Timers and event handling

- microkernels often require procedures to be activated at periodic intervals
  - minute, second and hour hand of a graphic clock
  - computer network protocols implementing timeouts
  - implementing a dead mans handle

Implementation of timers and events

- microkernel may require more than one procedure to be timer driven at any one time

- consider a lunar lander monitoring various sensors as it descends
  - altitude reading every second
  - fuel monitoring every 2 seconds
  - oxygen monitoring every 5 seconds
  - general state information transmitted every 10 seconds back to earth

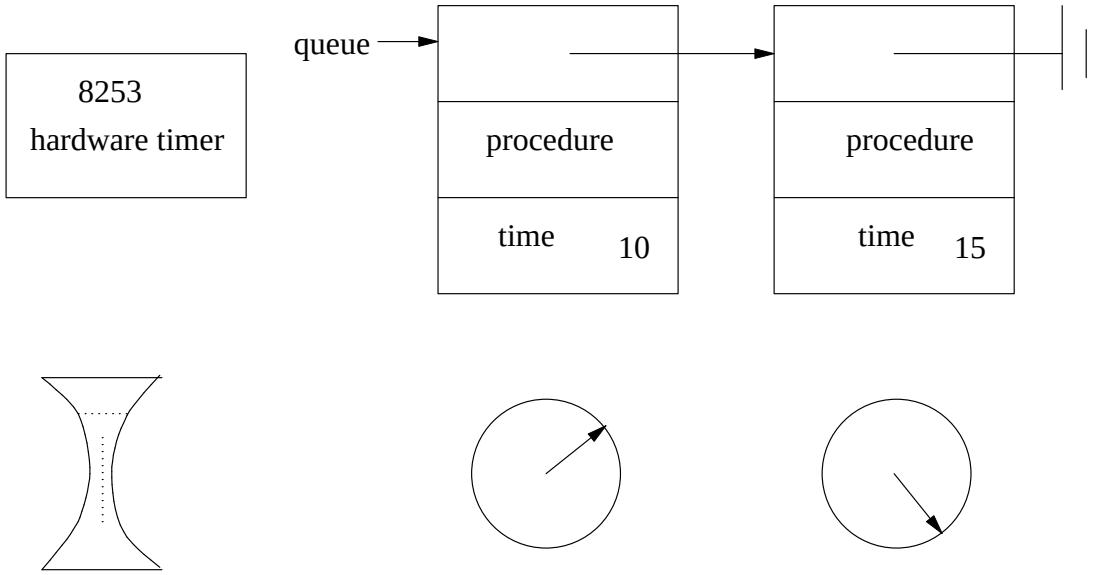
Implementation of timers and events

- not always possible to have multiple hardware timers
  - even if there are multiple hardware timers we might need more...
- how can we service many timer procedures with one hardware timer facility?
- most systems will have a hardware timer facility similar to the 8253 as discussed in the earlier part of this course

Solution

- maintain a list of outstanding timer events or procedures which are due to be serviced in the future
  - this list is consumed by a device driver
  - the device driver is activated by the hardware timer interrupt

Solution



- we construct many *virtual timers* through software

Functional interface

- there are many different procedural interfaces which can map onto virtual timers
- these range from
  - activating a procedure in *n* time units time
- to
  - suspending a process for *n* time units
- the interested reader should consult
  - Don Libes, Obfuscated C and Other Mysteries October 16, 1992, ISBN-10: 0471578053, ISBN-13: 978-0471578055, Edition: 1
  - Andrew Tanenbaum, Operating Systems Design and Implementation, P155-157, Edition 1, 1987

TimerHandler module

- provides a simple set of timer functions microkernel
- provides the Executive with a basic round robin scheduler
- sets a timer device to issue an interrupt 100 times per second as defined by this constant in TimerHandler.h
-

```
#define TimerHandler_TicksPerSecond  100

typedef void Event;
```

TimerHandler

- exports an opaque or hidden type, `Event`, upon which all timer actions are held

- ```
  /*
   *  GetTicks - returns the number of ticks since boottime.
   */

  extern int TimerHandler_GetTicks (void);
  ```
  ```

TimerHandler

```
/*
 *  Sleep - suspends the current process for a time, t.
 *          The time is measured in ticks.
 */

extern void TimerHandler_Sleep (int t);
```

ArmEvent

- initializes an event, e, to occur at time, t
  - the time, t, is measured in ticks
  - the event is NOT placed onto the event queue

```
extern Event *TimerHandler_ArmEvent (int t);
```

WaitOn

- places event, `e`, onto the event queue and then the calling process suspends
  - it is resumed up by either the event expiring or the event, `e`, being cancelled
  - `TRUE` is returned if the event was cancelled
  - `FALSE` is returned if the event expires

```
extern int TimerHandler_WaitOn (Event *e);
```

Cancel

- cancels the event, `e`, on the event queue and makes the appropriate process runnable again
  - `TRUE` is returned if the event was cancelled
  - `FALSE` is returned is the event was not found or no process was waiting on this event.

```
extern int TimerHandler_Cancel (Event *e);
```

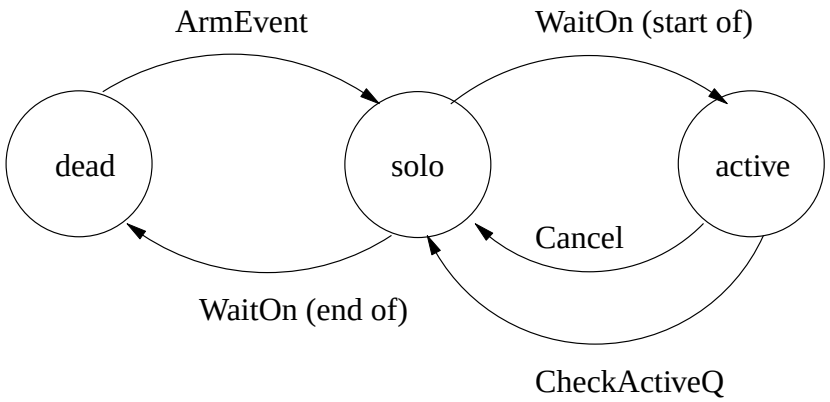
ReArmEvent

- removes an event, e, from the event queue.
  - a new time is given to this event and it is then re-inserted onto the event queue in the correct place
  - `TRUE` is returned if this occurred
  - `FALSE` is returned if the event was not found

```
extern int TimerHandler_ReArmEvent (Event *e, int t);
```

TimerHandler.c

- state transition diagram for the events within this module can be described as follows:



KeyboardLEDs Module

- used to switch
  - caps lock, scroll lock and num lock LEDs on and off
- this code turns the scroll LED on
- ```
  KeyBoardLEDs_SwitchScroll(TRUE);
  ```
- and this code turns the scroll LED off
- ```
  KeyBoardLEDs_SwitchScroll(FALSE);
  ```

How might a microkernel use TimerHandler?

- here is a simple example of use for the TimerHandler
- two processes are created and sleep for 10 and 60 seconds, then print a message
- the process sleeping for 60 seconds can be woken up before the 60 second have expired

TenSeconds

```
void TenSeconds (void)
{
  OnOrOff OldInts = SYSTEM_TurnInterrupts(On);

  while (TRUE) {
    TimerHandler_Sleep(10*TimerHandler_TicksPerSecond);
    Debug_DebugString("..10..");
  }
}
```

SixtySeconds

```
static Event *timeout;

void SixtySeconds (void)
{
  OnOrOff OldInts = SYSTEM_TurnInterrupts(On);

  while (TRUE) {
    timeout = TimerHandler_ArmEvent(60*TicksPerSecond);
    if (TimerHandler_WaitOn(timeout))
      Debug_DebugString("..been cancelled..");
    else
      Debug_DebugString("..60 seconds alarm..");
  }
}
```

Cancelling an event

- is achieved by another process executing this:

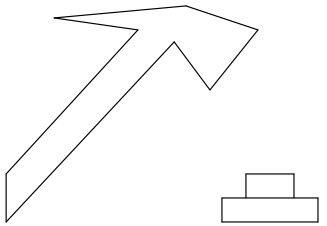
```
if (TimerHandler_Cancel(timeout))
  Debug_DebugString("have cancelled timeout");
else
  Debug_DebugString("not cancelled - expired");
```

How might the timerhandler module be used?

- a watchdog timer is often present in a microkernel
- consider a network router which spans two 802.3 subnets
- or consider some important monitoring software for a chemical plant
  - it must be operational all the time
- admit there *might* be a bug in the system which under some conditions will cause it to hang/crash!

How might the timerhandler module be used?

- one solution is to build a watchdog reset function into the software so that if it crashes the system will reboot



reset button

Example: code for hardware watchdog

```
void preventWatchDog (void)
{
   int cancelled;  /* not really used */
   Event *e;

   while (TRUE) {
      e = TimerHandler_ArmEvent(halfSecond) ;
      cancelled = TimerHandler_WaitOn(e);
      rechargeWatchDog();
   }
}
```

- requires additional circuitary to allow the system to charge up a capacitor
  - when it dischanges it resets the microprocessor

Software watchdog

- debugging technique which allows a program to place messages into a debugging buffer
  - the dead mans handle will activate if no message is dumped within 10 seconds
  - presumably because the system has gone wrong!
  - though not wrong enough to blow away the dead mans handle..

Example: code for dead mans handle

```
static Event *e;

void deadMansHandle (void)
{
   OnOrOff ToOldState = SYSTEM_TurnInterrupts(Off);

   while (TRUE) {
      e = TimerHandler_ArmEvent(10*TimerHandler_TicksPerSecond);
      if (! TimerHandler_WaitOn (e))
         dumpDebugBuffer();
   }
}

void message (char *s)
{
   OnOrOff ToOldState = SYSTEM_TurnInterrupts(Off);

   if (! TimerHandler_ReArmEvent(e, 10*TimerHandler_TicksPerSecond))
      dumpDebugBuffer();
   addMessageToBuffer(s);
   ToOldState = SYSTEM_TurnInterrupts(ToOldState);
}
```