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Mutex Vs Binary Semaphore

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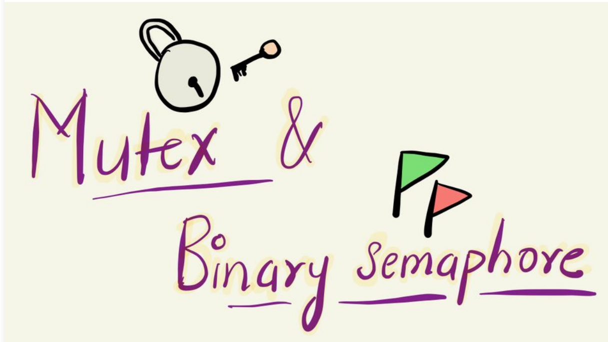

Before we even begin, let us be on the same page with some terms and conventions to be used in the rest of the explanation.

1. A > B > C in terms of execution priority!
2. Added means the process was added to the queue.
3. Exit would mean the process terminated.
4. A and C share a resource.
5. In our case, C acquires the resource first and A waits for C to release it!
6. A dark circle represents a shared resource being acquired.
7. The Hollow circle represents wanting to acquire the resource.
8. The scheduler is called every time a Process is added.

binary semaphore

Look at what happens when A is added (@ t=7) and B is executing. In the case of a semaphore being used between A and C - there is **priority inversion**!

A is a higher priority than B, but B gets to execute because B is a higher priority than C, and note that C has the resource that A depends on! Hence, A cannot be run anyway!

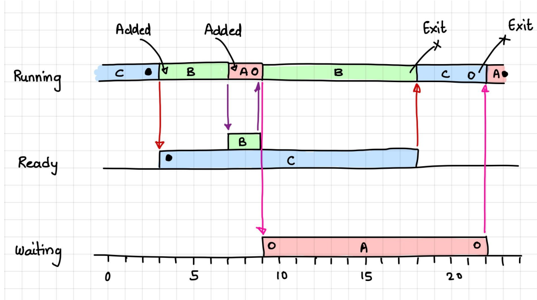

figure #1: Semaphore being used between A and C to access a shared resource.

```
Priority inversion is when a lower priority
process is scheduled over a higher priority
process.
```

Note how B gets to run while A is waiting! This is bad and the consequences can be really bad if we are talking about a real-time operating system.

How do we avoid a higher priority process not getting scheduled because the resource it needs is acquired and held by a much lower priority process?

One way is to increase the priority of the process that has the resource!

mutex

If a mutex is used. Note that the scheduler is aware of the dependency of A on C and C gets scheduled! Priority inversion is minimized.

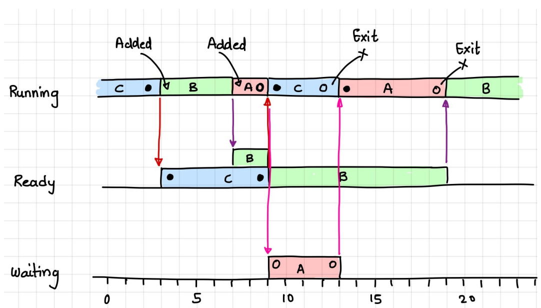

figure #2: Mutex is being used between A and C to access a shared resource.

A mutex will inherit the process priority and the scheduler can figure out if a higher priority process is blocked on a resource acquired and held by a lower priority process. Note in the figure above, as soon as A tries to acquire the resource held by C (@ t=9), the scheduler lets C run and then immediately schedules A after C has released the resource (@ t=13).

Notice the difference in the wait time compared to figure #1 where a semaphore is used.

mechanism: the key difference

There are many differences between semaphore and mutex, but the absolute major one is -

```
mutex has a notion of inheritance of the priority
of the process which minimizes priority inversion
while semaphore doesn't have that!
```

Note:

Be aware that the mutex being able to inherit the priority of a process is usually a configurable parameter. One needs to specifically program it to behave in ways I described.

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Authoritative Account

The mars rover would reset itself over and over. Turned out there was priority inversion resultant of the priority inherence parameter in the mutex left un-configured.

On the usage

A mutex is usually considered for cases where the access to a critical section/memory is to be synchronized.

```
A and B both need to work on the same memory
region. If A has the mutex on that shared memory,
B waits. If B has the mutex A waits!
```

A semaphore is to be used for signalling purposes only.

```
Process A cannot proceed until B has completed an
action. A waits for a signal from B. A and B use a
semaphore.

An embedded systems example for this can be - A
wants to turn on an LED only when B signals that a
button was pressed. A can then wait on a semaphore
that B can give when B detects a button press.
```

References

Hands-On RTOS with Microcontrollers | Packt

Build a strong foundation in designi

Packt • Brian Amos

Refer to "4. Task Signaling and Communication Mechanisms"

Difference between binary semaphore and mutex

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