Embedded Systems Advanced Nano Degree

Real-Time Operating System Project

Implementing EDF Scheduler Report

Verifying the system implementation

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Introduction

The following report verifies system implementation with the EDF (Earliest Deadline First) scheduler using analytical methods, using Simso offline simulator, and using Keil simulator in run-time.

Analytical Methods

1. System Hyperperiod

Task	Periodicity
Button 1 Monitor	50
Button 2 Monitor	50
Periodic Transmitter	100
Uart Receiver	20
Load 1 Simulation	10
Load 2 Simulation	100

Hyperperiod = Least Common Multiplier of all tasks periodicities

Therefore,

$$Hyperperiod = LCM\,(50, 50, 100, 20, 10, 100)$$

$$Hyperperiod = 100$$

2. CPU Load

Task	Execution Time	Occurrence During Hyperperiod
Button 1 Monitor	29 uS	2
Button 2 Monitor	29 uS	2
Periodic Transmitter	93 uS	1
Uart Receiver	30 uS	5
Load 1 Simulation	5 ms	10
Load 2 Simulation	12 ms	1

Utilization = Total Execution Time During Hyperperiod / Hyperperiod

$$U = \frac{(29\mu*2)+(29\mu*2)+(93\mu)+(30\mu*5)+(5m*10)+(12m)}{100m} \times 100\% = 62.36\%$$

3. System Schedulability

Check system schedulability using URM and time demand analysis techniques (Assuming the given set of tasks are scheduled using a fixed priority rate -monotonic scheduler)

- Rate-Monotonic Utilization Bound

A system is said to be feasible (Schedulable) if :

$$U \leq n(2^{\frac{1}{n}} - 1)$$

In our case :

$$U = 0.6236 , \qquad U_{rm} = 6\,(2^{1/6} - 1) = 0.7348 , \qquad Therefore,\ U < Urm$$

Therefore, The system is feasible (Schedulable).

- Time Demand Analysis

Measures time required against time provided

$$w_i(t) = e_i + \sum_{k=1}^{i-1} \left\lceil \frac{t}{P_k} \right\rceil e_k$$

Where,

w: worst response time

e: execution time

t: time instance

P: periodicity

i: task number

In our case, critical instant = 100ms

Task	Periodicity	Execution Time
Load 1 Simulation	10	5 ms
Uart Receiver	20	30 uS
Button 1 Monitor	50	29 uS
Button 2 Monitor	50	29 uS
Periodic Transmitter	100	93 uS
Load 2 Simulation	100	12 ms

For Task 1 : Load 1 Simulation (E: 5ms , P: 10ms, Provided Time=10ms)

$$w_1(10) = 5m + 0 = 5 \quad , w(10) = 5 < 10$$

Therefore, Task 1 : Load 1 simulation is schedulable

For Task 2 : Uart Receiver (E: 30us , P: 20ms, Provided Time=20ms)

$$w_2(20) = 30\mu + (20/10)\,5m = 10.03\,ms \quad , w(20) = 10.03 < 20$$

Therefore, Task 2 : Uart Receiver is schedulable

For Task 3 : Button 1 Monitor (E: 29us , P: 50ms, Provided Time=50ms)

$$w_3(50) = 29\mu + (50/10)\,5m + (50/20)\,30\mu = 25.059\,ms \; , w(50) = 25.059 < 50$$

Therefore, Task 3 : Button 1 Monitor is schedulable

For Task 4 : Button 2 Monitor (E: 29us , P: 50ms, Provided Time=50ms)

$$w_4(50) = 29\mu + (50/10)\,5m + (50/20)\,30\mu + (50/50)29\mu = 25.087\,ms$$

$$w(50) = 25.087 < 50$$

Therefore, Task 4 : Button 2 Monitor is schedulable

For Task 5 : Periodic Transmitter (E: 93 us , P: 100ms, Provided Time=100ms)

$$w_5(100) = 93\mu + (100/10)\,5m + (100/20)\,30\mu + (100/50)29\mu + (100/50)29\mu = 50.359\,ms$$

$$w(100) = 50.359 < 100$$

Therefore, Task 5 : Periodic Transmitter is schedulable

For Task 6 : Load 2 Simulation (E: 12ms , P: 100ms, Provided Time=100ms)

$$w_6(100) = 12m + (100/10)5m + (100/20)30\mu + (100/50)29\mu + (100/50)29\mu + (100/100)93\mu$$

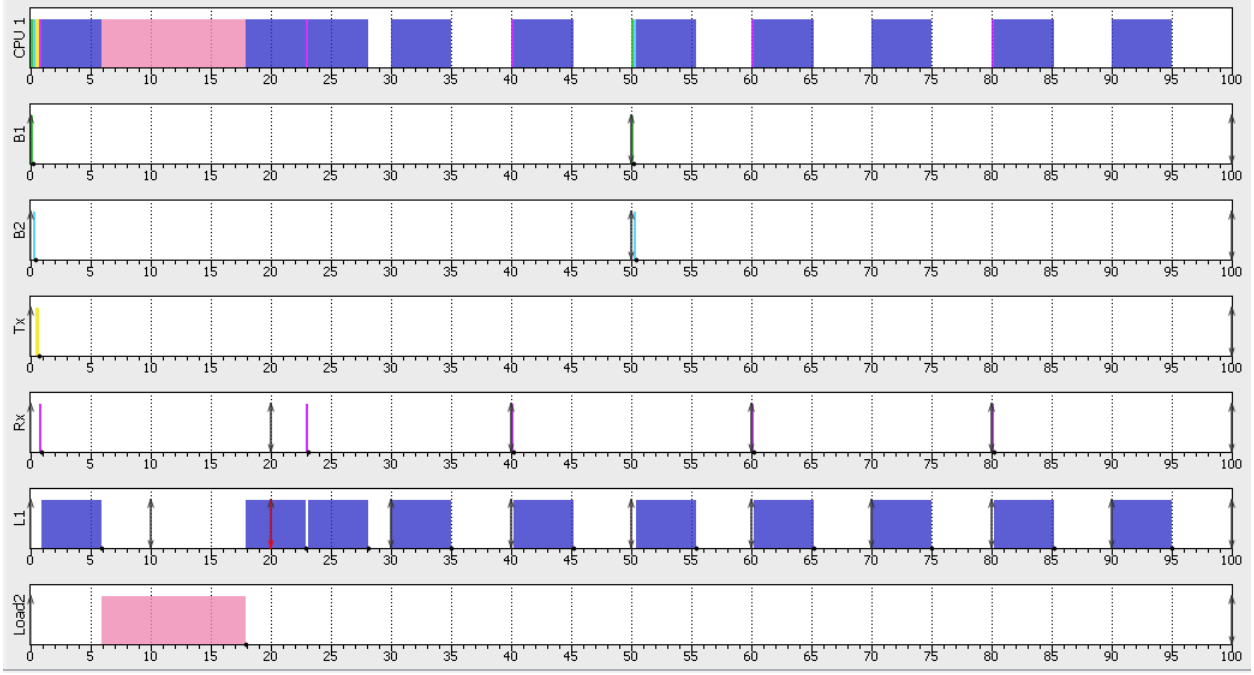
$$w(100) = 62.452 < 100$$

Therefore, Task 6 : Load 2 Simulation is schedulable

Therefore the system is Schedulable

Simso Offline Simulator

Simulate the given set of tasks assuming “Fixed priority rate monotonic scheduler”



Keil Simulator

- Calculating the CPU usage time using timer 1 and trace macros

Where, cpu_load : Carries cpu load percentage

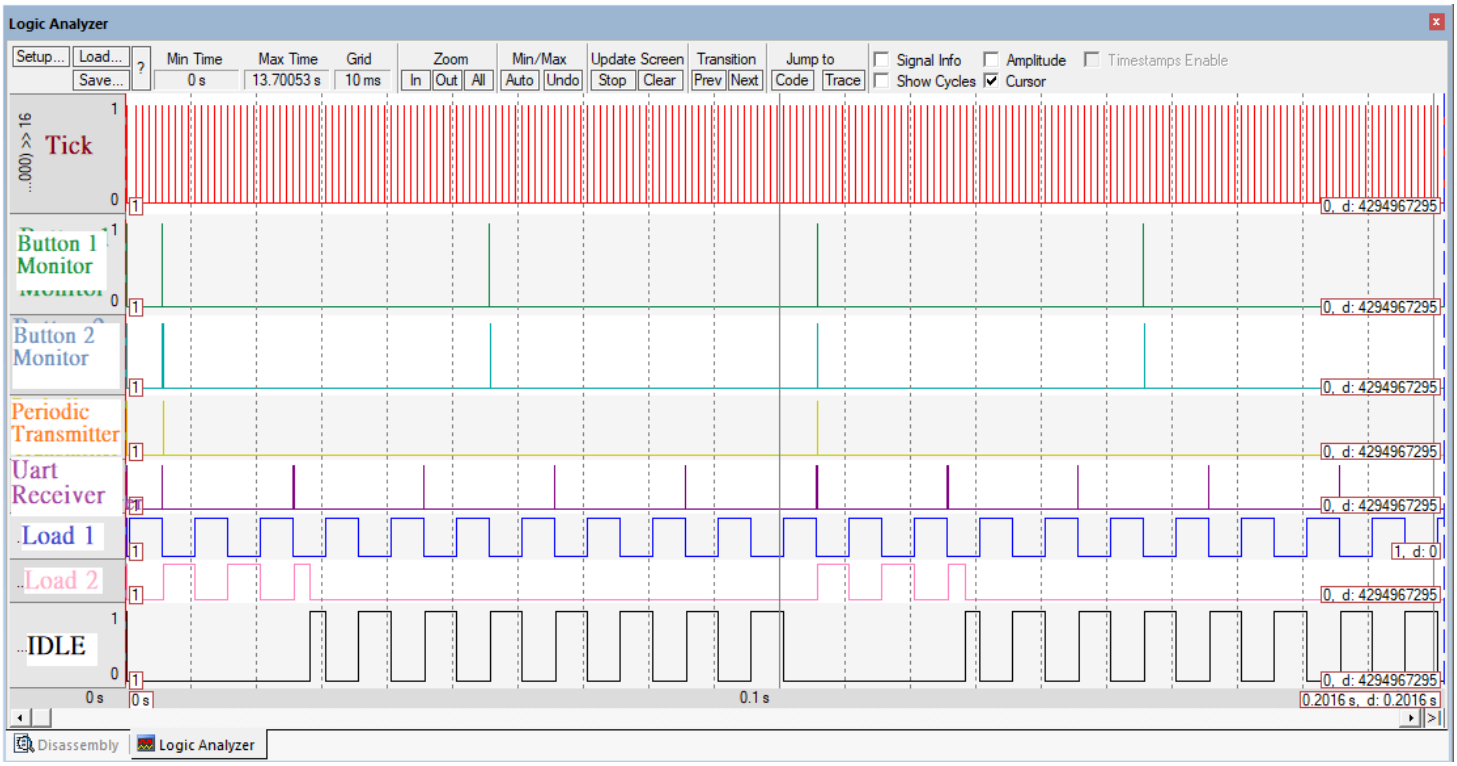
toatl_exec: Carries total execution time for all tasks in terms of timer1 ticks

T1TC: Timer 1 Ticks which represents system time as well

Watch 1

Name	Value	Type
RTstats	0x00000000	uchar[300]
cpu_load	63	uint
total_exe	756275	uint
T1TC	1198526	ulong

- Using trace macros and GPIOs to plot the execution of all tasks, tick, and the idle task on the logic analyzer



Conclusion

- Although using different verification methods, final results tends to be similar if not the same.
- EDF scheduler is a suitable scheduling policy for such tasks. As it keeps the system feasible.
- Fixed priority rate monotonic scheduling policy does not keep this system feasible as tasks keep missing deadlines as there is not a preemptive scheduling policy.