Project Progress report: January 2013

Previous work

My most recent Project Proposal (14/11/2012) outlined the following work that had been carried out on the project:

1. An informal but in-depth code examination has been carried out on the current telemetry device software. The knowledge gained from this will allow for an in-depth review of the software as it stands, giving a benchmark that can be used to measure the performance of the proposed system (exact performance metrics are yet to be established).
2. A review of the current hardware and software functionality has been carried out including cost analysis, vehicle system integration and future-casting.
3. Developed a tool / script in C to analyse CAN data logs from the vehicles. This has given an insight into the behaviour of the CAN bus on live vehicles, but has been configured around a single-message acceptance filter. Further work is required to adapt this simulation to include the multi-filter scheme proposed in this document.

Lessons and Conclusions from Previous Work

As this is the first progress report I have written for this project, I shall go into a little more detail on the work done prior to this month.

To provide a benchmark for success, a CAN trace was sent to an existing Remote Device (RD) several times to ascertain how many times the each ID was logged. The device firmware was modified to output, to its debug port, the ID of every message it saw on the CAN bus. This output was logged and a simple script was used to count the occurrences of each CAN ID. The results of these tests can be seen in Table 2.

It can be seen that the capture rate per ID is very unpredictable in nature. This is most likely due to the 2 message buffers on the device's CAN transceivers becoming full, blocking other new messages, before the firmware polls them.

The first CAN analysis script in (3) above, was based around a single-ID filter, and used the time stamp on each message in the CAN trace to predict whether or not that message would have been logged by the dynamic filtering system. This script became over-complicated as I added more and more factors to try and get the most realistic results (source code available on request). It did, however, produce some useful information about the timing of each CAN ID in the CAN trace, including the variation in 'period' of each ID (see Table 3).

A logging sequence was found by recording the order in which CAN ID's first appeared in the trace. The script then operated on the assumption that a message would be 'caught' if it fell before or on its target time, and if the previous ID matched the ID that preceded it in the sequence. This target was based on the period of the message. The high level of variation in timing (particularly in the 0x7nn series of ID's) meant that the single-ID acceptance filter could not be guaranteed to catch as many messages as the existing firmware. For example, ID 0x709 had a capture rate of only 15.89% (Table 3), compared to the 87.75 – 89.63% rate of the existing firmware (Table 2). Although this capture rate was not high enough, the script did demonstrate that, unlike the existing firmware, the messages captured using dynamic filtering would produce the same results every time, bringing predictability to the system.

Work this month

This month, I have spent time re-working the CAN analysis script from (3) above to simulate the filtering system in my most recent proposal, utilising multiple acceptance filters. As the single-ID filter could not cope well with the varying sequence on the CAN bus, it was hoped that allowing a block of different ID's at any one time, and replacing those ID's with new ones as they appeared on the bus, would have a higher success rate.

Script

The revised script follows process below:

- **Find logging sequence** – Finds all unique ID's in the CAN trace that are included in the logging list. These ID's are arranged into a sequence. For now, this is the order that ID's first appear on the CAN bus.
- **Count sequence** – Counts the number of unique ID's in the Logging Sequence.
- **Check logability** – This simulates the multi-ID acceptance filter, and performs the main 'logability' analysis on the CAN trace. It functions as follows:
    - A time-triggered, periodical logging task is simulated that, in a real embedded system, would read all logged messages from the CAN buffer, and update the acceptance filter. The period of this simulated task is controlled by "LOGGING_TASK_PERIOD_us".
    - The number of ID's in the acceptance filter (represented by the array, "acceptanceFilter[]") is configurable with the argument, "filterSize".
    - acceptanceFilter[] is loaded from the top of the loggingSequence[] array up to the size, filterSize.
    - A variable, "sequencePointer", is used to keep track of the location in loggingSequence[].
    - The CAN trace is read, line-by-line, and each CAN ID is extracted.
    - The CAN ID is first checked to see if it falls in the Logging List.
        - If the ID is in the Logging List, acceptanceFilter[] is interrogated to see if the ID is present.
            - If the ID is present in the acceptance filter, the ID has been 'captured'.
            - A counter relating to the captured ID is incremented, as is a general "IDLogCount".
            - The ID is marked as 'logged' in the acceptance filter.
        - If the ID is not present in the acceptance filter, the ID has been 'missed' and IDMissedCount is incremented.
    - The timestamp of each message is interrogated to identify when the simulated logging task should run. When LOGGING_TASK_PERIOD_us has expired, each ID in the acceptance filter that has been marked as 'logged' is replaced by the next ID in the logging sequence that isn't already present in the acceptance filter.

Tests

Below are descriptions of the tests carried out using the analysis script:

Initial Tests

Early iterations of the script displayed very poor results, with capture rates of only ~20%. This was found to be due to the logic that replaced logged ID's in the acceptance filter. Originally, the script would replace any logged ID with the next ID in the sequence, without checking to see if that ID was already in the acceptance filter. This meant that the acceptance filter quickly filled up with repeats of the less frequent ID's in the trace file, blocking the more frequent ID's from being captured.

The script was then modified to replace the logged ID's with the next ID in the logging sequence that *wasn't already included in the acceptance filter.* This change allowed me to obtain much more encouraging results.

Filter Size Variation

This test was used to investigate the effect of the number of ID's loaded into the Acceptance Filter at any one time.

- "LOGGING_TASK_us" was kept at a constant arbitrary value of 1000 µs
- "filterSize" was varied from 1 to 32 (the total number of ID's in the logging sequence).

The results of this test can be seen below:

TABLE 1: LOGGED AND MISSED MESSAGES FOR VARYING FILTER SIZE

filterSize	Logged	Missed
1	51895	1292354
2	122888	1221361
3	224627	1119622
4	297623	1046626
5	300914	1043335
6	397833	946416
7	558586	785663
8	787651	556598
9	921503	422746
10	1203899	140350
11	1281245	63004
12	1297853	46396
13	1315810	28439
14	1333643	10606
15	1339364	4885
16	1338773	5476
17	1336931	7318
18	1336142	8107
19	1335824	8425
20	1335596	8653
21	1335426	8823
22	1334978	9271
23	1334455	9794
24	1333316	10933
25	1331130	13119
26	1327875	16374
27	1321761	22488
28	1316137	28112
29	1337313	6936
30	1343771	478
31	1344235	14
32	1344249	0

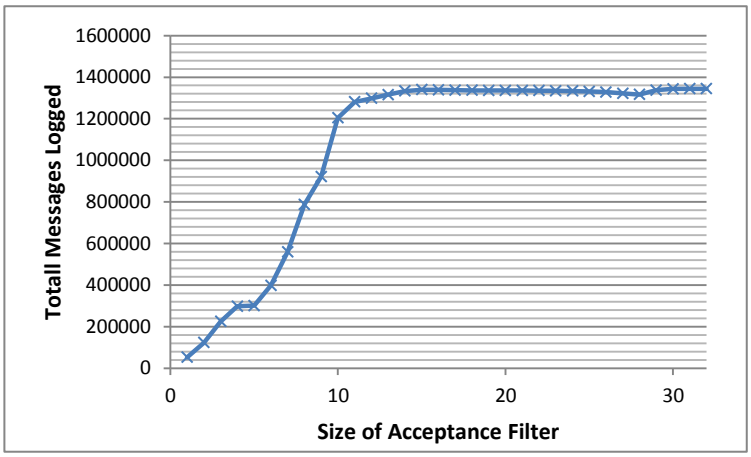


FIGURE 1: TOTAL MESSAGES LOGGED VS ACCEPTANCE FILTER SIZE

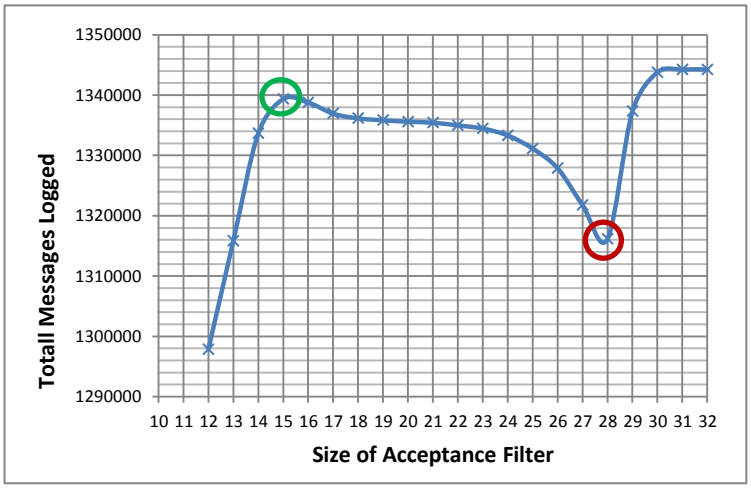


FIGURE 2: TOTAL MESSAGES LOGGED VS ACCEPTANCE FILTER SIZE (DETAIL)

The results of this test show an upwards trend in the number of messages logged compared to the size of the acceptance filter (Figure 1). Which is to be expected, when working under the assumption that the more ID's the acceptance filter recognises, the greater the chance of a message arriving on the CAN bus is going to satisfy the filter.

One aspect of behaviour of this test that was unexpected, however, is shown in Figure 2. When the filter size reaches 15 the capture rate peaks. After this peak, the capture rate reaches an intermediate minimum at a filter size of 28, before climbing steeply to achieve the expected 100% capture rate when the filter size equals the number of ID's to log. The difference between this intermediate peak and trough is not insignificant (23227 messages) and the same pattern has occurred in other tests. I am yet to explain why this happens and need to review the code in my script to confirm that there are no errors in the logic around the point where the acceptance filter is updated with new ID's. For the purposes of testing, this peak has been used as a preliminary 'optimum' size for the acceptance filter, being small enough for the CAN hardware to contain, and whilst offering the greatest capture rate.

Task Period Variation

A further test carried out involved keeping the size of the acceptance filter constant, but varying the period of the logging task. From the results of the above test, the optimum filter size of 15 was used, and the logging task period varied in 500 μs increments from 500 to 2500 μs.

The results of this test can be seen in Table 4 and Figures Figure 3, Figure 4, Figure 5 and Figure 6. Here, it is shown that the capture rate increases the more frequently the acceptance filter is updated. This is due to the fact that, when the acceptance filter is updated less frequently, there is a more of a chance that ID's will be present on the CAN bus that the filter is not looking for; the filter will still be configured to accept messages that have already arrived.

It can also be seen in these results that, compared to the existing algorithm, the spread of capture is much more consistent. For example, there is a difference of 8.027 % with the existing algorithm, compared to only 0.111 % using the script and a task period of 500 μs.

Conclusions and plan for February

The results from the initial tests run using the simulation script are very promising. The variable acceptance filter, once configured to expect multiple ID's, appears to offer much more consistent results than the 'hit and miss' method currently in use on the telemetry device. There is some unexpected behaviour from the script, namely the trend in the capture rate when varying the filter size, and it is this that I plan on focusing on in February following the steps below:

- Review the script code for errors that could explain the Filter Size Variation results.
- Read around the statistical phenomena / processes that will influence the capture rate and hopefully explain the behaviour seen in the Filter Size Variation tests if no errors are found in the code review.

- Test the effect of varying the number of expected ID's is varied, related to the total number of unique ID's in the CAN trace.
- Investigate the effect that the logging sequence order has on the capture rate, and how the order can be optimised either statically or dynamically.
- Further repeats of the above tests are needed using different CAN traces.

Test Results

TABLE 2: BENCHMARK ID COUNTS FROM EXISITING REMOTE DEVICE FIRMWARE

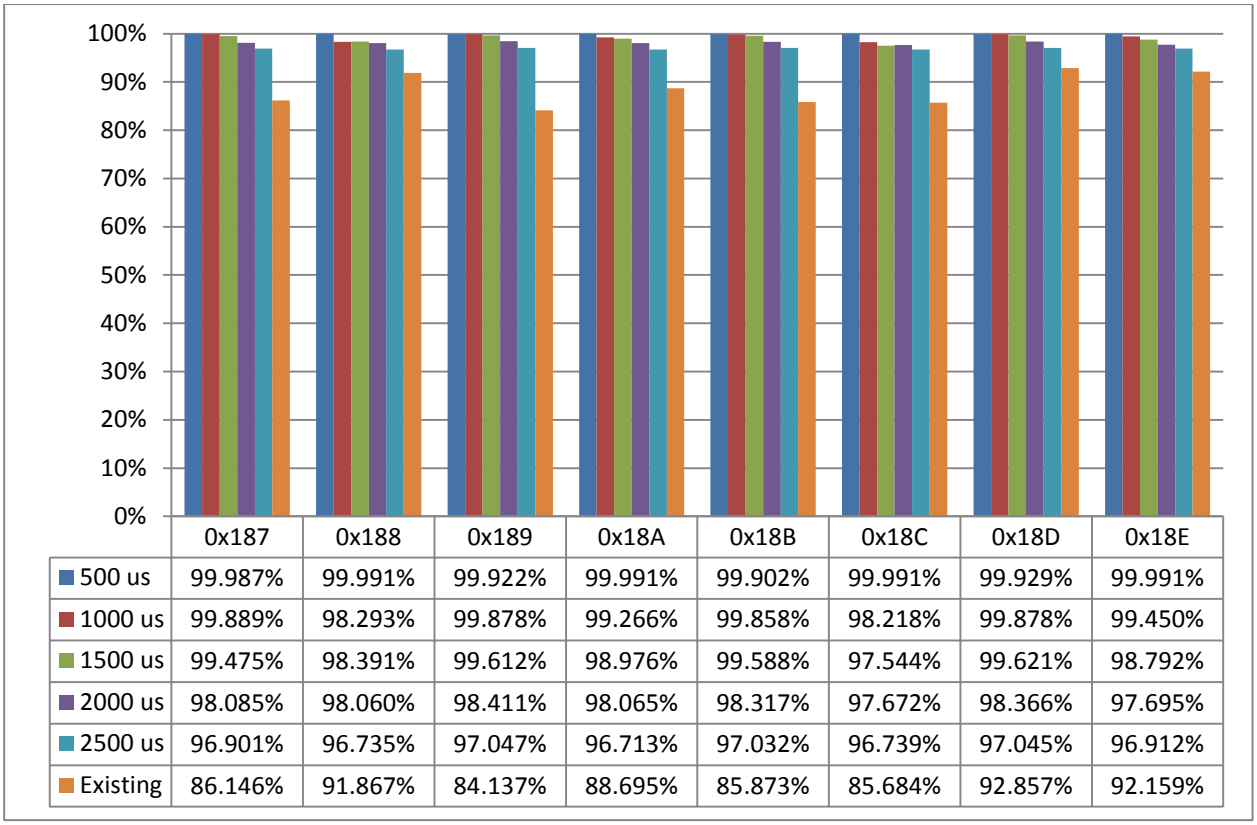
CAN ID	Total	RD 1		RD 2		RD 3		RD 4	
		logs	Percent	logs	Percent	logs	Percent	logs	Percent
0x187	45107	41178	91.29	40042	88.77	40104	88.91	39986	88.65
0x188	45111	38738	85.87	38598	85.56	37962	84.15	38390	85.10
0x189	45110	41442	91.87	40380	89.51	40229	89.18	40119	88.94
0x18A	45111	41887	92.85	41006	90.90	40776	90.39	40577	89.95
0x18B	45111	40011	88.69	38911	86.26	39544	87.66	38847	86.11
0x18C	45111	37954	84.13	37060	82.15	37413	82.94	37426	82.96
0x18D	45109	38653	85.69	37049	82.13	37054	82.14	37317	82.73
0x18E	45111	39273	87.06	38167	84.61	38391	85.10	38145	84.56
0x207	45107	38858	86.15	38045	84.34	38412	85.16	37880	83.98
0x209	45110	41574	92.16	40486	89.75	40345	89.44	40342	89.43
0x20B	45111	41078	91.06	40075	88.84	39746	88.11	40126	88.95
0x20D	45109	40332	89.41	39448	87.45	39313	87.15	39707	88.02
0x287	45107	40749	90.34	39843	88.33	39579	87.74	39687	87.98
0x289	45110	41172	91.27	40153	89.01	39989	88.65	40015	88.71
0x28B	45111	41575	92.16	40291	89.32	40535	89.86	40459	89.69
0x28D	45109	41564	92.14	40757	90.35	40572	89.94	40534	89.86
0x307	45107	39491	87.55	38626	85.63	38820	86.06	38579	85.53
0x309	45110	36911	81.82	36119	80.07	36439	80.78	36505	80.92
0x30B	45111	37032	82.09	35878	79.53	36347	80.57	36513	80.94
0x30D	45109	37569	83.28	36807	81.60	36789	81.56	36577	81.09
0x385	45111	36647	81.24	33236	73.68	35105	77.82	33872	75.09
0x387	45107	39684	87.98	38817	86.06	38854	86.14	38597	85.57
0x389	45110	41572	92.16	40819	90.49	40338	89.42	40323	89.39
0x38B	45111	41846	92.76	40896	90.66	40756	90.35	40688	90.20
0x38D	45109	41464	91.92	40242	89.21	40275	89.28	39998	88.67
0x407	45107	39284	87.09	38286	84.88	38127	84.53	37984	84.21
0x409	45110	38438	85.21	37638	83.44	37394	82.90	37617	83.39
0x40B	45111	39377	87.29	37911	84.04	38306	84.91	38214	84.71
0x40D	45109	39898	88.45	39259	87.03	39021	86.50	39077	86.63
0x707	9018	8051	89.28	7883	87.41	7884	87.43	7885	87.44
0x709	9018	8083	89.63	7914	87.76	8000	88.71	7913	87.75
0x70B	9018	7855	87.10	7638	84.70	7682	85.19	7614	84.43
0x70D	9018	7959	88.26	7806	86.56	7784	86.32	7837	86.90

TABLE 3: MESSAGE TIMING AND PREDICTED CAPTURE RATES FOR SINGLE-ID ACCEPTANCE FILTER

CAN ID	Total logs	Total captured	Times on Target	Times before Target	Percent Captured	Times after Target	Max. Jitter (us)	Av. Period (us)	Max. Period (us)	Min. Period (us)	Offset (us)	Dif (us)
0x187	45107	41249	0	41249	91.45	1	81726	41653	100485	18759	20644	7774
0x188	45111	42930	0	42930	95.17	0	81378	50328	100472	19094	614	340
0x189	45110	45057	0	45057	99.88	2	83770	36811	100495	16725	20918	274
0x18A	45111	45108	0	45108	99.99	1	91752	36176	100498	8746	21192	274
0x18B	45111	39027	0	39027	86.51	0	81458	50377	100482	19024	274	274
0x18C	45111	43073	0	43073	95.48	0	81817	47759	100496	18679	21760	266
0x18D	45109	41702	0	41702	92.45	1	82085	45313	100498	18413	21494	302
0x18E	45111	43469	0	43469	96.36	1	82567	42897	100499	17932	22287	266
0x207	45107	45100	0	45100	99.98	1	86315	42095	100499	14184	22021	261
0x209	45110	44059	0	44059	97.67	1	82573	41828	100499	17926	22549	262
0x20B	45111	45078	1	45077	99.93	7	84280	26136	100474	16194	22799	250
0x20D	45109	45095	0	45095	99.97	13	92210	23998	100354	8144	3329	2715
0x287	45107	44863	28	44835	99.46	243	92192	22265	100338	8146	3589	260
0x289	45110	43467	110	43357	96.36	1639	91873	21045	100017	8144	3847	258
0x28B	45111	43295	143	43152	95.97	1815	91881	20820	100009	8128	4105	258
0x28D	45109	42838	403	42435	94.97	2270	73451	20559	81590	8139	4363	258
0x307	45107	41716	1469	40247	92.48	3390	73273	20327	81412	8139	4619	256
0x309	45110	39684	3193	36491	87.97	5420	52103	20202	60240	8137	4875	256
0x30B	45111	39175	3279	35896	86.84	5935	52105	20183	60242	8137	5131	256
0x30D	45109	37838	3430	34408	83.88	7270	52007	20143	60141	8134	5387	256
0x385	45111	43264	0	43264	95.91	0	81275	54450	100490	19215	140248	112880
0x387	45107	43565	146	43419	96.58	1541	92067	20887	100205	8138	5645	258
0x389	45110	44571	430	44141	98.81	533	92065	20887	100223	8158	5903	258
0x38B	45111	44838	74	44764	99.39	272	92069	20880	100223	8154	6169	266
0x38D	45109	44898	48	44850	99.53	210	92072	20863	100228	8156	6437	268
0x407	45107	44906	47	44859	99.55	200	91923	20841	100085	8162	6863	426
0x409	45110	35572	14953	20619	78.86	9535	71987	20046	80155	8168	7117	254
0x40B	45111	35424	16168	19256	78.53	9685	51956	20041	60126	8170	7368	251
0x40D	45109	35227	17445	17782	78.09	9881	51965	20035	60136	8171	7616	248
0x707	9018	1687	449	1238	18.71	6494	2703	99901	100498	97795	12870	142
0x709	9018	1433	304	1129	15.89	6847	19855	99878	100499	80644	9720	2104
0x70B	9018	2373	1030	1343	26.31	5923	3267	99927	100495	97228	12728	3008
0x70D	9018	5198	3798	1400	57.64	3123	16252	99953	100498	84246	27368	4569

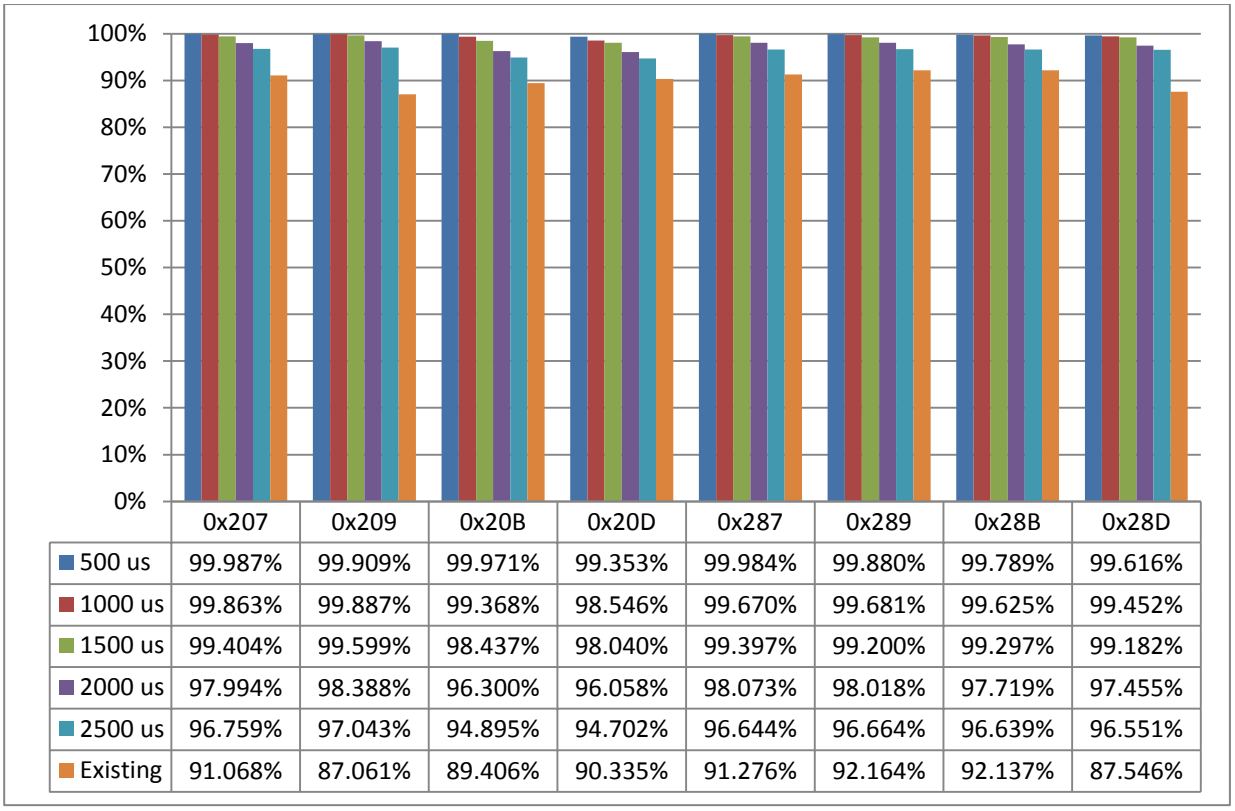
TABLE 4: LOGGING ANALYSIS RESULTS FOR VARYING LOGGING TASK PERIOD

CAN ID	Total	500 us			1000 us			1500 us			2000 us		
		Logged	Missed	Percent	Logged	Missed	Percent	Logged	Missed	Percent	Logged	Missed	Percent
0x187	45107	45101	6	99.987%	45057	50	99.889%	44870	237	99.475%	44243	864	98.085%
0x188	45111	45107	4	99.991%	44341	770	98.293%	44385	726	98.391%	44236	875	98.060%
0x189	45110	45075	35	99.922%	45055	55	99.878%	44935	175	99.612%	44393	717	98.411%
0x18A	45111	45107	4	99.991%	44780	331	99.266%	44649	462	98.976%	44238	873	98.065%
0x18B	45111	45067	44	99.902%	45047	64	99.858%	44925	186	99.588%	44352	759	98.317%
0x18C	45111	45107	4	99.991%	44307	804	98.218%	44003	1108	97.544%	44061	1050	97.672%
0x18D	45109	45077	32	99.929%	45054	55	99.878%	44938	171	99.621%	44372	737	98.366%
0x18E	45111	45107	4	99.991%	44863	248	99.450%	44566	545	98.792%	44071	1040	97.695%
0x207	45107	45101	6	99.987%	45045	62	99.863%	44838	269	99.404%	44202	905	97.994%
0x209	45110	45069	41	99.909%	45059	51	99.887%	44929	181	99.599%	44383	727	98.388%
0x20B	45111	45098	13	99.971%	44826	285	99.368%	44406	705	98.437%	43442	1669	96.300%
0x20D	45109	44817	292	99.353%	44453	656	98.546%	44225	884	98.040%	43331	1778	96.058%
0x287	45107	45100	7	99.984%	44958	149	99.670%	44835	272	99.397%	44238	869	98.073%
0x289	45110	45056	54	99.880%	44966	144	99.681%	44749	361	99.200%	44216	894	98.018%
0x28B	45111	45016	95	99.789%	44942	169	99.625%	44794	317	99.297%	44082	1029	97.719%
0x28D	45109	44936	173	99.616%	44862	247	99.452%	44740	369	99.182%	43961	1148	97.455%
0x307	45107	45091	16	99.965%	45042	65	99.856%	44915	192	99.574%	44111	996	97.792%
0x309	45110	45090	20	99.956%	45032	78	99.827%	44819	291	99.355%	44165	945	97.905%
0x30B	45111	45087	24	99.947%	45048	63	99.860%	44752	359	99.204%	44269	842	98.133%
0x30D	45109	45084	25	99.945%	45034	75	99.834%	44804	305	99.324%	44265	844	98.129%
0x385	45111	45107	4	99.991%	44883	228	99.495%	44166	945	97.905%	44143	968	97.854%
0x387	45107	45103	4	99.991%	45077	30	99.933%	44946	161	99.643%	44188	919	97.963%
0x389	45110	45101	9	99.980%	45077	33	99.927%	44877	233	99.483%	44154	956	97.881%
0x38B	45111	45106	5	99.989%	45084	27	99.940%	44880	231	99.488%	44280	831	98.158%
0x38D	45109	45106	3	99.993%	45083	26	99.942%	44960	149	99.670%	44346	763	98.309%
0x407	45107	45101	6	99.987%	45078	29	99.936%	44951	156	99.654%	44344	763	98.308%
0x409	45110	45100	10	99.978%	45077	33	99.927%	44954	156	99.654%	44288	822	98.178%
0x40B	45111	45106	5	99.989%	45083	28	99.938%	44954	157	99.652%	44276	835	98.149%
0x40D	45109	45106	3	99.993%	45079	30	99.933%	44959	150	99.667%	44361	748	98.342%
0x707	9018	9018	0	100.000%	9018	0	100.000%	9018	0	100.000%	9018	0	100.000%
0x709	9018	9018	0	100.000%	9018	0	100.000%	9018	0	100.000%	9018	0	100.000%
0x70B	9018	9018	0	100.000%	9018	0	100.000%	9018	0	100.000%	9018	0	100.000%
0x70D	9018	9018	0	100.000%	9018	0	100.000%	9018	0	100.000%	9018	0	100.000%
Total	1344249	1343301	948	99.929%	1339364	4885	99.637%	1333796	10453	99.222%	1317083	27166	97.979%



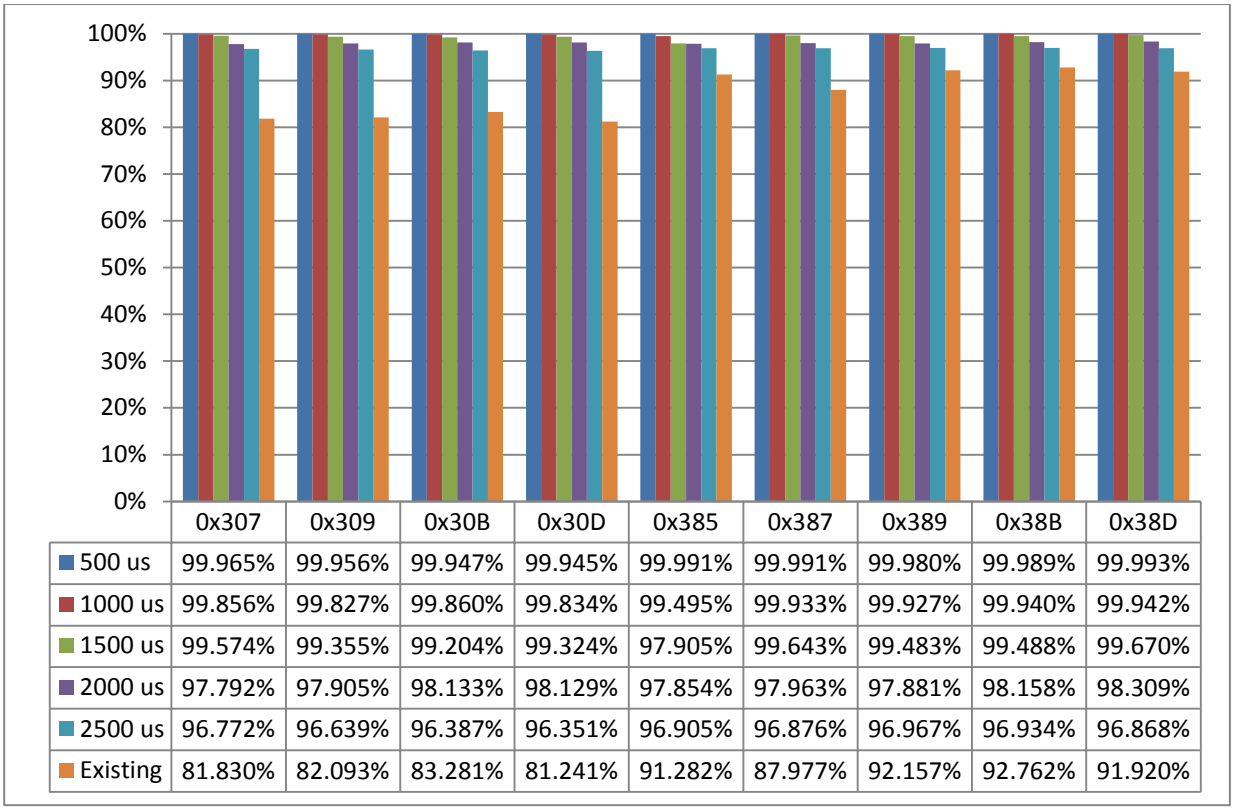
	0x187	0x188	0x189	0x18A	0x18B	0x18C	0x18D	0x18E
500 us	99.987%	99.991%	99.922%	99.991%	99.902%	99.991%	99.929%	99.991%
1000 us	99.889%	98.293%	99.878%	99.266%	99.858%	98.218%	99.878%	99.450%
1500 us	99.475%	98.391%	99.612%	98.976%	99.588%	97.544%	99.621%	98.792%
2000 us	98.085%	98.060%	98.411%	98.065%	98.317%	97.672%	98.366%	97.695%
2500 us	96.901%	96.735%	97.047%	96.713%	97.032%	96.739%	97.045%	96.912%
Existing	86.146%	91.867%	84.137%	88.695%	85.873%	85.684%	92.857%	92.159%

FIGURE 3: CAPTURE RATE COMPARISSON FOR ID'S 0X18N



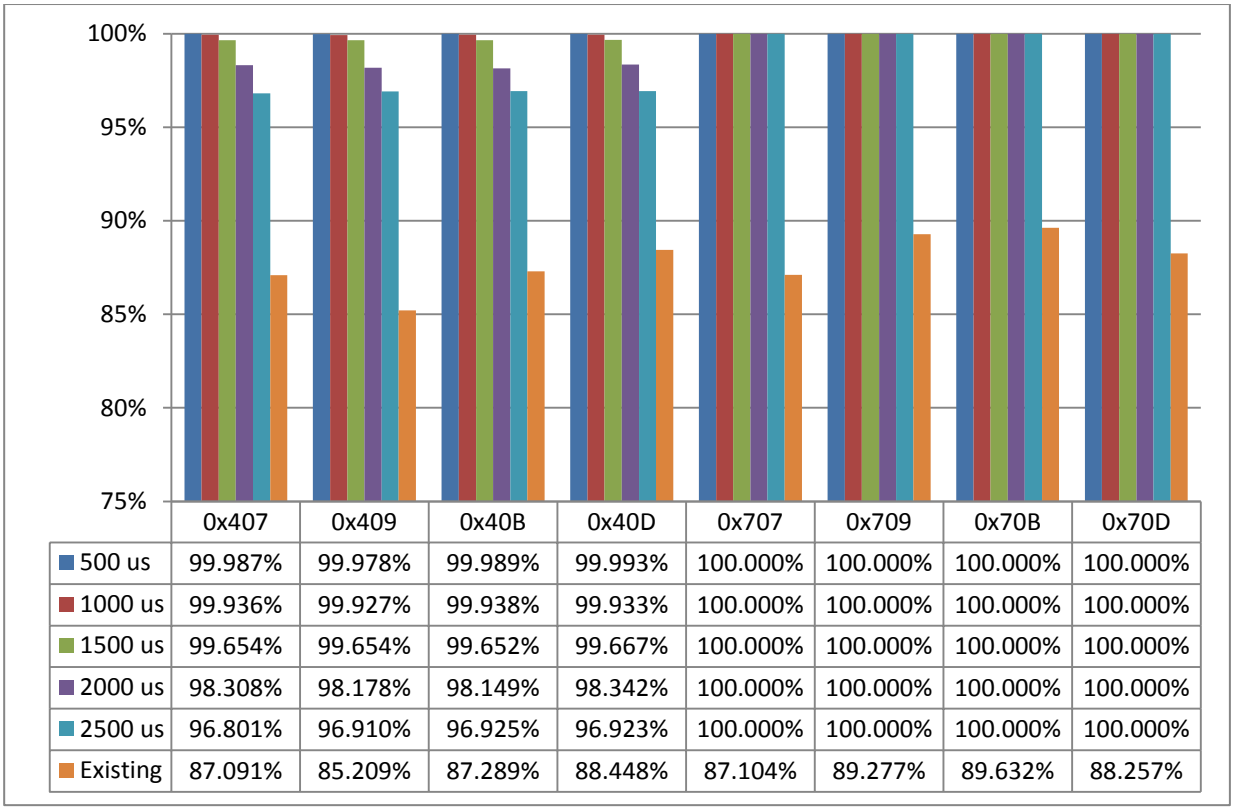
	0x207	0x209	0x20B	0x20D	0x287	0x289	0x28B	0x28D
500 us	99.987%	99.909%	99.971%	99.353%	99.984%	99.880%	99.789%	99.616%
1000 us	99.863%	99.887%	99.368%	98.546%	99.670%	99.681%	99.625%	99.452%
1500 us	99.404%	99.599%	98.437%	98.040%	99.397%	99.200%	99.297%	99.182%
2000 us	97.994%	98.388%	96.300%	96.058%	98.073%	98.018%	97.719%	97.455%
2500 us	96.759%	97.043%	94.895%	94.702%	96.644%	96.664%	96.639%	96.551%
Existing	91.068%	87.061%	89.406%	90.335%	91.276%	92.164%	92.137%	87.546%

FIGURE 4: CAPTURE RATE COMPARISSON FOR ID'S 0X2NN



	0x307	0x309	0x30B	0x30D	0x385	0x387	0x389	0x38B	0x38D
500 us	99.965%	99.956%	99.947%	99.945%	99.991%	99.991%	99.980%	99.989%	99.993%
1000 us	99.856%	99.827%	99.860%	99.834%	99.495%	99.933%	99.927%	99.940%	99.942%
1500 us	99.574%	99.355%	99.204%	99.324%	97.905%	99.643%	99.483%	99.488%	99.670%
2000 us	97.792%	97.905%	98.133%	98.129%	97.854%	97.963%	97.881%	98.158%	98.309%
2500 us	96.772%	96.639%	96.387%	96.351%	96.905%	96.876%	96.967%	96.934%	96.868%
Existing	81.830%	82.093%	83.281%	81.241%	91.282%	87.977%	92.157%	92.762%	91.920%

FIGURE 5: CAPTURE RATE COMPARISSON FOR ID'S 0X3NN



	0x407	0x409	0x40B	0x40D	0x707	0x709	0x70B	0x70D
500 us	99.987%	99.978%	99.989%	99.993%	100.000%	100.000%	100.000%	100.000%
1000 us	99.936%	99.927%	99.938%	99.933%	100.000%	100.000%	100.000%	100.000%
1500 us	99.654%	99.654%	99.652%	99.667%	100.000%	100.000%	100.000%	100.000%
2000 us	98.308%	98.178%	98.149%	98.342%	100.000%	100.000%	100.000%	100.000%
2500 us	96.801%	96.910%	96.925%	96.923%	100.000%	100.000%	100.000%	100.000%
Existing	87.091%	85.209%	87.289%	88.448%	87.104%	89.277%	89.632%	88.257%

FIGURE 6: CAPTURE RATE COMPARISSON FOR ID'S 0X40N & 0X70N

Source Code

Below is the source code for the main analysis portion of the script:

```
#define BUFFERSIZE                  (81)
#define FILTERSIZE                  (35)
#define MAX_TRACE_LINES             (0)      /* Set to zero to analyse entire trace */
#define LOGGING_TASK_PERIOD_us      (1000)

#define FREEZE_TRIES                (0)
#define MESSAGE_TIME_DELTA_MAX      (100500)
#define MESSAGE_TIME_DELTA_MIN      (0)

unsigned long  ID, timeDelta;
int noIDs;
unsigned int filterPointer;


typedef struct
{
         int canID;
         unsigned long counter;
         unsigned long loggedCounter;
} logging_Sequence_t;

typedef enum {TRUE, FALSE}flag_t;

typedef struct
{
         int canID;
         int sequencePointer;
         flag_t loggedFlag;
} filter_t;


logging_Sequence_t loggingSequence[BUFFERSIZE];
filter_t acceptanceFilter[FILTERSIZE];

void getSimpleCanSequence(char *filename, FILE *log);
void checkLogability(char *filename, FILE *log, int filterSize, int sequenceSize);
void orderSequence(void);
int countSequence(void);

int main(void)
{
    char *CANlogFile = "Log_for_analysis2.asc";
    int i, sequenceSize;

    FILE *outputFile = fopen("output.txt", "w");

    FILE *logFile = fopen("CAN_Logging_Simple_29-01-2013_Timing_1000us.csv", "w");

    noIDs = 0;

/* source for getSimpleCanSequence() and countSequence() omitted due to simplicity – available on request */

    getSimpleCanSequence(CANlogFile, logFile);

    sequenceSize = countSequence();
    printf("\n\n\n");
    printf("\n\n %u ID's",sequenceSize);


    printf("\n\n\nChecking logability...\r\n\n");
    fprintf(logFile,"\n\n,,Filter Size,Logged,Missed\n");

    for(i = 1; i <= (sequenceSize-1); i++)
    {
        checkLogability(CANlogFile, logFile, i, sequenceSize);
    }


    fclose(outputFile);
    fclose(logFile);

    return EXIT_SUCCESS;
}
```

```
void checkLogability(char *filename, FILE *log, int filterSize, int sequenceSize)
{
    char inputStr[200];
    char canData[200];
    int i = 0, j = 0, sequencePointer = 0, sequencePointerStart = 0, IDLogCount = 0, IDMissedCount = 0;
    flag_t IDlogged = FALSE, IDfound = FALSE;
    unsigned long timeNow_s ,timeNow_us, timeOrigin, lineCounter;

    int ID;

    /* open trace file */
    FILE *bufferFile = fopen(filename, "r");


    /* Put first filterSize CAN ID's from sequence into acceptanceFilter */
    for(i = 0; i < filterSize; i++)
    {
        acceptanceFilter[i].canID = loggingSequence[i].canID;
        acceptanceFilter[i].sequencePointer = i;
        acceptanceFilter[i].loggedFlag = FALSE;
        sequencePointer = i;
    }

    timeOrigin = 0;

    /* loop through trace lines in file for MAX_TRACE_LINES */
    while((fgets(inputStr, 190, bufferFile) != NULL) && ((lineCounter++ < MAX_TRACE_LINES) || (MAX_TRACE_LINES == 0)))
    {

        /* Extract values from input string */
        unsigned int scanReturn = sscanf(inputStr, logFormat, &timeNow_s, &timeNow_us, &ID, &canData);
        if(scanReturn == 4) /* valid line in trace */
        {

            /* Time calculation from seconds and microseconds */
            timeNow_us += (timeNow_s * 1000000);

            /* Set time origin on first run */
            if(timeOrigin == 0)
            {
                timeOrigin = timeNow_us;
            }

            /* Find current time delta from origin */
            timeDelta = (timeNow_us - timeOrigin);
            /* Output so I can see it doing something */
            printf("%u %lu\n", filterSize, timeNow_us);

            /* Logging task has run - replace logged ID's in filter */
            if(timeDelta >= LOGGING_TASK_PERIOD_us)
            {

                /* Iterate through whole acceptance filter */
                for(i = 0; i < filterSize; i++)
                {
                    /* loggedFlag is set when ID is logged for first time */
                    if(acceptanceFilter[i].loggedFlag == TRUE)
                    {
                        /* look through logging sequence for next ID not contained in acceptance filter */
                        sequencePointerStart = sequencePointer;
                        do
                        {
                            sequencePointer++;
                            if(sequencePointer >= sequenceSize)
                            {
                                sequencePointer = 0;
                            }

                            IDfound = FALSE;

                            for(j = 0; j < filterSize; j++)
                            {
                                if(acceptanceFilter[j].canID == loggingSequence[sequencePointer].canID)
                                {
                                    IDfound = TRUE;
                                }
                            }

                        }while((sequencePointer != sequencePointerStart) && (IDfound == TRUE));
```

```
                    /* ID found not already in acceptance filter - replace Id in filter */
                    if(IDfound == FALSE)
                    {
                        acceptanceFilter[i].canID = loggingSequence[sequencePointer].canID;
                        acceptanceFilter[i].sequencePointer = sequencePointer;
                        acceptanceFilter[i].loggedFlag = FALSE;
                    }
                }
            }

            /* Reset time origin to current time */
            timeOrigin = timeNow_us;
        }

        /* ID is in logging list */
        if(GetCAN1BufferPointer(ID) == 1)
        {
            IDlogged = FALSE;
            i = 0;

            /* look for ID in acceptance filter */
            do
            {
                if(acceptanceFilter[i].canID == ID)
                {
                    /* ID found, increment counters */
                    IDLogCount++;
                    loggingSequence[acceptanceFilter[i].sequencePointer].loggedCounter++;
                    acceptanceFilter[i].loggedFlag = TRUE;

                    IDlogged = TRUE;
                }

                i++;

            }while((IDlogged == FALSE) && (i < filterSize));

            /* ID not found in filter, so would be missed */
            if(IDlogged == FALSE)
            {
                IDMissedCount++;
            }
        }
    }
}

    printf("filterSize: %u   Logged: %u    Missed %u\n", filterSize, IDLogCount, IDMissedCount);


/* Output code commented out when not in use TODO: make these separate functions */
/* Use below to output individual ID counts */
//  for(i = 0; i < BUFFERSIZE; i++)
//  {
//      if(loggingSequence[i].canID != 0)
//      {
//          fprintf(log,",,0x%03X,%lu,%lu,%lu\n",loggingSequence[i].canID, loggingSequence[i].loggedCounter,
(loggingSequence[i].counter - loggingSequence[i].loggedCounter), loggingSequence[i].counter);
//      }
//  }
//  fprintf(log,"\n");

    /* Use below to output overall, per filterSize, hit / miss counts */
    fprintf(log,",,%u,%u,%u\n", filterSize, IDLogCount, IDMissedCount);

}
```