Interrupt Handling

Background

In this article, we will mainly focus on how to handle conflict without RTOS on embedded systems

Shared-Data Problem

For non-atomic operation, context switch may happen:

- main to interrupt
- interrupt 1 to interrupt 2

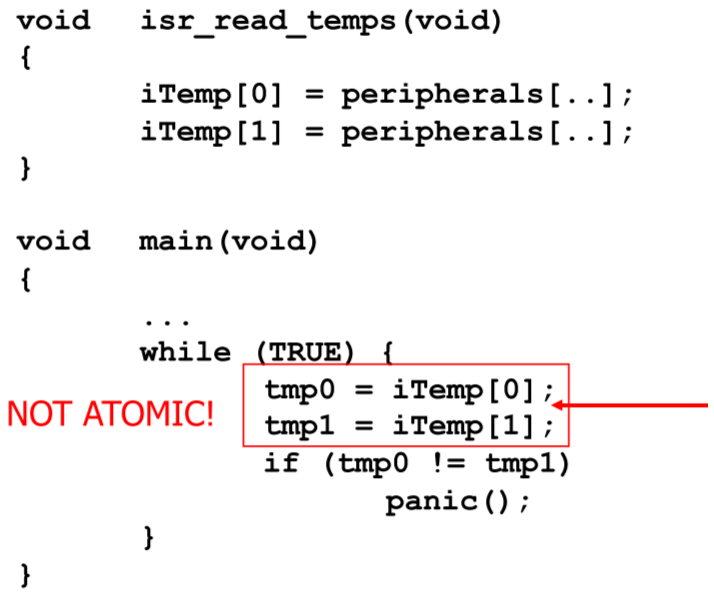
they may use the same data/memory, when interrupt happen:

- 首先，将断点处的**PC**值（即下一条应执行指令的地址）推入堆栈保留下来，这称为保护断点，由硬件自动执行。
- 然后，将有关的寄存器内容和标志位状态推入堆栈保留下来，这称为保护现场，由用户自己编程完成。

However, the memory is not always be protected, so there may be conflict

Solutions

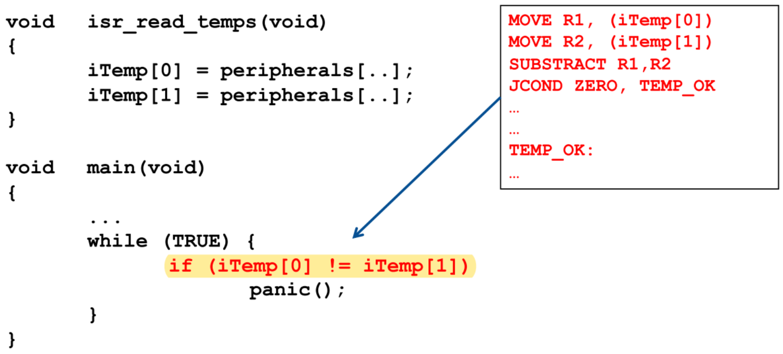
1. Change to Atomic Operations



```
void   isr_read_temps(void)
{
        iTemp[0] = peripherals[..];
        iTemp[1] = peripherals[..];
}

void   main(void)
{
        ...
        while (TRUE) {
           tmp0 = iTemp[0];
           tmp1 = iTemp[1];
           if (tmp0 != tmp1)
                panic();
        }
}
```

NOT ATOMIC!



```
void   isr_read_temps(void)
{
        iTemp[0] = peripherals[..];
        iTemp[1] = peripherals[..];
}

void   main(void)
{
        ...
        while (TRUE) {
           if (iTemp[0] != iTemp[1])
                panic();
        }
}
```

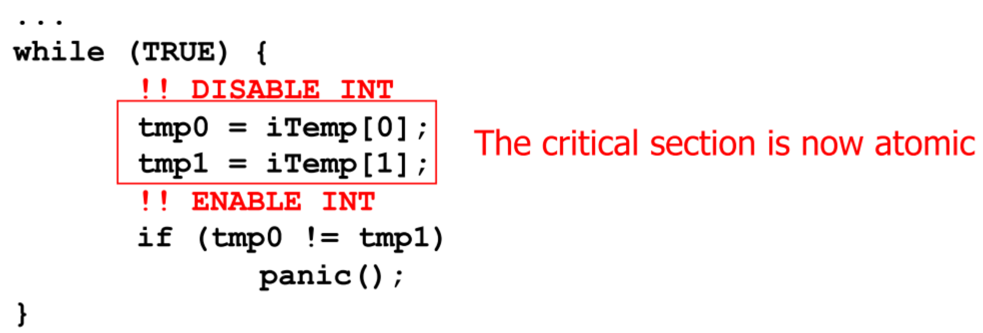
```
MOVE R1, (iTemp[0])
MOVE R2, (iTemp[1])
SUBSTRACT R1,R2
JCOND ZERO, TEMP_OK
…
…
TEMP_OK:
…
```

Notice: The **atomic** should be atomic at least on assembly code layer, which means, a single C words may not be atomic

2. Disable interrupts (transform it into atomic)

Disable interrupts for the ISRs that share the data, two general rules:

- keep the critical sections SHORT
- keep the ISRs SHORT (to minimize latency)



```
...
while (TRUE) {
        !! DISABLE INT
        tmp0 = iTemp[0];
        tmp1 = iTemp[1];
        !! ENABLE INT
        if (tmp0 != tmp1)
                panic();
}
```

The critical section is now atomic

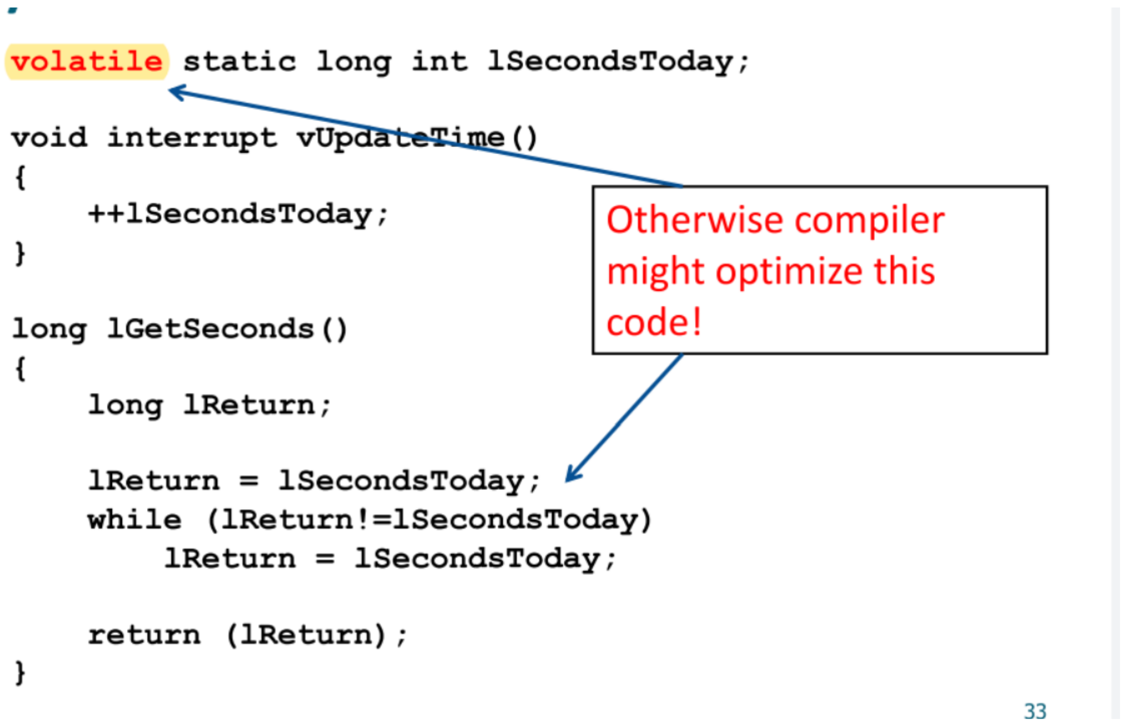
Volatile

> *https://blog.csdn.net/yanbober/article/details/8275341*

volatile的本意是“易变的” 由于访问寄存器的速度要快过RAM,所以编译器一般都会作减少存取外部RAM的优化，但有可能会读脏数据。当要求使用volatile 声明的变量的值的时候，系统总是重新从它所在的内存读取数据，即使它前面的指令刚刚从该处读取过数据。而且读取的数据立刻被保存。

Classical Scenarios：

1. 并行设备的硬件寄存器（如：状态寄存器）
2. 一个中断服务子程序中会访问到的非自动变量(Non-automatic variables)
3. 线程应用中被几个任务共享的变量



```
volatile static long int lSecondsToday;

void interrupt vUpdateTime()
{
    ++lSecondsToday;
}

long lGetSeconds()
{
    long lReturn;

    lReturn = lSecondsToday;
    while (lReturn!=lSecondsToday)
        lReturn = lSecondsToday;

    return (lReturn);
}
```

Otherwise compiler might optimize this code!

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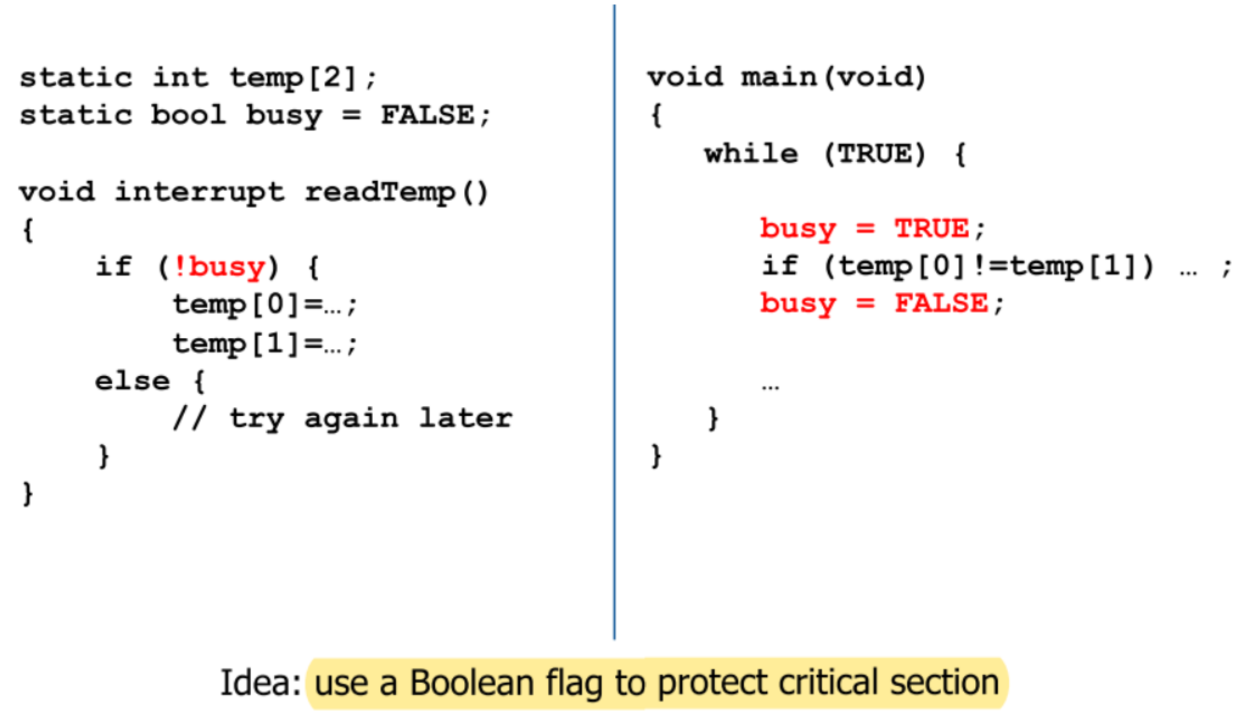
3. Alternative to disable()

3.1. Artificial Mutex and Semaphore

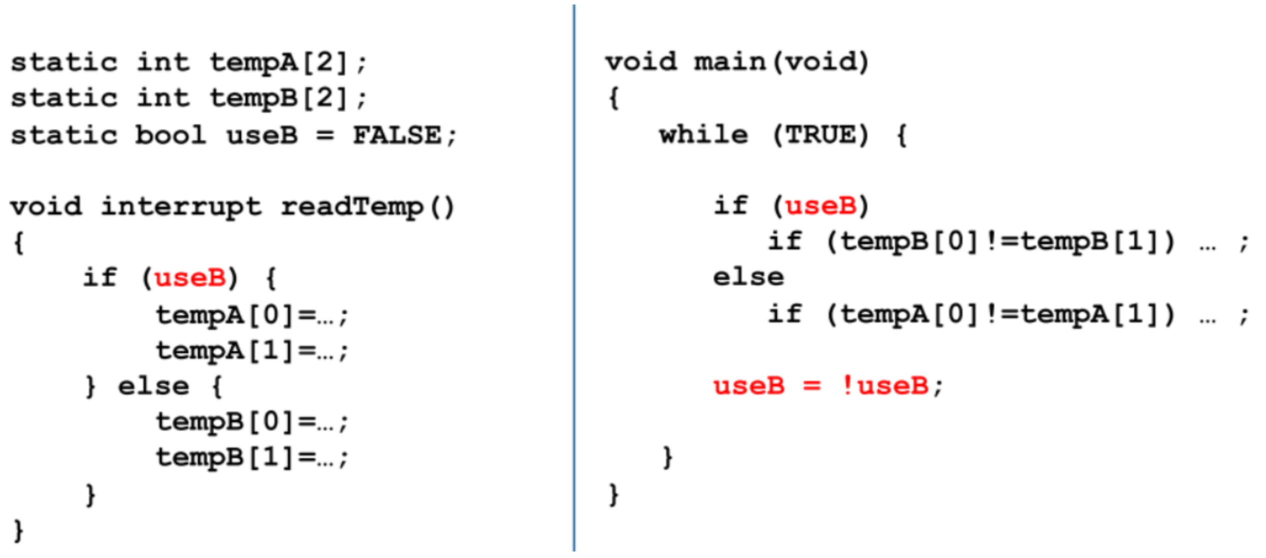


```
static int temp[2];
static bool busy = FALSE;

void interrupt readTemp()
{
    if (!busy) {
        temp[0]=…;
        temp[1]=…;
    else {
        // try again later
    }
}
```

```
void main(void)
{
   while (TRUE) {

      busy = TRUE;
      if (temp[0]!=temp[1]) … ;
      busy = FALSE;

      …
   }
}
```

Idea: use a Boolean flag to protect critical section

3.2. By alternating data buffers



```
static int tempA[2];
static int tempB[2];
static bool useB = FALSE;

void interrupt readTemp()
{
    if (useB) {
        tempA[0]=…;
        tempA[1]=…;
    } else {
        tempB[0]=…;
        tempB[1]=…;
    }
}
```

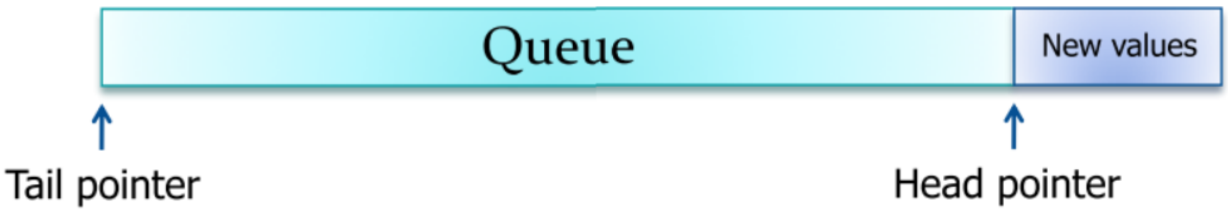
```
void main(void)
{
   while (TRUE) {

      if (useB)
         if (tempB[0]!=tempB[1]) … ;
      else
         if (tempA[0]!=tempA[1]) … ;

      useB = !useB;

   }
}
```

3.3. By using queues

Operation

- Interrupt adds **readings to the queue** (modifies the head pointer)

- Main code **extracts readings** from the queue (modifies the tail pointer)



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