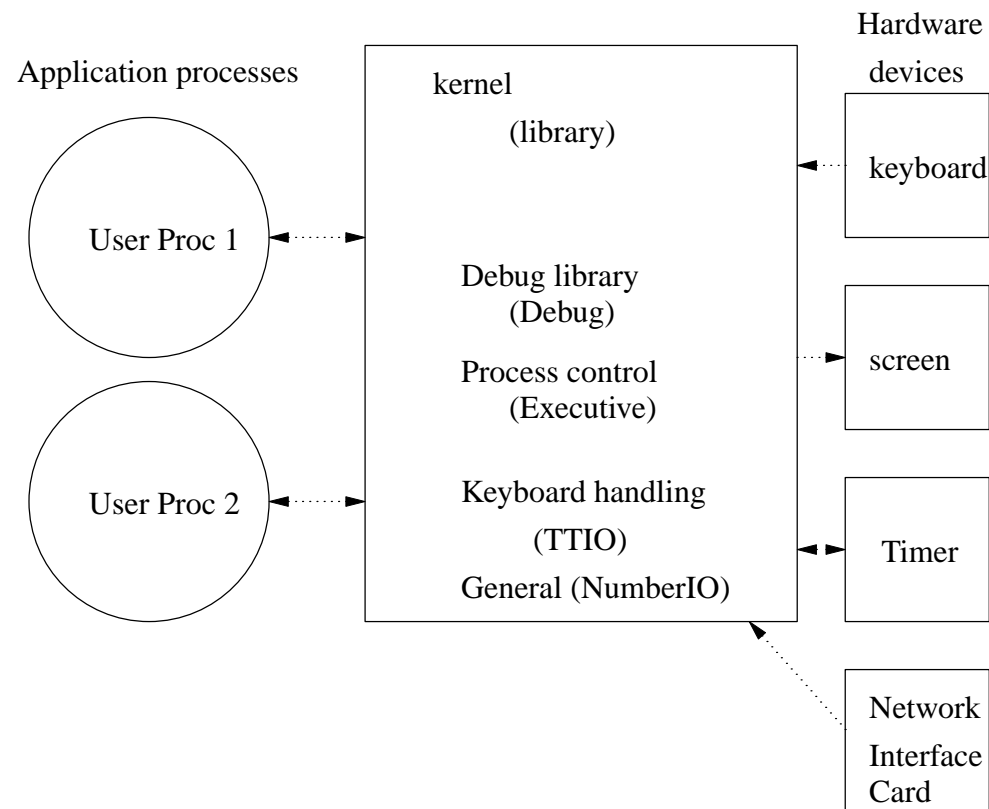


Inside the microkernel

- what are the software components of a microkernel?
- typical microkernel might consist of:



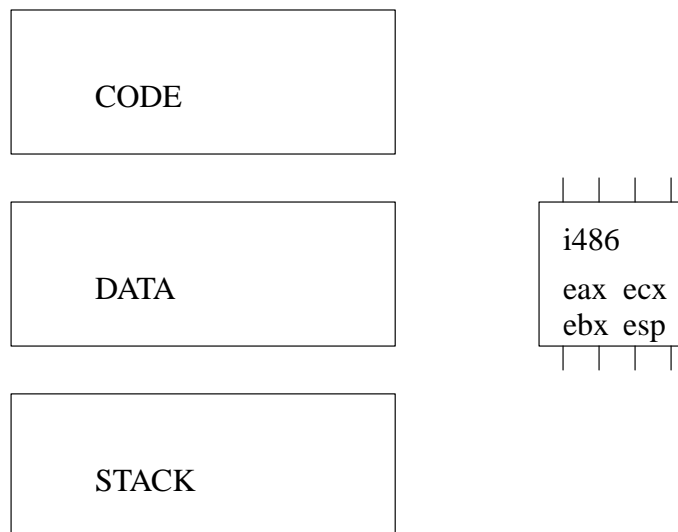
A tiny example of two simple processes in the microkernel

```
void Process1 (void)
{
    while (TRUE) {
        WaitForACharacter();
        PutCharacterIntoBuffer();
    }
}

void Process2 (void)
{
    while (TRUE) {
        WaitForInterrupt();
        ServiceDevice();
    }
}
```

High level facilities for low level control

- look at a conventional program running in memory (single program running on a computer)



High level facilities for low level control

- four main components
 - code
 - data
 - stack
 - processor registers (volatiles)

Concurrency

- suppose we want to run two programs concurrently?
 - we could have two programs in memory. (Two stacks, code, data and two copies of a volatile environment)
 - on a single processor computer we can achieve apparent concurrency by running a fraction of the first program and then run a fraction of the second.
 - if we repeat this then apparent concurrency will be achieved
 - in operating systems and microkernels multiple concurrent programs are often called *processes*

Concurrency

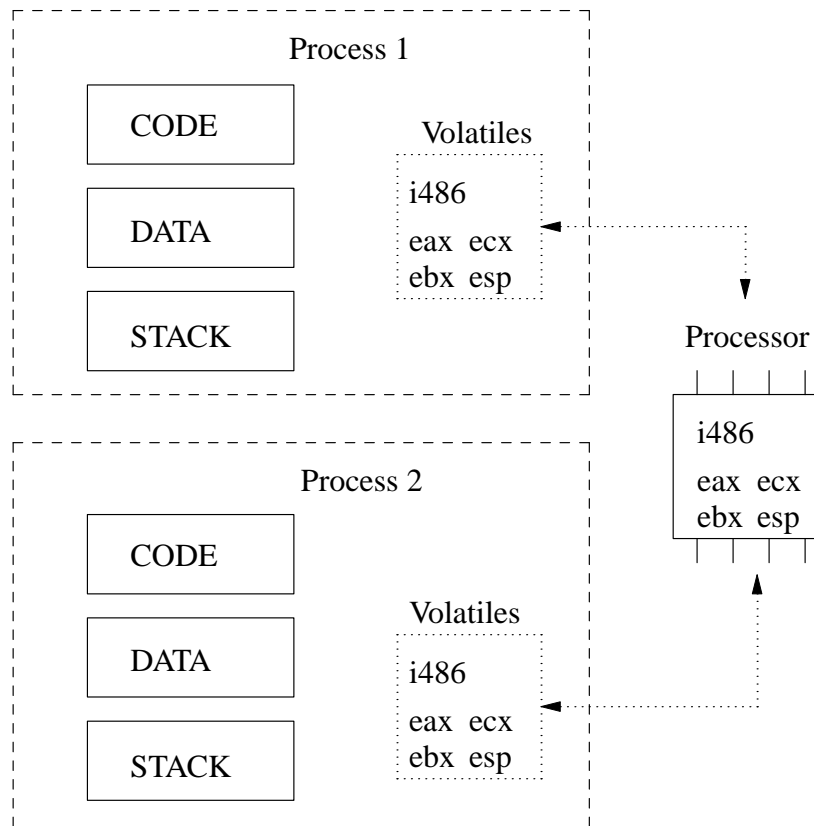
- what technical problems need to be solved so achieve apparent concurrency?
 - require a mechanism to switch from one process to another

- remember our computer has one processor but needs to run multiple processes
 - the information about a process is contained within the volatiles (or simply: processor registers)

Implementing concurrency

- we can switch from one process 1 to process 2 by:
 - copying the current volatiles from the processor into an area of memory dedicated to process 1
 - now copying some new volatiles from memory dedicated to process 2 into the processor registers

Implementing concurrency



Implementing concurrency

- this operation is call a context switch (as the processors context is switched from process 1 to process 2)
 - by context switching we have a completely new set of register values inside the processor
 - so on the i486 we would change **all** the registers. Some of which include: EAX, EBX, ECX, EDX, ESP and flags.
 - note that by changing the ESP register (stack pointer) we have effectively changed stack

Thread primitives in the microkernel

- the previous description of context switching is very low level
- in a high level language it is desirable to avoid the assembler language details as far as possible
 - NEWPROCESS
 - TRANSFER
 - IOTRANSFER
- **it is possible to build a microkernel (including context switching) using these primitives without having to descend into assembly language**
- see the module [SYSTEM](http://floppsie.comp.glam.ac.uk/Glamorgan/gaius/operating/luk/system.h.html) (<http://floppsie.comp.glam.ac.uk/Glamorgan/gaius/operating/luk/system.h.html>) in our microkernel

Thread primitives in the microkernel

- in fact the thread or concurrent basic building blocks we have examined were defined in the Modula-2 PIM2 library devised by N. Wirth
- we retain these primitives in the microkernel since they are simple, very elegant and sufficient for our needs

Thread primitives in the microkernel

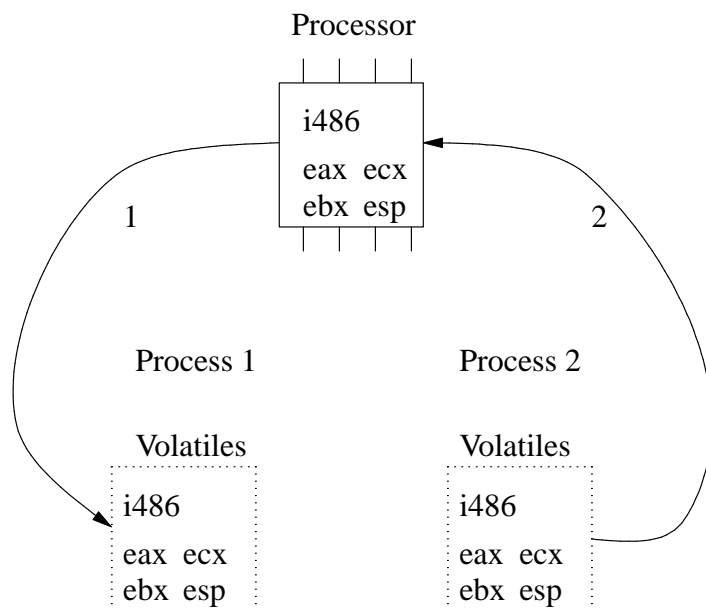
- the primitives NEWPROCESS, TRANSFER and IOTRANSFER are concerned with copying *Volatiles between process and processor*
- the procedure TRANSFER transfers control from one process to another process
- these primitives are *low level* primitives
 - later on we will build higher level process control functions

TRANSFER

- the C definition is:

```
extern void SYSTEM_TRANSFER(void **p1, void *p2);
```

- and it performs the following action:



TRANSFER

- (examine the **SYSTEM** `<http://floppsie.comp.glam.ac.uk/Glamorgan/gaius/operating/luk/system.h.html>` module in the microkernel)

IOTRANSFER

- the procedure IOTRANSFER allows process contexts to be changed when an interrupt occurs

- its function can be explained in two stages
 - firstly it transfers control from one process to another process (in exactly the same way as TRANSFER)
 - secondly when an interrupt occurs the processor is context switched back to the original process

Creating a process using SYSTEM

- a mechanism is needed to initially create a process
- the Modula-2 library defined the procedure NEWPROCESS as

```
extern void SYSTEM_NEWPROCESS (void (*p)(void), void *a,  
                               unsigned long n, void **new);
```

- p is a pointer to a function.
 - this function will be turned into a process
 - a the start address of the new processes stack
 - n the size in bytes of the stack
 - new a variable of type PROCESS which will contain the volatiles of the new process

Creating processes in the microkernel

- concurrent applications inside the microkernel will *always* use the module `Executive` as it presents a high level interface to thread/process manipulation
- but `Executive` has to create processes using the primitives seen on the previous slides

Creating processes in the microkernel

- examine the function `InitProcess` in the module [Executive](http://floppsie.comp.glam.ac.uk/Glamorgan/gaius/operating/luk/executive.h.html)
(<http://floppsie.comp.glam.ac.uk/Glamorgan/gaius/operating/luk/executive.h.html>)

Creating processes in the microkernel

```
Descriptor *Executive_InitProcess (void (*p)(void), unsigned int StackSize,  
                                   char *Name, unsigned int Name_High)  
{  
    Descriptor *d;  
    OnOrOff ToOldState;  
  
    ToOldState = SYSTEM_TurnInterrupts(Off);  
    SysStorage_ALLOCATE((void **) &d,  
                        sizeof(Descriptor));  
    d->Size = StackSize;  
  
    SysStorage_ALLOCATE((void **) &d->Start,  
                        StackSize);  
    SYSTEM_NEWPROCESS(p, d->Start,  
                     StackSize, &d->Volatiles);  
    ...  
}
```

The Module Executive

- the primitives: TRANSFER, IOTRANSFER and NEWPROCESS are present in the SYSTEM module
 - they are built from a high level language and assembly language
- the module Executive sits on top of SYSTEM and presents a higher level of abstraction
- examine the Executive source code in C (<http://floppsie.comp.glam.ac.uk/Glamorgan/gaius/operating/luk/executive.h.html>) and the equivalent C file in `luk-version/lab/executive/Executive.c`