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 Norm	nal Signals are	as Follows			
Priority	Message ID	Size	Jitter	Time Period	Deadline	125 Kbps	250 Kbps	500 Kbps	1 Mbps
53	14		0.1	50	5	1.544	0.772	0.386	0.193
52	9	1	0.2		5	2.048	1.024	0.512	0.256
51	49		0.2			2.552	1.276	0.638	0.319
50	42		0.2			3.056	1.528	0.764	0.382
49	8		0.1			3.56	1.78	0.89	0.445
48	7		0.1			4.064	2.032	1.016	0.508
47	43	1	0.1			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 38	44	1 1	1.2	50 50	20 20	-1 -1	4.3	2.15	1.075
38 37	40 39	1	1.1	50 50	20 20	-1 -1	4.552 4.804	2.276 2.402	1.138 1.201
37 36	39 27	1	0.9	50 50	20 20	-1 -1	4.804 5.056	2.402 2.528	1.201
36 35	38	1	0.9 0.9	50	20 20	-1 -1	7.324	2.528	1.264
34	36 37	1	0.8	50 50	20	-1 -1	7.576	2.78	1.39
33	52	1	0.8	50	20	-1 -1	7.828	2.78	1.453
33 32	26	1	0.8	50	20 20	-1 -1	8.08	3.032	1.453
31	35	1	0.7	50	20	-1 -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	ī	0.5	50	20	-1	12.868	4.166	2.083
22	19	ī	0.5	50	20	-1	13.12	4.292	2.146
21	25	ī	0.4	50	20	-1	13.372	4.418	2.209
20	17	ī	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		0.3	50	20	-1	14.632	5.048	2.524
15	41		0.3	50	20	-1	14.884	6.182	2.587
14	23		0.2	50	20	-1	15.136	6.308	2.65
13	15		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		0.8	100	100	-1	17.908	6.686	2.839
10	2		0.7	100	100	-1	18.16	6.812	2.902
9	1		0.6	100	100	-1	18.412	6.938	2.965
8	12		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 Norr	nal Signals are	as Follows			
Priori	ty 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	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 44 29	1	0.1	5 10	5 10	-1 -1	3.472	1.736	0.868
	44 29 43 30	1	0.3	10	10 10	-1 -1	3.8 4.128	1.9 2.064	0.95 1.032
	43 30 42 53	1	0.4 1.5	10 50	20	-1 -1	4.128 4.456	2.004	1.032
	42 53 41 48	1	1.4	50 50	20 20	-1 -1	4.436	2.392	1.114
	40 46	1	1.3	50	20	-1 -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 -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	<u>14.296</u>	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 23 28	1	0.5	50 50	20	-1 -1	18.888	6.492	2.59 2.672
	23 28 22 19	1	0.5 0.5	50 50	20 20	-1 -1	19.216 19.544	6.656 6.82	2.754
	21 25	1	0.4	50 50	20 20	-1 -1	19.872	6.984	2.734
	20 17	1	0.4	50	20	-1 -1	-1	7.148	2.918
	19 45	1	0.4	50	20	-1	-1 -1	7.312	3
	18 24	1	0.3	50	20	-1 -1	-1	7.476	3.082
	17 16	1	0.3	50	20	-1	-1	7.64	3.164
	16 18	ī	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 6 36	1	0.2	100 1000	100 1000	-1 -1	33.648 33.976	9.28	3.984
	6 36 5 33	1	1.7 1.6	1000	1000	-1 -1	33.976 34.304	9.444 9.608	4.066 4.148
	4 13	1	1.0	1000	1000	-1 -1	34.304 34.632	9.608	4.148
	3 5	1	1.1	1000	1000	-1 -1	34.96	9.772	4.312
	2 3	1	1 1	1000	1000	-1 -1	35.288	10.1	4.394
	1 21	1	0.3	1000	1000	-1	38.2399	11.904	4.476
			015	1000	1000		5012555	111701	

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.

			1	The Schedling	Result for Norma	al Signals are a	as Follows			
Pri	ority	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	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	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 4.796	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 8.576	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 1	0.3	50	20	-1 -1	17.648	7.056	3.524
	15 14	41 23	1	0.3 0.2	50 50	20		17.9 18.152	7.182	3.587
	14 13	23 15	1		50 50	20 20	-1 -1	18.152 18.404	7.308	3.65
	13 12	15 6	1	0.2			-1 -1	18.404	7.434	3.713
	12	6 4	1	0.9 0.8	100 100	100 100	-1 -1	18.656	7.56 7.686	3.776 3.839
	10	2	1	0.8 0.7	100	100	-1 -1	18.908 19.16	7.812	3.839 3.902
	9	1	1	0.7 0.6	100	100	-1 -1	19.16	7.812 7.938	3.902 3.965
	8	12	1	0.6 0.4	100	100	-1 -1	19.412 19.664	7.938 8.064	4.028
	8 7	12 10	1	0.4 0.2	100	100	-1 -1	19.916	8.064 8.19	4.028
	6	36	1	1.7	1000	1000	-1 -1	20.168	8.316	4.154
	5	33	1	1.6	1000	1000	-1 -1	22.94	8.442	4.134
	4	13	1	1.2	1000	1000	-1 -1	23.192	8.568	4.217
	3	5	1	1.1	1000	1000	-1 -1	23.444	8.694	4.343
	2	3	1	1.1	1000	1000	-1 -1	23.444	8.82	4.406
	1	21	1	0.3	1000	1000	-1 -1	23.948	8.946	4.469
	-	21	-	0.5	1000	1000		23:370	0.570	7.703

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.

		Th	ne Schedling	Result for Norma	al Signals are a	as Follows			
	lessage 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 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:

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		-1	3.608	2.304	1.652
11		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

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

Signature				1	The Schedling	Result for Norma	al Signals are a	as Follows			
52 9 1 0.2 5 5 4.12 2.56 1.78 1.38 50 42 1 0.2 5 5 -1 3.66 2.33 1.65 40 7 1 0.1 5 5 -1 3.6 2.3 1.66 47 43 1 0.1 5 5 -1 4.12 2.25 1.78 46 13 1 0.1 5 5 -1 -1 3.34 2.17 45 32 1 0.1 5 5 -1 -1 -1 3.66 2.21 44 29 1 0.3 10 10 10 -1 -1 3.66 2.24 43 30 1 0.4 10 10 -1 -1 -1 4.12 2.26 42 43 30 1 1.4 4.5 50 20 -1 -1 </th <th>Р</th> <th>riority</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>500 Kbps</th> <th>1 Mbps</th>	Р	riority								500 Kbps	1 Mbps
51		53	14		0.1	50	5	3.08	2.04	1.52	1.26
50					0.2			4.12	2.56	1.78	1.39
49 8 1 0.1 5 5 -1 4.12 2.56 1.78 48 7 1 0.1 5 5 5 -1 4.64 2.82 1.91 47 43 1 0.1 5 5 5 -1 -1 3.08 2.04 46 11 1 0.1 5 5 5 -1 -1 -1 3.08 2.04 46 332 1 0.1 5 5 5 -1 -1 -1 3.08 2.04 45 332 1 0.1 5 5 5 -1 -1 -1 3.08 2.04 46 332 1 0.1 5 5 5 -1 -1 -1 3.08 2.04 47 43 3 1 0.1 5 5 5 -1 -1 -1 3.08 2.04 48 3 30 1 0.1 5 5 5 -1 -1 -1 3.08 2.04 49 40 1 0.2 1 0 0 0 -1 -1 4.64 2.82 40 46 1 1.3 5 0 20 -1 -1 4.64 2.82 40 46 1 1.3 5 0 20 -1 -1 4.64 2.82 40 46 1 1.3 5 0 20 -1 -1 4.6 3.83 39 44 1 1.1 5 0 20 -1 -1 5.16 3.88 38 40 1 1.1 5 0 20 -1 -1 5.16 3.88 38 39 40 1 1.1 5 0 20 -1 -1 7.76 3.34 35 39 30 1 0.9 5 0 20 -1 -1 -1 8.8 3.83 39 40 1 0.1 1.0 5 0 20 -1 -1 -1 8.8 3.83 39 40 1 0.1 1.0 5 0 20 -1 -1 -1 8.68 3.77 31 35 37 39 1 0.8 5 0 20 -1 -1 -1 8.68 3.77 31 32 2 2 1 0.8 5 0 20 -1 -1 -1 8.8 3.88 32 2 2 3 3 1 0.8 5 0 20 -1 -1 8.8 3.88 33 35 2 1 0.8 5 0 20 -1 -1 8.8 3.88 34 40 1 1.1 5 0 20 -1 -1 9.86 3.99 31 35 1 0.8 5 0 20 -1 -1 9.86 3.99 31 35 1 0.7 5 0 20 -1 -1 9.86 3.99 31 35 1 0.7 5 0 20 -1 -1 9.86 3.99 31 35 1 0.7 5 0 20 -1 -1 1 9.86 3.98 31 35 1 0.7 5 0 20 -1 -1 1 9.88 4.25 29 22 1 0.7 5 0 20 -1 -1 1 9.84 4.38 22 26 1 0.8 5 0 20 -1 -1 1 9.88 4.25 29 22 1 0.7 5 0 20 -1 -1 1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1			49		0.2			-1	3.08	2.04	
48					0.2		5	-1	3.6	2.3	
47 43 1 0.1 5 5 5 -1 -1 3.08 2.04 46 11 1 1 0.1 5 5 5 -1 -1 3.6 2.3 44 29 1 0.3 10 10 -1 -1 3.6 2.3 43 30 1 0.4 10 10 -1 -1 4.12 2.56 41 48 1 1.4 50 20 -1 -1 4.38 2.60 41 48 1 1.4 50 20 -1 -1 4.64 2.28 41 48 1 1.4 50 20 -1 -1 4.64 2.28 42 53 1 1 1.5 50 20 -1 -1 4.64 2.28 44 4 1 1 1.2 50 20 -1 -1 5.6 5.8 2.6 45 46 1 1 1.3 50 20 -1 -1 5.6 5.8 2.6 46 47 39 46 1 1 1.1 50 20 -1 -1 5.6 5.8 2.8 39 46 1 1 1.1 50 20 -1 -1 5.6 5.8 3.9 39 50 70 1 0.9 50 20 -1 -1 -1 8.8 3.6 30 37 30 1 0.9 50 20 -1 -1 -1 8.82 37 39 30 1 1 0.9 50 20 -1 -1 -1 8.82 38 36 27 1 0.9 50 20 -1 -1 -1 8.82 39 39 30 1 1 0.7 50 20 -1 -1 1 8.82 30 30 30 1 1 0.7 50 20 -1 -1 1 8.94 30 30 51 1 0.8 50 20 -1 -1 -1 8.84 30 31 32 2 6 1 0.8 50 20 -1 -1 -1 8.84 30 31 32 2 7 1 0.8 50 20 -1 -1 -1 8.84 30 31 32 2 7 1 0.8 50 20 -1 -1 1 8.94 30 31 32 3 1 0.9 50 20 -1 -1 1 8.94 30 31 32 3 1 0.9 50 20 -1 -1 1 8.94 30 31 32 3 1 0.9 50 20 -1 -1 8.84 30 31 32 4 6 7 1 0.8 50 20 -1 -1 1 8.94 30 31 32 5 1 0.8 50 20 -1 -1 1 8.94 30 31 32 5 1 0.8 50 20 -1 -1 1 8.94 30 31 32 5 1 0.8 50 20 -1 -1 1 8.94 30 5 1 0.8 50 20 -1 -1 1 9.06 30 31 3 5 1 0.7 50 20 -1 -1 1 9.06 30 31 3 5 1 0.7 50 20 -1 -1 1 9.84 4.23 30 5 1 1 0.7 50 20 -1 -1 1 9.84 4.23 30 5 1 1 0.7 50 20 -1 -1 1 9.84 4.24 30 5 1 0.8 50 20 -1 -1 1 9.84 4.25 30 5 1 0.8 50 20 -1 -1 1 9.86 4.75 30 5 1 0.8 50 20 -1 -1 1 1.1 1.4 30 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5		49			0.1		5	-1	4.12		1.78
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5 33 1 1.6 1000 1000 -1 -1 23.36 8.54001		6	36	1	1.7		1000	-1	-1	23.1	8.41001
4 13 1 1.2 1 $\overline{000}$ 1000 -1 -1 23.62 8.67001		5	33		1.6		1000	-1		23.36	8.54001
					1.2						8.67001
3 5 1 1.1 1000 1000 -1 -1 23.88 8.80001		3									8.80001
2 3 1 1 1000 1000 -1 -1 24.14 8.93001										24.14	8.93001
1 21 1 0.3 1000 1000 -1 -1 24.4 9.06001		1	21	1	0.3	1000	1000	-1	-1	24.4	9.06001

		1	The Schedling	Result for Piggy	ybacked 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
	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
	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.