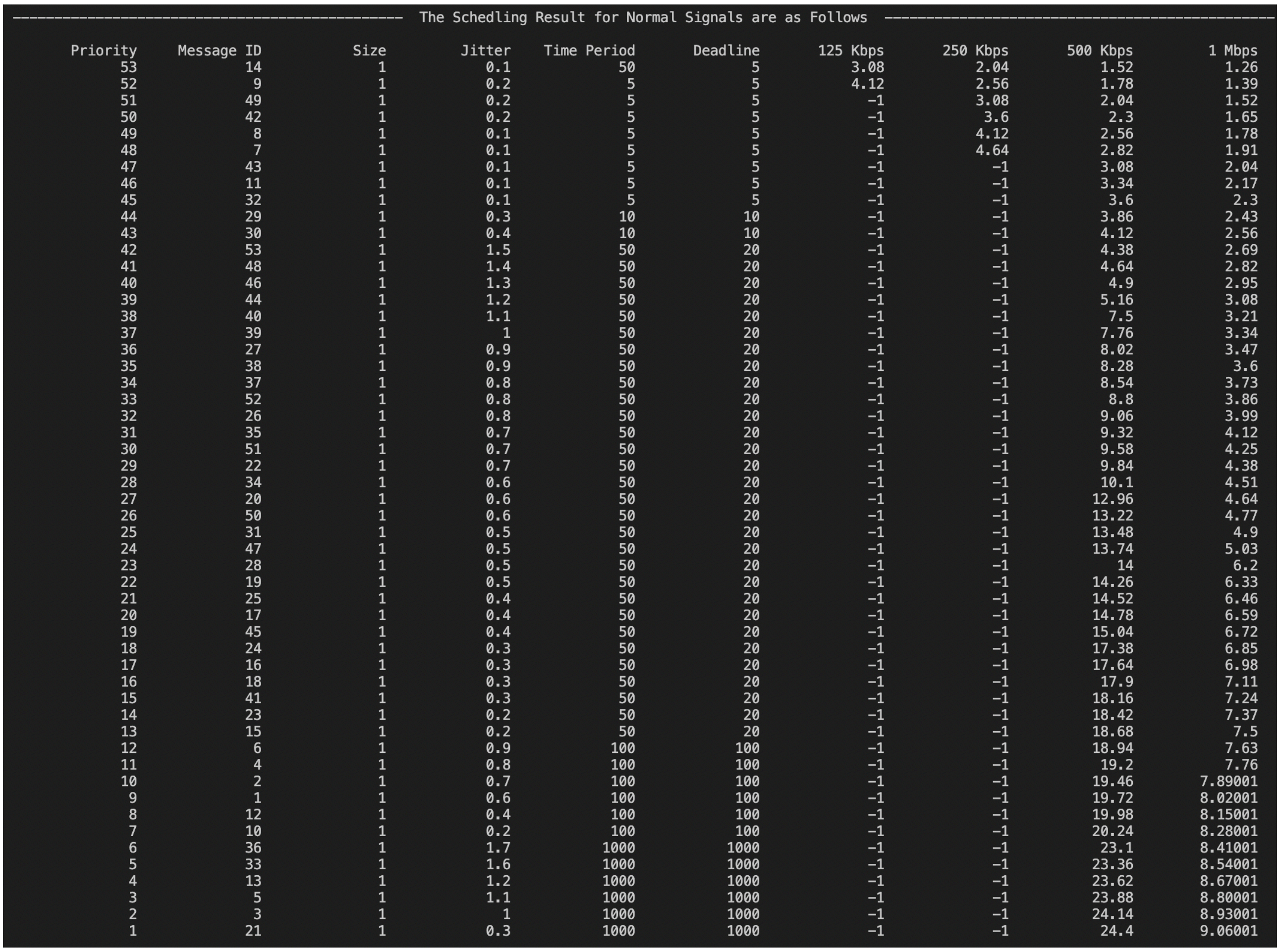
Fig : Task 3 Results

The above figure represents the scheduling results for piggybacked signals and we can see that over 250kbps bus all the signals can be successfully scheduled which was not the case earlier without using piggybacking. Thus piggybacking helps in reducing the message communication overhead.

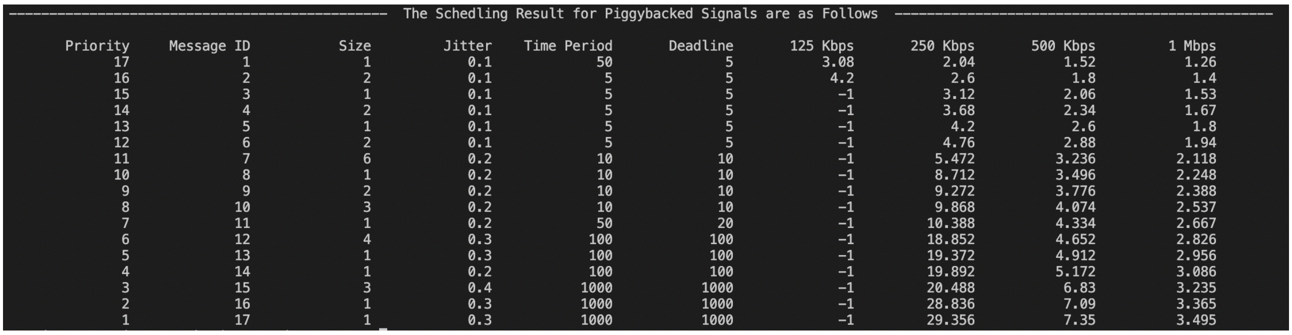
Below is the random result generated to show how much effective the piggybacking is: Here we are considering MAC size of 7 Bytes.



```
Enter MAC size : 7
Enter MAC Generation Time : 0.5
Enter MAC Veriication Time : 0.5
```



```
--------------------------------------------  The Schedling Result for Normal Signals are as Follows  --------------------------------------------

      Priority    Message ID          Size        Jitter   Time Period      Deadline      125 Kbps      250 Kbps      500 Kbps        1 Mbps
            53            14             1           0.1            50             5          3.08          2.04          1.52          1.26
            52             9             1           0.2             5             5          4.12          2.56          1.78          1.39
            51            49             1           0.2             5             5            -1          3.08          2.04          1.52
            50            42             1           0.2             5             5            -1           3.6           2.3          1.65
            49             8             1           0.1             5             5            -1          4.12          2.56          1.78
            48             7             1           0.1             5             5            -1          4.64          2.82          1.91
            47            43             1           0.1             5             5            -1            -1          3.08          2.04
            46            11             1           0.1             5             5            -1            -1          3.34          2.17
            45            32             1           0.1             5             5            -1            -1           3.6           2.3
            44            29             1           0.3            10            10            -1            -1          3.86          2.43
            43            30             1           0.4            10            10            -1            -1          4.12          2.56
            42            53             1           1.5            50            20            -1            -1          4.38          2.69
            41            48             1           1.4            50            20            -1            -1          4.64          2.82
            40            46             1           1.3            50            20            -1            -1           4.9          2.95
            39            44             1           1.2            50            20            -1            -1          5.16          3.08
            38            40             1           1.1            50            20            -1            -1           7.5          3.21
            37            39             1             1            50            20            -1            -1          7.76          3.34
            36            27             1           0.9            50            20            -1            -1          8.02          3.47
            35            38             1           0.9            50            20            -1            -1          8.28           3.6
            34            37             1           0.8            50            20            -1            -1          8.54          3.73
            33            52             1           0.8            50            20            -1            -1           8.8          3.86
            32            26             1           0.8            50            20            -1            -1          9.06          3.99
            31            35             1           0.7            50            20            -1            -1          9.32          4.12
            30            51             1           0.7            50            20            -1            -1          9.58          4.25
            29            22             1           0.7            50            20            -1            -1          9.84          4.38
            28            34             1           0.6            50            20            -1            -1          10.1          4.51
            27            20             1           0.6            50            20            -1            -1         12.96          4.64
            26            50             1           0.6            50            20            -1            -1         13.22          4.77
            25            31             1           0.5            50            20            -1            -1         13.48           4.9
            24            47             1           0.5            50            20            -1            -1         13.74          5.03
            23            28             1           0.5            50            20            -1            -1            14           6.2
            22            19             1           0.5            50            20            -1            -1         14.26          6.33
            21            25             1           0.4            50            20            -1            -1         14.52          6.46
            20            17             1           0.4            50            20            -1            -1         14.78          6.59
            19            45             1           0.4            50            20            -1            -1         15.04          6.72
            18            24             1           0.3            50            20            -1            -1         17.38          6.85
            17            16             1           0.3            50            20            -1            -1         17.64          6.98
            16            18             1           0.3            50            20            -1            -1          17.9          7.11
            15            41             1           0.3            50            20            -1            -1         18.16          7.24
            14            23             1           0.2            50            20            -1            -1         18.42          7.37
            13            15             1           0.2            50            20            -1            -1         18.68           7.5
            12             6             1           0.9           100           100            -1            -1         18.94          7.63
            11             4             1           0.8           100           100            -1            -1          19.2          7.76
            10             2             1           0.7           100           100            -1            -1         19.46       7.89001
             9             1             1           0.6           100           100            -1            -1         19.72       8.02001
             8            12             1           0.4           100           100            -1            -1         19.98       8.15001
             7            10             1           0.2           100           100            -1            -1         20.24       8.28001
             6            36             1           1.7          1000          1000            -1            -1          23.1       8.41001
             5            33             1           1.6          1000          1000            -1            -1         23.36       8.54001
             4            13             1           1.2          1000          1000            -1            -1         23.62       8.67001
             3             5             1           1.1          1000          1000            -1            -1         23.88       8.80001
             2             3             1             1          1000          1000            -1            -1         24.14       8.93001
             1            21             1           0.3          1000          1000            -1            -1          24.4       9.06001
```



```
--------------------------------------------  The Schedling Result for Piggybacked Signals are as Follows  --------------------------------------------

      Priority    Message ID          Size        Jitter   Time Period      Deadline      125 Kbps      250 Kbps      500 Kbps        1 Mbps
            17             1             1           0.1            50             5          3.08          2.04          1.52          1.26
            16             2             2           0.1             5             5           4.2           2.6           1.8           1.4
            15             3             1           0.1             5             5            -1          3.12          2.06          1.53
            14             4             2           0.1             5             5            -1          3.68          2.34          1.67
            13             5             1           0.1             5             5            -1           4.2           2.6           1.8
            12             6             2           0.1             5             5            -1          4.76          2.88          1.94
            11             7             6           0.2            10            10            -1         5.472         3.236         2.118
            10             8             1           0.2            10            10            -1         8.712         3.496         2.248
             9             9             2           0.2            10            10            -1         9.272         3.776         2.388
             8            10             3           0.2            10            10            -1         9.868         4.074         2.537
             7            11             1           0.2            50            20            -1        10.388         4.334         2.667
             6            12             4           0.3           100           100            -1        18.852         4.652         2.826
             5            13             1           0.3           100           100            -1        19.372         4.912         2.956
             4            14             1           0.2           100           100            -1        19.892         5.172         3.086
             3            15             3           0.4          1000          1000            -1        20.488          6.83         3.235
             2            16             1           0.3          1000          1000            -1        28.836          7.09         3.365
             1            17             1           0.3          1000          1000            -1        29.356          7.35         3.495
```

We were successfully able to schedule all the piggybacked signals but with normal we couldn't schedule them effectively over 250 kbps bus.

Thank You !