

EE345L – Lab 2: Performance Debugging

Antonius Keddiss and Stephen To
02/14/07

1.0 OBJECTIVE

The lab aimed to familiarize students with dynamic and real-time performance debugging techniques with various degrees of intrusiveness. Oscilloscopes, logic analyzers, and software dumps were used to observe data.

Profiling also presented the detection and visualization of program activity. The program we profiled implemented a FIFO queue with interrupts enabled.

2.0 ANALYSIS AND DISCUSSION

2.1 Theoretical Data

By observing the cycle count in the listing file, we calculated the total time to call and execute RxFifo_Get with Equation 1.

$$total\ time = \frac{50\ cycles}{1} \cdot \frac{1\ second}{24 \cdot 10^6\ cycles} = 2.08\ \mu s \quad (\text{Equation 1})$$

2.2 Experimental Data

2.2.1 Observing the Debugging Profile

PT0 -> Channel 1: Interrupt
rising edge is start of interrupt
falling edge is end of interrupt

PT1 -> Channel 2: Foreground
rising edge is foreground processing
falling edge is foreground waiting

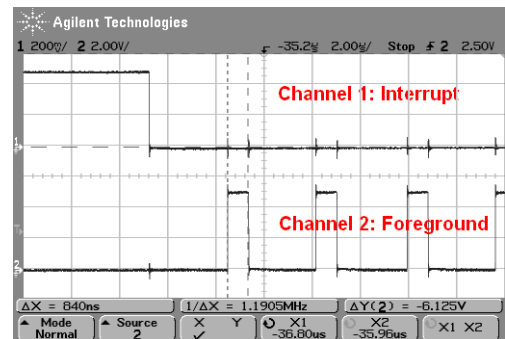


Figure 1: PT0 (top), PT1 (bottom)

2.2.2 Instrumentation Measuring with Independent Counter, TCNT

We observed the cycle counts for three different versions of RxFifo_Get: without debugging (A), with debugging print (B), and with debugging dump (C). The hyperterminal output was collected into Table 1. The results for Version A confirm our theoretical prediction and indicate minimal intrusiveness (that the profiling software minimally affects the execution speed).

Version	Cycles	Execution Time (sec)
A	50	2.08E-06
B	16584	6.91E-04
C	84	3.50E-06

Table 1: RxFifo_Get execution times

2.2.3 Instrumentation Output Port

Instructions were placed before and after the RxFifo_Get function to “turn on” and “turn off” PT0. Figure 2 depicts the output of PT0. However, the measurement instruction themselves are intrusive. Notice the execution time is slightly longer than the theoretical prediction.

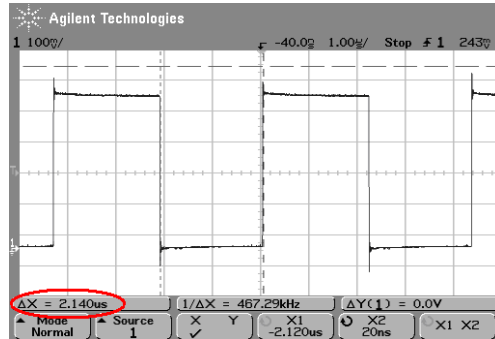


Figure 3: PT0 (on during RxFifo_Get execution)

2.2.4 Profiling with a Software Dump

Two arrays were added as a software dump: one to record the time of an activity (timeBuf[]), one to record the location of activity (placeBuf[]). Refer to Appendix A and B for the software dump output.

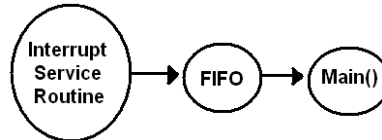


Figure 3: Data flow graph of the system

2.2.5 Threading Profile using Hardware

We observed the currently running function by associating a function with a single output port (ie PT3 for RxFifo_Put). Figure 4 illustrates the oscilloscope output.

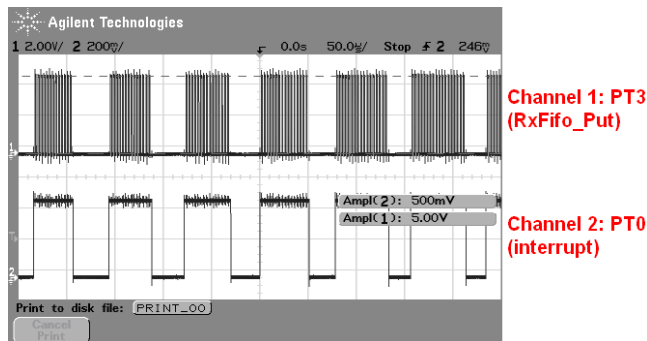


Figure 4: Hardware Thread Profile

2.3 Conclusions

Therefore, if we expected the execution speed to vary (ie from 5 to 20ms), we would use a software dump to determine execution speed. We would be able to calculate minimum, maximum, and average speed by observing the execution pattern.

For large execution speeds (ie 20s), we would use hardware profiling. During 20s, the program would have executed $20 \times 24 \times 10^6$ cycles, and TCNT would be unable to capture this quantity. Using hardware, the profiling instruction would be nearly negligible compared to the program itself: microseconds compared to seconds.

Appendix A: timeBuf[]

The screenshot displays the True-Time Simulator & Real-Time Debugger interface. The main window shows a memory dump for the variable `timeBuf[0]` at memory addresses 3822-3823. The data is presented in a grid format with 16 columns and 32 rows. The first row (address 003820) contains the following values: 0, 9, -3, -54, -2, 93, -2, -1, -1, 99, -1, -103, 92, 30, 93, 56, followed by the ASCII string `..[.]...c...\}8`. The second row (address 003830) contains: 93, 110, 93, -46, 94, 8, -71, -33, -69, 42, -69, 96, -69, -60, -69, -6, followed by `]n).^....*.\....`. The third row (address 003840) contains: -68, 94, -68, -108, 23, -99, 25, 57, 25, 111, 25, -45, 26, 9, 26, 109, followed by `..^.....9.o.....m`. The fourth row (address 003850) contains: 26, -93, 27, 7, 27, 61, 117, 95, 119, 39, 119, 93, 119, -63, 119, -9, followed by `.....=u_w*w]w.w.`. The fifth row (address 003860) contains: 120, 91, 120, -111, 120, -11, 121, 43, 121, -113, 121, -59, -45, 31, -43, 50, followed by `x[x.x.y+y.y....2`. The sixth row (address 003870) contains: -43, 104, -43, -52, -42, 2, -42, 102, -42, -100, -41, 0, -41, 54, -41, -102, followed by `.h.....f.....6..`. The seventh row (address 003880) contains: -41, -48, -40, 52, -40, 106, 48, -35, 51, 30, 51, 84, 51, -72, 51, -18, followed by `...4.j0.3.3T3.3.`. The eighth row (address 003890) contains: 52, 85, 52, -117, 52, -17, 53, 37, 53, -119, 53, -65, 54, 35, 54, 89, followed by `4U4.4.5%5.5.6#6Y`. The ninth row (address 0038A0) contains: 54, -67, 54, -13, -114, -99, -111, 40, -111, 94, -111, -62, -111, -8, -110, 92, followed by `6.6....(^.....\`. The tenth row (address 0038B0) contains: -110, -110, -110, -10, -109, 44, -109, -112, -109, -58, -108, 42, -108, 96, -108, -60, followed by `.....D.v.....`. The eleventh row (address 0038C0) contains: -108, -6, -107, 94, -107, -108, -20, 93, -17, 14, -17, 68, -17, -88, -17, -34, followed by `...^...].D....`. The twelfth row (address 0038D0) contains: -16, 66, -16, 120, -16, -36, -15, 18, -15, 118, -15, -84, -14, 16, -14, 70, followed by `.B.x.....z.....P`. The thirteenth row (address 0038E0) contains: -14, -86, -14, -32, -13, 68, -13, 122, -13, -34, 0, 0, 0, 4, 0, 1, followed by `.....D.v.....`. The fourteenth row (address 0038F0) contains: 0, 2, 0, 1, 0, 4, 0, 2, 0, 1, 0, 2, 0, 1, 0, 4, followed by `.....`. The fifteenth row (address 003900) contains: 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 4, 0, 2, followed by `.....`. The sixteenth row (address 003910) contains: 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 4, followed by `.....`. The seventeenth row (address 003920) contains: 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, followed by `.....`. The eighteenth row (address 003930) contains: 0, 2, 0, 1, 0, 4, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, followed by `.....`. The nineteenth row (address 003940) contains: 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 4, followed by `.....`. The twentieth row (address 003950) contains: 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, followed by `.....`. The twenty-first row (address 003960) contains: 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 4, 0, 2, followed by `.....`. The twenty-second row (address 003970) contains: 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, followed by `.....`. The twenty-third row (address 003980) contains: 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 4, followed by `.....`. The twenty-fourth row (address 003990) contains: 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, followed by `.....`. The twenty-fifth row (address 0039A0) contains: 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, 0, 2, 0, 1, followed by `.....`. The twenty-sixth row (address 0039B0) contains: 0, 2, 109, -8, 92, 66, -36, 124, -36, 16, -87, -106, 104, -6, 85, -95, followed by `..m.\B.|....h.U.`. The twenty-seventh row (address 0039C0) contains: -56, -66, 118, -121, -48, 7, -126, 98, -100, -37, -125, 93, -102, 9, -68, -93, followed by `..v....b...]....`. The twenty-eighth row (address 0039D0) contains: -125, 102, 74, 104, -65, -80, 79, -33, 54, 83, -18, -104, -101, -44, -105, -92, followed by `.fJh..O.6S.....`. The twenty-ninth row (address 0039E0) contains: 81, 118, -3, 116, -107, 119, 103, 69, 69, 104, -72, 37, 80, 117, -105, 20, followed by `Qv.t.wgEBh.&Pu..`. The thirtieth row (address 0039F0) contains: -120, -19, 108, -59, -18, 58, 26, -12, -25, 61, -13, -97, 127, -60, -64, -48, followed by `..l.....=.....`. The thirty-first row (address 003A00) contains: 106, 99, -73, 112, -23, -63, 53, -38, -19, -11, 114, -40, -14, -73, 113, -3, followed by `jc.p..5...r...q.`. The thirty-second row (address 003A10) contains: 74, 70, -37, 127, -92, 27, 53, 110, -107, -16, -44, -61, 36, -107, -127, 126, followed by `JF....5n....$.~`. The thirty-third row (address 003A20) contains: -96, 39, -51, -104, -20, 16, 67, 108, -83, -8, -122, -22, 72, -116, 123, -47, followed by `..*....Cl....H.{.`. The thirty-fourth row (address 003A30) contains: 114, 122, 57, 104, 121, 124, 87, 115, 71, 42, 84, 84, 111, 42, 50, 40, followed by `..-0...tmm...t`. The status bar at the bottom indicates 'Automatic (triggers, breakpoints, watchpoints, and trace possible)', 'MC9S12C32', and 'RUNNING'. The taskbar shows the Start button and several open applications: Mail :: INBO..., http://Users..., Metrowerks..., partd time..., C:\Docume..., lab2g listing..., and True-Time ... The system clock shows 8:58 PM.

Appendix B: placeBuf[]

True-Time Simulator & Real-Time Debugger C:\Documents and Settings\kceddis\Desktop\Lab2g\Monitor.ini - [Memory]

File View Run MONITOR-HCS12 Component Memory Window Help

placeBuf[0] 38EA-38EB Auto

0038E0	-14	-86	-14	-32	-13	68	-13	122	-13	-34	0	0	0	4	0	1	.....D.z.█.....
0038F0	0	2	0	1	0	4	0	2	0	1	0	2	0	1	0	4	.....
003900	0	2	0	1	0	2	0	1	0	2	0	1	0	4	0	2	.....
003910	0	1	0	2	0	1	0	2	0	1	0	2	0	1	0	4	.....
003920	0	2	0	1	0	2	0	1	0	2	0	1	0	2	0	1	.....
003930	0	2	0	1	0	4	0	2	0	1	0	2	0	1	0	2	.....
003940	0	1	0	2	0	1	0	2	0	1	0	2	0	1	0	4	.....
003950	0	2	0	1	0	2	0	1	0	2	0	1	0	2	0	1	.....
003960	0	2	0	1	0	2	0	1	0	2	0	1	0	4	0	2	.....
003970	0	1	0	2	0	1	0	2	0	1	0	2	0	1	0	2	.....
003980	0	1	0	2	0	1	0	2	0	1	0	2	0	1	0	4	.....
003990	0	2	0	1	0	2	0	1	0	2	0	1	0	2	0	1	.....
0039A0	0	2	0	1	0	2	0	1	0	2	0	1	0	2	0	1	.....
0039B0	0	2	109	-8	92	66	-36	124	-36	16	-87	-106	104	-6	85	-95	..m.\B.|...h.U.
0039C0	-56	-66	118	-121	-48	7	-126	98	-100	-37	-125	93	-102	9	-68	-93	..v...b...].
0039D0	-125	102	74	104	-65	-80	79	-33	54	83	-18	-104	-101	-44	-105	-92	.fJh..O.6S.....
0039E0	81	118	-3	116	-107	119	103	69	69	104	-72	37	80	117	-105	20	Qv.t.wgEEh.%Pu...
0039F0	-120	-19	108	-59	-18	58	26	-12	-25	61	-13	-97	127	-60	-64	-48	..l.....=.....
003A00	106	99	-73	112	-23	-63	53	-38	-19	-11	114	-40	-14	-73	113	-3	jc.p..5...r...q.
003A10	74	70	-37	127	-92	27	53	110	-107	-16	-44	-61	36	-107	-127	126	JF...5n...\$.~
003A20	-96	39	-51	-104	-20	16	67	108	-83	-8	-122	-22	72	-116	123	-47	.'....Cl....H.{.
003A30	114	122	57	104	121	124	-87	-115	-71	42	84	84	111	-47	59	49	rz9hy|...*TTo.;1
003A40	38	-126	59	48	78	-111	-36	-79	-64	63	30	-68	-67	46	-62	-66	&.;0N...?.....
003A50	-70	-52	-58	-41	100	63	97	-108	32	-57	29	-117	124	86	67	-68	....d?a...|VC.
003A60	12	-6	119	-63	-60	-22	100	-37	-63	-11	-24	-25	-74	-43	43	-99	..w...d.....+.
003A70	60	78	0	101	67	24	110	-24	-41	-17	15	35	64	26	101	-51	<N.ec.n...#@.e.
003A80	-29	-48	114	-3	-105	-73	33	20	16	122	1	5	-89	-89	-89	31	..r...!..z.....
003A90	1	5	64	-5	-73	18	61	0	1	-4	-25	0	1	56	-4	125	..@...=.....8.)
003AA0	-5	35	-64	31	56	56	31	0	-58	65	127	56	31	64	-53	64	..#.88...A.8.@.@
003AB0	66	92	45	-1	-26	-37	89	-37	-29	121	-41	-112	-40	30	-103	-108	B\...Y..y.....
003AC0	72	30	117	100	-54	45	-91	65	-124	120	-68	-25	113	100	-96	-69	H.ud...A.x...qd..
003AD0	77	-60	113	-60	-5	25	19	44	64	96	-49	-121	-80	-92	9	-10	M.q...,@`.....
003AE0	46	-69	-106	-87	-35	61	-90	-103	75	63	63	-66	-104	115	4	-81	.....K??...s..
003AF0	25	116	7	80	82	50	100	44	72	101	2	100	51	11	21	101	#...=...w...@.

For Help, press F1 Automatic (triggers, breakpoints, watchpoints, and trace possible) MC9S12C32 RUNNIN

Start Mail :: INBO... http://Users... Metrowerks ... partd timeb... C:\Docume... lab2g listing ... True-Time ... 9:00 PM