Lucerne University of
Applied Sciences and Arts

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Technik & Architektur

Reentrancy, and all the other things…

“Everything you were afraid to ask …”

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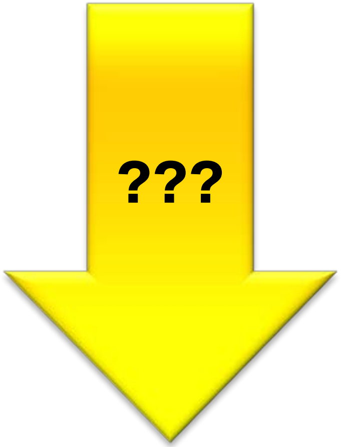
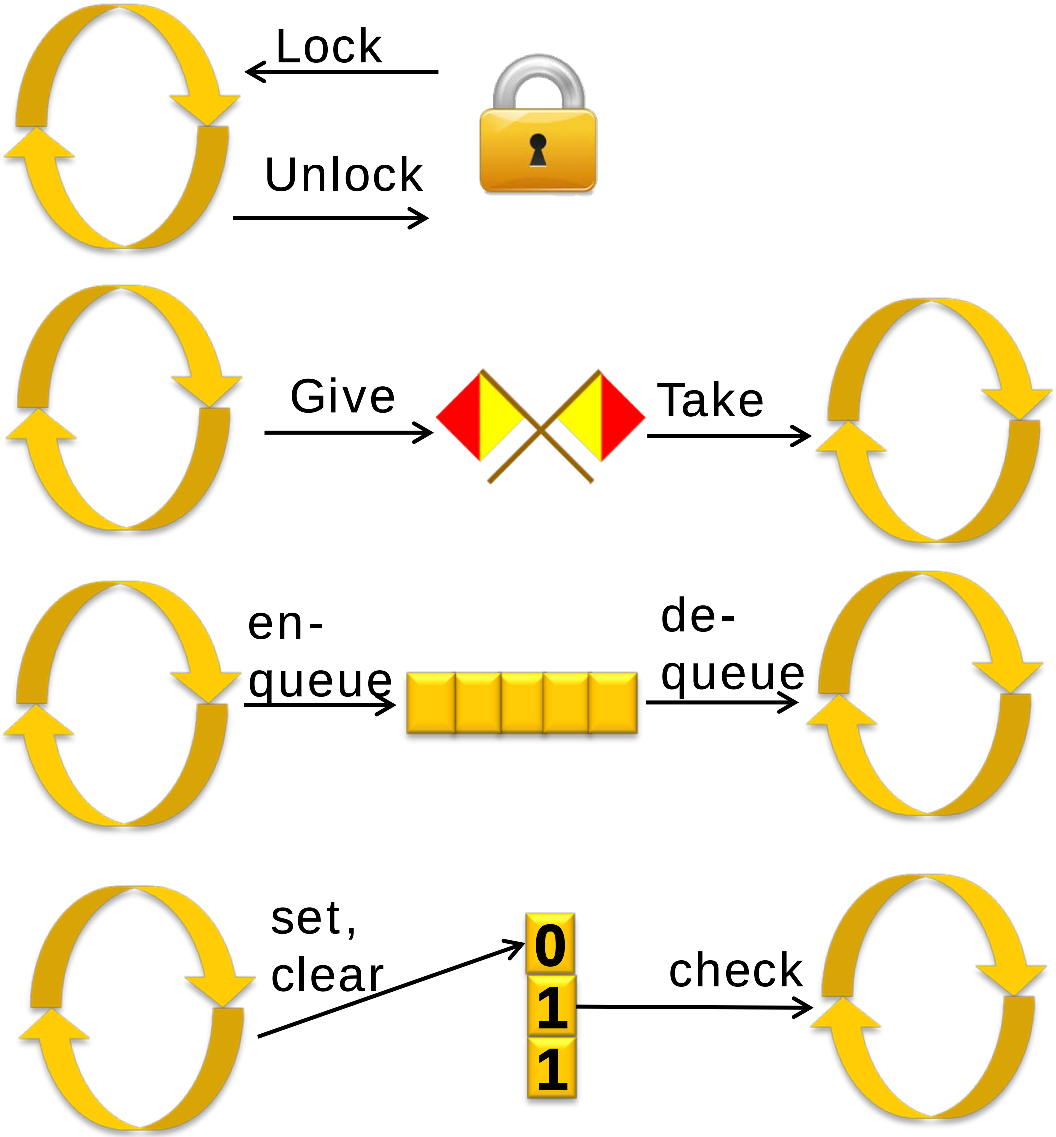
Learning Goals

- Reentrancy
- Critical Section
- Thread Safe
- Semaphore
- Mutex
- Thread Safe
- FreeRTOS Implementation



Synchronization Primitives



- Mutex
  - mutual exclusion
- Semaphore
  - Sync, Notify
- Queues
  - Communication
- Flags
  - Synchronization

Reentrancy

Behaviour of a programm

- Attribute of a program or subroutine
- Can be interrupted in the middle of execution
    - thread/task
    - interrupt
- **Reentrant**: Can be safely called (re-entered) by other thread/task or interrupt

it's not reentrant, because can not interrupt the sequenz of this code

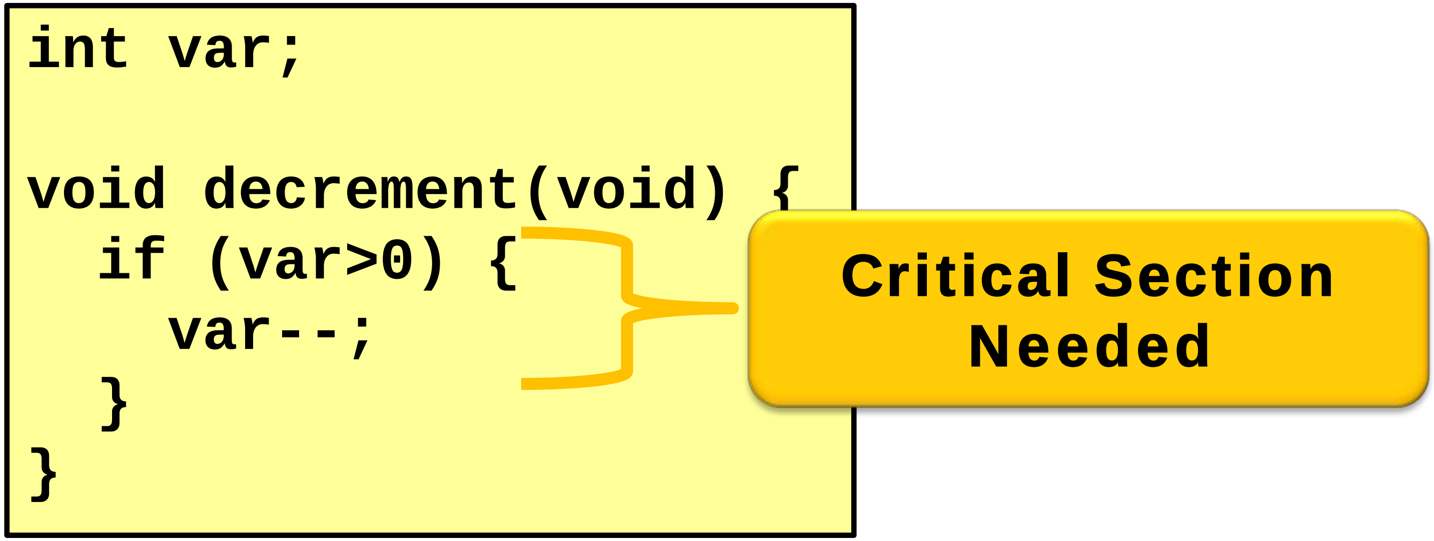
```
int var;

void decrement(void) {
  if (var>0) {
    var--;
  }
}
```

Critical Section

- Sequence of code
- Protected against concurrent execution
- Only **one** program flow is inside critical section
- Used to protect access to shared resource

IMPLEMENTATION with: Disable Interrupts, EnterCritical(),..



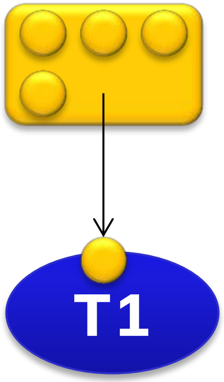
```
int var;

void decrement(void) {
  if (var>0) {
    var--;
  }
}
```

Critical Section Needed

Semaphore

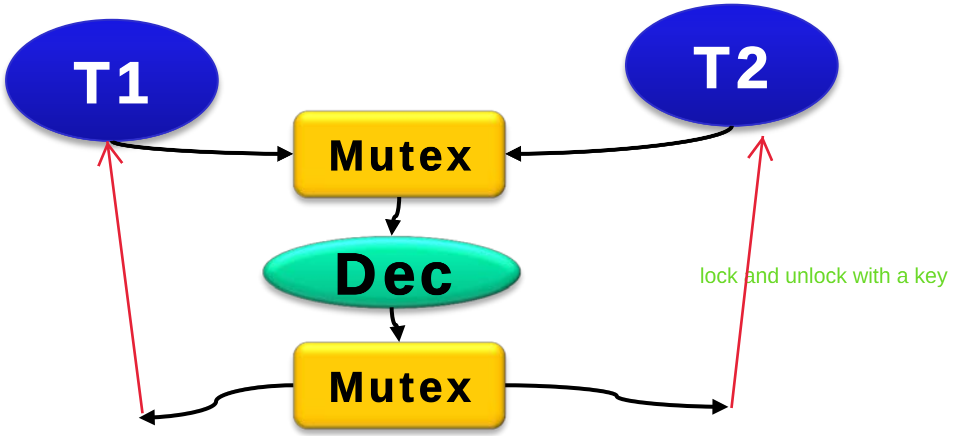
- Variable or abstract data type
- Used for synchronization
- Used to control access to a shared resource
  - By tasks, threads and interrupts
- **Can** be used to implement a Critical Section



- Binary and Counting semaphore
- Example **counting** semaphore
  - N Study Rooms
  - Students need to request and release room at front desk
  - Front desk decreases/increases number of available rooms
  - ➔ how many, not which room

Mutual Exclusion, Mutex

- Mutual Exclusion: Property of concurrency control to establish a critical section
- Establishes mutual exclusive execution of program sequence
- **Mutex**: abstract data type used for Mutual Exclusion
- Used for
  - Synchronization
  - Preventing race conditions



Thread Safe

- Attribute of a program or subroutine
- Guarantees safe execution by multiple **threads**
- Closely related to Reentrancy
- **Not** the same as Reentrancy
    - Does not include the presence of interrupts
    - Thread might use Mutex to be thread-save
    - Interrupt could run into Mutex (starves/blocks)
    - ➔ not safe!

in reentrancy we consider interrupts as well

```
int var;

void decrement(void) {
  LockMutex();
  if (var>0) {
    var--;
  }
  ReleaseMutex();
}
```

typically we have a LockMutex() from ISR and a LockMutex() like that

Implementation in FreeRTOS

- Implemented as Queues with no data

- **Semaphore** does not implement priority inheritance
  - Binary, Counting binary (one flag one use)
  - Must not be returned
  - Used for critical sections and message passing

- **Mutex**
  - Binary (normal) and Recursive
  - Implements **priority inheritance**
  - MUST be returned
  - Used for critical sections

Quiz:
taskDISABLE_INTERRUPTS() -> just disable the interrupts, not designed for netsting, no context switch
taskExitCritical -> inside the nested section, allowed in a nested way
vTaskSuspendAll() -> stopps the scheduler from, context switch, really disable the scheduler, all the rest is running (lika a car in front of a red trafficlight)

How are context switch handled? What can trigger a context-switch -> interrupt Systick, yield(), API call (vTaskDelay()
Task context switch! -> ABKLÄREN
BASEPRI (M4) & PRIMASK (on our M0)
operating system uses taskExitCritical

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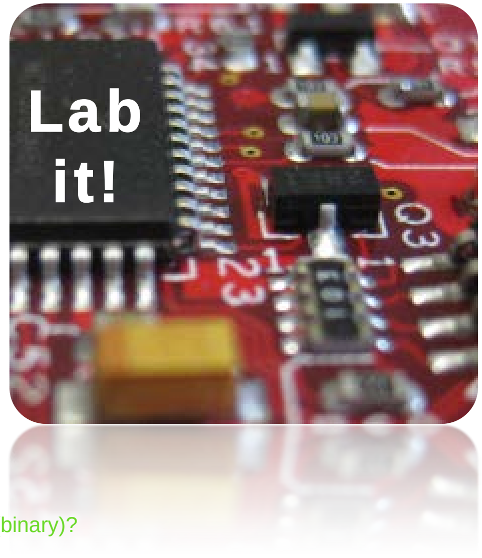
Discussion: File System

- Discuss in Groups
  - File System, SPI bus to memory/SD Card
  - Multiple task using file system
  - open/write/read/close file(s)
- Identify Needs
  - Reentrancy, Critical Section,
  - Semaphore, Mutex



Needs to be protected with a Mutex (binary)?

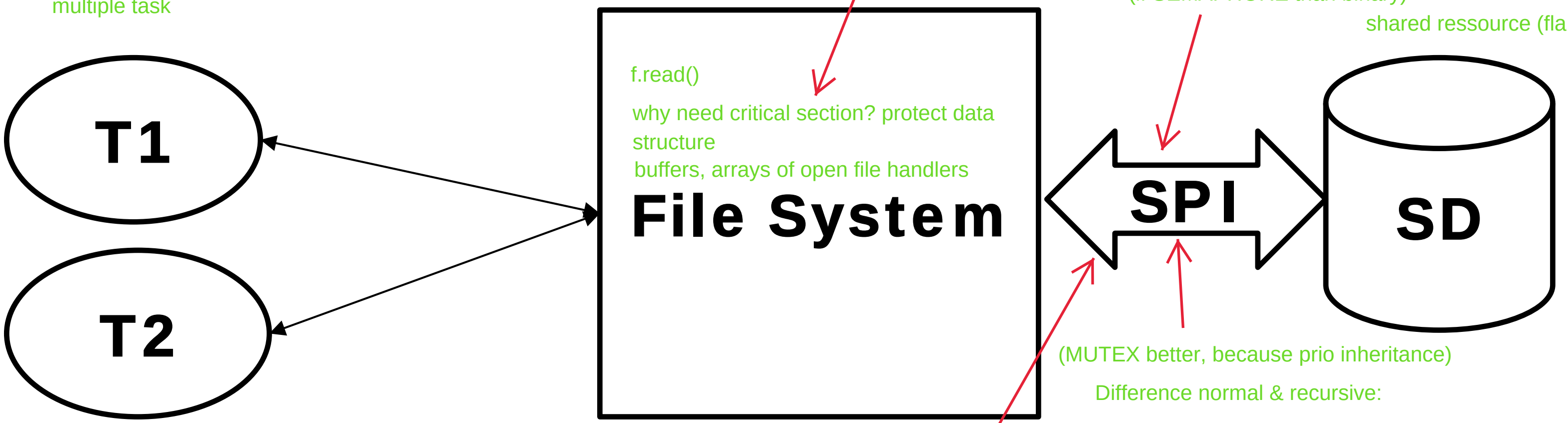
binary mutex is a bit easier to handle

read, write from a file

(if SEMAPHORE than binary)

shared ressource (flash)

multiple task



f.read()

why need critical section? protect data structure

buffers, arrays of open file handlers

(MUTEX better, because prio inheritance)

Difference normal & recursive:

mutex on File System

T3

in FileSystem sind die Daten shared, wenn nun diese einzeln bei T1 und T2 sind braucht es keine globale Daten und deshalb keine Critcal Section im File-System. (Wenn z.B. T3 für Sensoren auf den SPI zugreiffen will...)