Pomona College

Computer Science

Fall 2024: CSCI 181RT

Real-Time Systems in the Real World

Lecture 9

Tuesday, September 24, 2024
Edmunds Hall 105
2:45 PM - 4:00 PM

Professor Jennifer DesCombes

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Agenda

- Go Backs
- Discussion on Reading
- Initial Discussion on Semaphores
- Discussion on Semaphores
- Lab Overview
- Assignment
- Look Ahead
- Action Items

Go Backs

- General?
- Action Item Status
  - AI240910-2: Find recommended book on computer architecture.

Discussion on Reading - The Mythical Man Month

Initial Discussions of Semaphores

- The semaphore concept was invented by Dutch computer scientist **Edsger Dijkstra** in 1962 or 1963, when Dijkstra and his team were developing an operating system for the Electrologica X8. That system eventually became known as the *THE multiprogramming system*.
- Counting semaphores are equipped with two operations, historically denoted as P and V. Operation V increments the semaphore *S*, and operation P decrements it.

Origin and Uses of Semaphores

- Semaphore (literally 'apparatus for signaling'; from Ancient Greek σῆμα (sêma) 'mark, sign, token' and Greek -φόρος (-phóros) 'bearer, carrier')
- Railway semaphore signal is one of the earliest forms of fixed railway signals. This semaphore system involves signals that display their different indications to train drivers by changing the angle of inclination of a pivoted 'arm'. Semaphore signals were patented in the early 1840s by Joseph James Stevens, and soon became the most widely used form of mechanical signal.

Dijkstra's Semaphores

- Dijkstra's model (for the invention of the Semaphore) was the operation of railroads: consider a stretch of railroad in which there is a single track over which only one train at a time is allowed.
- The mnemonic significance of P and V is unclear to most of the world, as Dijkstra is Dutch. However, in the interest of true scholarship: P stands for prolagen, a made-up word derived from proberen te verlagen, which means try to decrease. V stands for verhogen, which means increase. This is discussed in one of Dijkstra's technical notes, EWD 74.
  - P stands for prolagen, a made-up word derived from proberen te verlagen, which means try to decrease
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Discussions of Semaphores

- POSIX (Portable Operating System Interface) is a set of standard operating system interfaces based on the Unix operating system.
- FreeRTOS - Provides a single and independent solution for many different architectures and development tools
- VxWorks is a real-time operating system (or RTOS) developed as proprietary software by Wind River Systems, a subsidiary of Aptiv

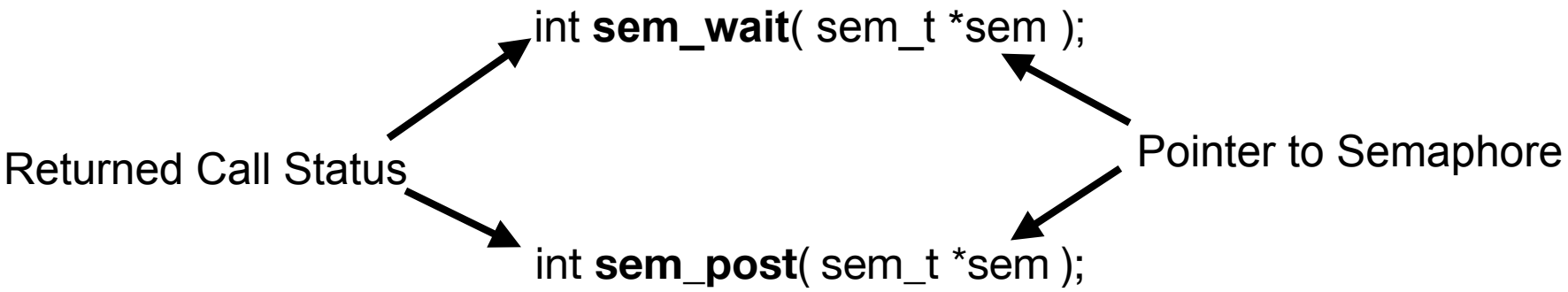
Discussions of Semaphores

- Semaphore Functions in Different RTOS

RTOS	P-Action	V-Action
POSIX	int **sem_wait**(sem_t *sem);	int **sem_post**(sem_t *sem);
FreeRTOS	pdStatus **xSemaphoreTake**(SemaphoreHandle_t xSemaphore, TickType_t xTicksToWait);	pdStatus **xSemaphoreGive**(SemaphoreHandle_t xSemaphore);
VxWorks	STATUS **semTake**(SEM_ID semId, int timeout);	STATUS **semGive**(SEM_ID semId);

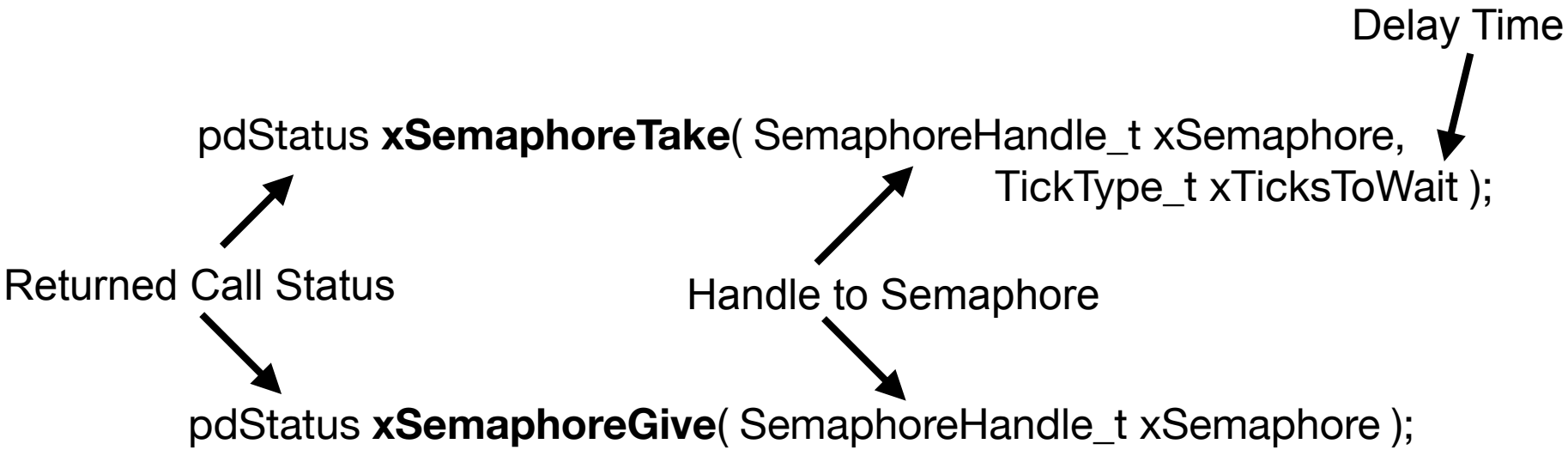
Discussions of Semaphores

- POSIX Semaphore Calls



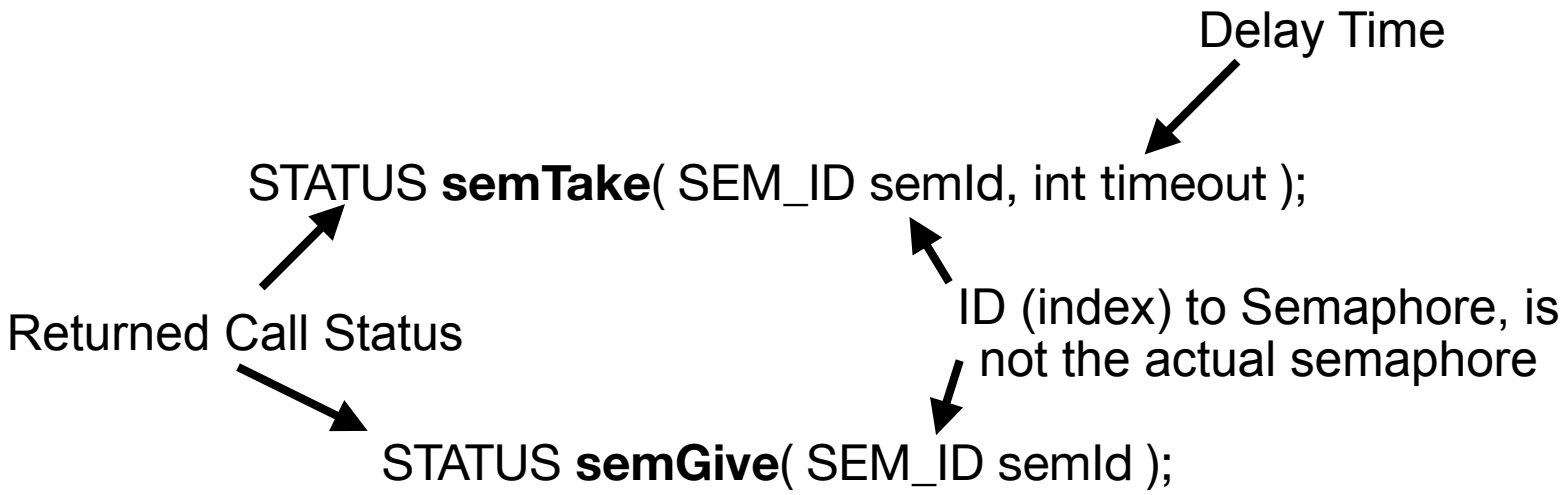
Discussions of Semaphores

- FreeRTOS Semaphore Calls



Discussions of Semaphores

- VxWorks Semaphore Calls



Operation of Semaphores - Wait / Take / P

- POSIX Extension [int sem_wait(sem_t *sem)]
- Use sema_wait() to block the calling thread until the count in the semaphore pointed to by sem becomes greater than zero, then atomically decrement it prior to returning to the calling thread.

```
// Prototype
int sem_wait(sem_t *sem);

sem_t mySem;
int myRet;

myRet = sem_wait( &mySem );     /* wait for semaphore */

// Return Values
//
// sem_wait() returns zero after completing successfully.
// Any other return value indicates that an error occurred.
```

Operation of Semaphores - Wait / Take / P

- POSIX Extension [int sem_wait(sem_t *sem)]
- Detailed Process Description
  - If the Semaphore value is greater than zero (> 0), then decrement the semaphore value and continue with the calling thread.
  - If the Semaphore value is equal to zero (= 0), then …
    - Halt the calling thread, it does not have permission to continue processing.
    - Once the Semaphore value is greater than zero (> 0, either via a sem_post or other action), decrement the semaphore and continue with the calling thread.
- P stands for prolagen, a made-up word derived from proberen te verlagen, which means ***try to decrease***

Operation of Semaphores - Post / Give / V

- POSIX Extension [int sem_post(sem_t *sem)]
- Use sem_post( ) to atomically increment the semaphore pointed to by sem. When any threads are blocked on the semaphore, one of them is unblocked.

```
// Prototype
int sem_post(sem_t *sem);

sem_t mySem;
int myRet;

myRet = sem_post( &mySem );     /* semaphore is posted */

// Return Values
//
// sem_post() returns zero after completing successfully.
// Any other return value indicates that an error occurred.
```

Operation of Semaphores - Post / Give / V

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Other Types of Semaphore Operations

- Counting Semaphores (we have been discussing this type)
- Binary Semaphores
- Locks and Mutexes
- Supervisor Mode / Interrupt Semaphore Calls
- Direct to Task Notifications

Lab 4 Goals

- Complete Any Remaining TE Measurements
- Complete PWM Software
- Design and Testing of a 5ms +/- 2ms Loop
- Design and Testing of a 3-cycle (15ms) Debounce

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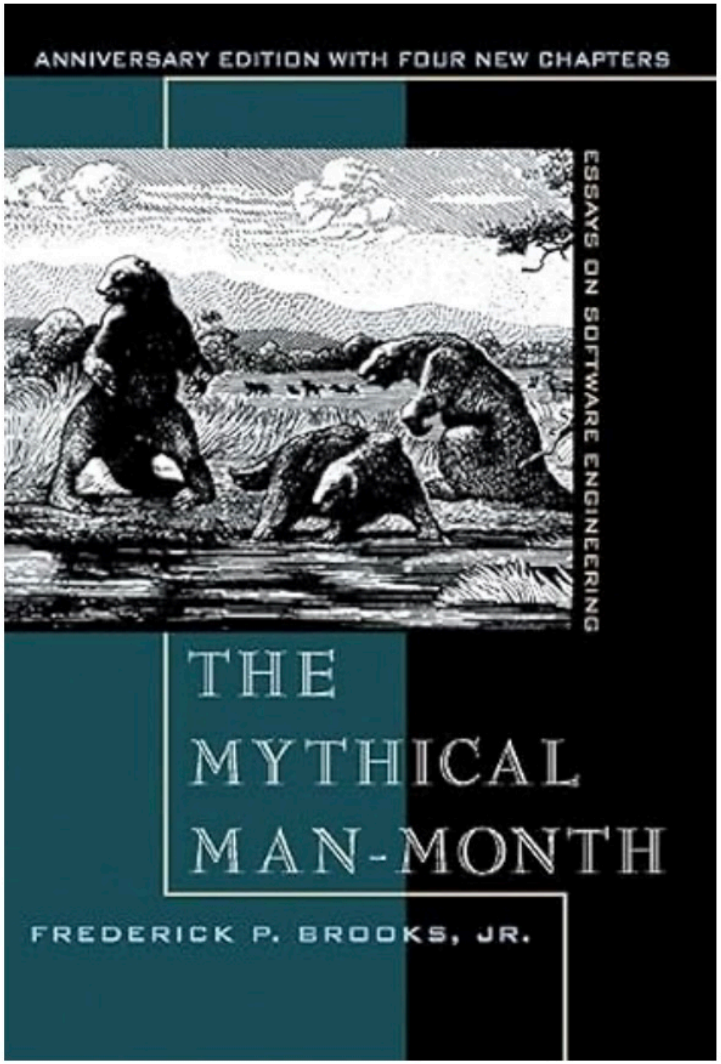
Assignment - Readings

- The Mythical Man Month
  - Chapter 3: The Surgical Team
- Send Me Discussion Topics by 10:00 on Thursday, Sep. 26, 2024.



Look Ahead

- Review of Reading
- Review of Lab 4
- More Discussions Semaphores and OS Control

References

- https://en.wikipedia.org/wiki/Semaphore
- https://en.wikipedia.org/wiki/Railway_semaphore_signal
- https://docs.oracle.com/cd/E19683-01/806-6867/6jfpgdcnj/index.html

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Action Items and Discussion

AI#:	Owner	Slide #	Document	Action