ECEN 5803- Mastering Embedded System Architecture

Homework set 5

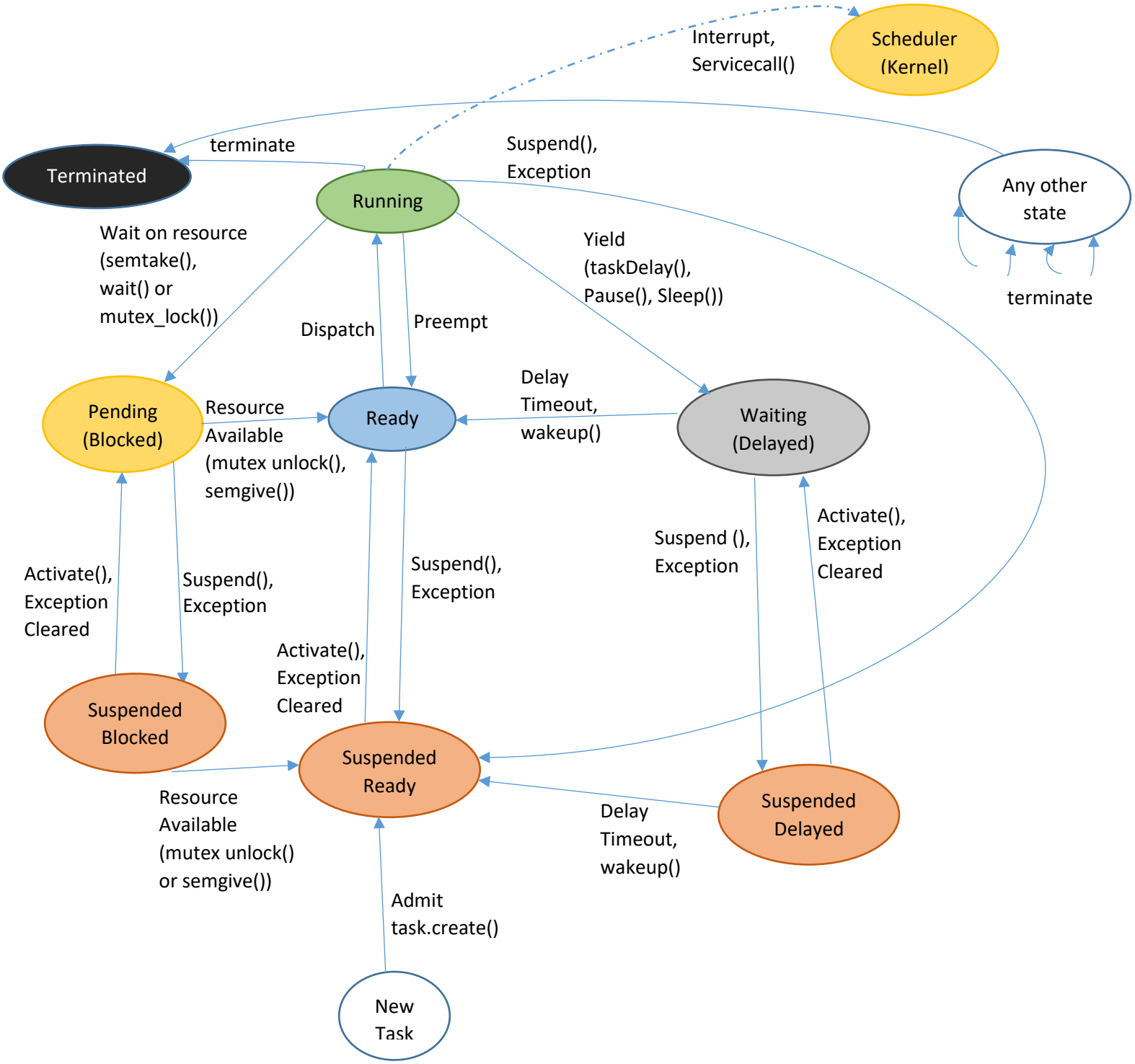
Due Date: 2021/11/29

Theory and Analysis:

State Machines

1. (10 pts.) State Machines are an important concept in developing robust embedded software.

a. Write a C code function that executes the state machine shown. Assume this describes the scheduling algorithm for each task in a priority based OS scheduler. Be sure to select a default state that makes sense. Assume that state transition input variables representing the events depicted are available to your state machine function. The transition to the scheduler is not part of the state machine, it just FYI only.



b. Submit your code to Canvas, along with a log of state transitions printed during execution.
c. Could you create this state machine in hardware? Would you – why or why not?

2. (10 pts.) You've been drafted into the Military of your country of origin. Your first assignment is to design an embedded system for an Armored Troop Transport (ATT) with a 50mm gun, scanning radar, and Internal/External Comm system. Inputs are video from the external comm; 4 HDMI cameras; radar telemetry; GPS positioning; gun heading and angle of elevation joystick inputs for both commander and gunner; and keyboard and mouse. Outputs are 5 channels of USB Audio for the commander, gunner and crew headsets; 1 channel of streaming video to the external comm; scanning radar heading control via CAN network; Ethernet to the gun position control system; and 1920 x 1080 LCD Display.
   The system must meet Military standards for reliability and soft real-time response is required, except for the gun control system, which must be hard real-time with 10 ms guaranteed response.
   a. What operating system will you recommend for this embedded system? Discuss the pro and cons of Linux, QNX, and Windows Embedded Compact.
   b. Draw a block diagram of your proposed system.
   c. What type of Embedded System Architecture would you use to construct this system? MCU, MPU, DSP, FPGA or Embedded PC?

3. (14 pts.) You have been contracted by Avaya to design an Enterprise VoIP PBX that supports up to 2000 voice channels. They want you to determine whether to build a monolithic chip-down design from scratch, or buy an embedded system board or modular chassis system. They have 3 main functional requirements. First, calls can be received over the Gigabit Ethernet connections or from 2 fiber optic T4 lines. Calls are distributed using 10/100 Ethernet networks. Second, Operating and Monitoring is done using a PC monitoring station with display, keyboard, and mouse connected to the PBX unit using Ethernet or USB. Third, Alarming should be done in response to dropped calls or failed maintenance tests. The embedded system should be scalable to handle a few as 200 calls and as many as 2000. Each call requires about 20 DMIPS to process for the G.729 Codec and echo cancellation. Volumes are 1k units/month, competitive systems spend between $3k (200 lines) and $10k (2000 lines) per unit on the embedded system. They are willing to spend much on the design to get a good result. Power is an issue, as the system should be battery backed to run for up to 24 hours on battery, but generally the system can use a significant amount of power without performance issues. Field upgrades are a requirement, and bug fixes and upgrades must be done remotely as well as on site. System speed is fast.
   a. Draw a block diagram of the embedded system.
   b. Should it be based on a custom board made from an MCU, an MPU, an FPGA, an ASIC, or a SOM; or should it be based on an Embedded PC or a MicroTCA chassis? Consider the Buy vs. Build decision in part e and then explain the reasons for your answer.
   c. What would be a good OS choice for Avaya?
   d. What would be a good processor choice for Avaya for the custom design? For some processors, more than one may be needed. Up to N processors may be needed to support the number of lines required. Select one from the list here and support your answer with facts and reasoning. You must determine the value of N to use in your calculations based on the call load requirements given in part b and e. N is unique for each processor for each number of lines supported. The average value of N determines the total average cost.
      1. xN Freescale i.MX7 Dual – Nx 2280 DMIPS, $12.72, No FLASH, 768kB SRAM, USB, 2x Gigabit Ethernet
      2. xN Freescale LS1046ASE8MQA QorIQ Nx 22560 DMIPS, $53.53, 2000kB FLASH, 2M SRAM, USB, 7x Gig Ethernet,
      3. xN Texas Inst. AM3894BCYG150 – Nx 3000 DMIPS $48.30, no FLASH, 576kB SRAM, USB, Gigabit Ethernet
      4. xN Texas Inst. AM3352BZCED60 – Nx 1000 MIPS, $8.12, 175kB FLASH, 128kB SRAM, USB, Gig Ethernet
      5. x1 Intel Core i7-7500U - 49360 MIPS, $393, no FLASH, 4 MB SRAM, USB, Gigabit Ethernet

e. Should Avaya design their own circuit boards, or purchase an embedded PC board or a MicroTCA shelf? The NRE to build the custom system is $4M and the design will take 12 months to complete. Volume is expected to be 12000 units/year, evenly split between 200, 500, 1000, and 2000 Line Units. That means that 3000 units of the 200 line system will be sold, 3000 units of the 500 line system, etc. At that volume, unit cost of the custom design is $1000. Unit cost of the commercial off the shelf (COTS) Embedded PC unit with optical card is $3000 which support 2048 lines and it is available now (no delay). Unit Cost of the MicroTCA shelf is $2500, and each processor board which handles 512 calls costs $200, which are also available now. See http://www.vadatech.com/product.php?product=333&catid_prev=22&catid_now=125&parentcat=46&parentarc=2 for an example.
In this scenario, cost to the company for a 200 Line Unit system is $1000 for the custom design, $3000 for PC design, and $2500+$200 = $2700 for the MicroTCA design. Cost for a 2000 Line Unit system is $1000 for the custom design, $3000 for the PC design, and $2500 + 4*$200 = $3300 for the MicroTCA design. The total cost will be the volume of the Line Units each case (4 of them) times the cost per Line Unit, which varies only in the MicroTCA case as processor cards are added to handle more calls.
Fixed costs are $1M/month and start immediately in either of the cases.
The Gross selling price for the units is $2000 + $5 per line. ($3000 for 200 Line Unit, $12000 for 2000 Line Unit, etc.)
To determine the profit you will need to calculate the profit for each xN Line Unit product, and add the profit from the 4 products together.
Hint: Calculate the profit made in the first year, assuming the Embedded PC COTS solution, then the profit for the MicroTCA solution, then the cost savings/month of the build solution vs the better COTS solution, and then the breakeven point in months.
Choose what Avaya should do BUY COTS PC BUY COTS MicroTCA BUILD CUSTOM

Problems: 14.4, 14.23

14.4 The binary search algorithm has a worst case complexity of $O(\log_2 N)$ when N is the size of the search range. Provide the complexity analysis to show that this is correct.

14.23 A colleague has designed an embedded application that utilizes a timer that is supposed to interrupt every 5 ms. She is debugging the code and claims that she cannot determine whether the timer is working properly. Suggest a way she can instrument the code to enable her to determine whether the program is entering the interrupt service routine and, if so, at what interval.

Grading Rubric

1) [10 points]
   a) Correct Code - 3
   b) Log of state transitions – 3
   c) Hardware FSM – 2
2) [10 points]
   a) Correct OS Choice - 3
   b) Block Diagram – 3
   c) Correct ESA - 4
3) [14 points]
   a) Block Diagram - 2
   b) Architecture Choice – 4
   c) OS Selection – 2
   d) Processor Selection – 2
   e) Buy vs Build - 4
4) [3 points each] Problem question from the book.