Federated Systems

Lecture 8
Operating System Structure
Rich Martin
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Today

Kernel Structure for Federated Systems

- Unix, Thompson and Ritchie
- QNX
- Inferno

OS architecture and design

- What are the key abstractions of these OSes
- How do they map to real machine resources?
- What are the performance and fault characteristics of these designs?

Today (cont)

Common Themes

- Cooperating processes
  - How to connect them together
  - Name spaces to resource mappings
- OS structures
  - Processes, messages, namespaces
  - Mapping to a federated architecture

Unix

Abstractions

- Processes
- Pipes
- Hierarchical namespaces (Multics lite)
- Virtual memory (swapping)
- Unstructured files
- No special programs
- No special languages

Process

- address space
  - Segments (stack, heap, bss, etc)
- thread of control
  - one per process
  - machine register set (PC, a–regs, d–regs)
  - Machine registers not well–defined in unix+C
  - Allows ports to many machines

Pipes

How do processes send data to each other?

- Via the filesystem?
- via shared memory?

Pipe, like a file, an ordered, and unstructured

- byte stream vs. byte array

Pipes (cont)

Pros:

- Simple abstractions
- Easy to map to different communication hardware (e.g. ethernet, serial lines)

Too unstructured?

- Forces user to manage all details of communication

Basis of sockets

Address spaces

Process abstraction

- Fork(), exec()
  - compare with spawn() in QNX
- Easy to clean up resources on failure
- Harder to build abstraction
  - Compare with a Dis/Java VM
  - Even with MMU support, a pain
    - Look at x86 memory management hardware

Namespaces

Multics–style hierarchical namespace

- Modern unixes have multiple namespaces
  - (e.g. so an ipcs)

Alternatives today?

Q: Fundamental part of OS?

- vs. QNX, which only has process namespace?
- as in plan 9/inferno, where everything is a file?

Command Shells

Uniform programming interface

- Via system call interface
- few special programs (init+ swapper)
- Command shells are just programs

Unix Fault Model

Faults in address spaces

- Halt the AS
- clean up hernel resources:
  - Memory
  - Files descriptors and state (e.g. sockets)
  - Shared memory? Semaphores?

What about a fault in the executive?

QNX

Micro–kernel design

- Word overused, what does a µ–kernel mean?

OS abstractions

- processes, like unix
- messages, unlike unix
- networked PID space, unlike unix, inferno
- No filesystem namespace or FS in the kernel

QNX namespace

What belongs in the executive vs as an extension?

- address spaces
- messages–passing (restricted)
  - proxies
- signals
- scheduling

Process namespace

All processes are known by node:number

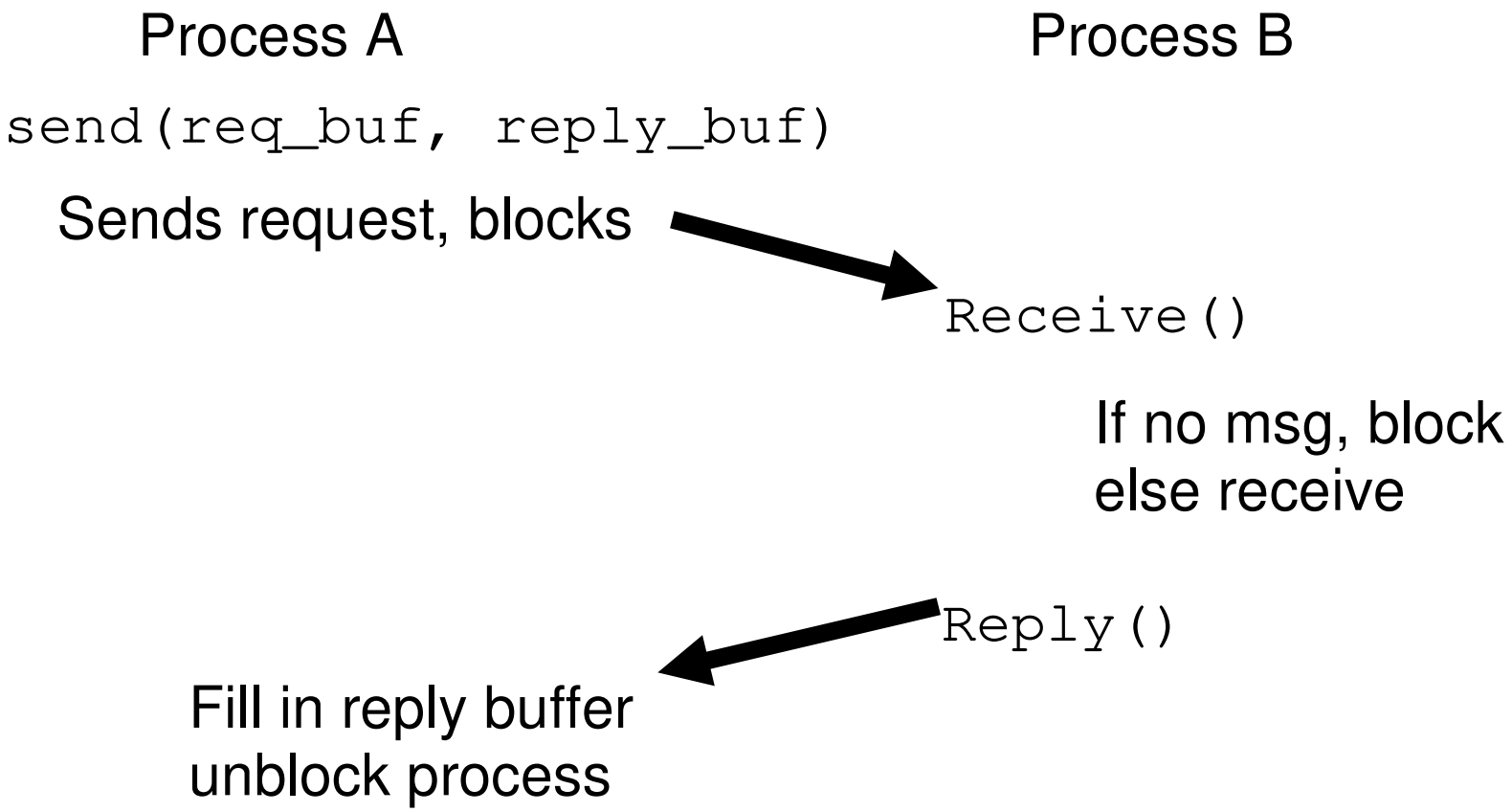
- Symbolic names to PIDs?
- A well known process must serve as a PID nameserver
- Similar issues as with the filesystem
  - e.g. /foo/bar/baz => inode X

QNX Messages

Message passing with restrictions

- Request/Reply model of message passing
- process scheduling tied to messaging
- Very simple abstraction
- Performance?

QNX Messages (cont)



Message Proxy

What if you can't wait?

- Idea: send a message to a proxy
- Proxy sends a pre–computed message to the recipient
- main process can continue
- what if you can't pre–compute the message?

Messaging & Scheduling

How to not copy data when sending?

- block sending process!
- Ties scheduling to messaging

- Q: How to form a smooth pipeline?
  - Must use a proxy
  - or Multiple processes

QNX Signals

How to force control change as well as data?

- send a signal
- Signal changes control of the recipient
  - Software interrupt
- Later versions of unix have expanded signal capabilities

Interaction of signals and messages?

- signals in blocked states cause aborted messages

Interrupt Handers

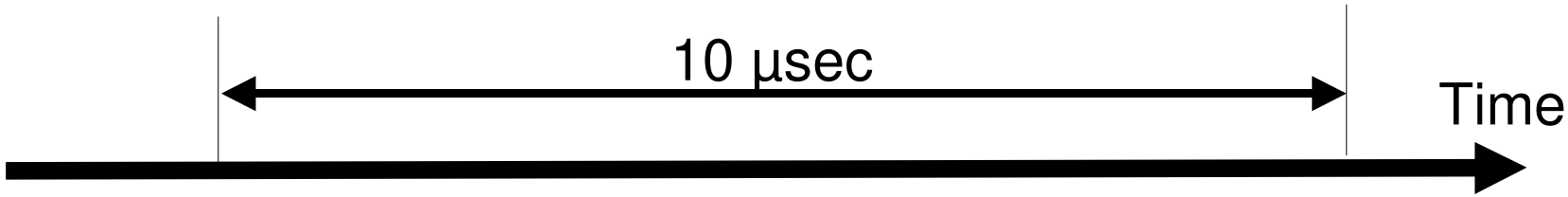
An interrupt occures. How long to unwind state to the the target process?

Three kinds of latency:

- From data ready to kernel ready
- Through kernel to handler
- From handler to user process

Simple Interrupt Experiment

```
Lanai polls clock
Lanai pulls IRQ
```

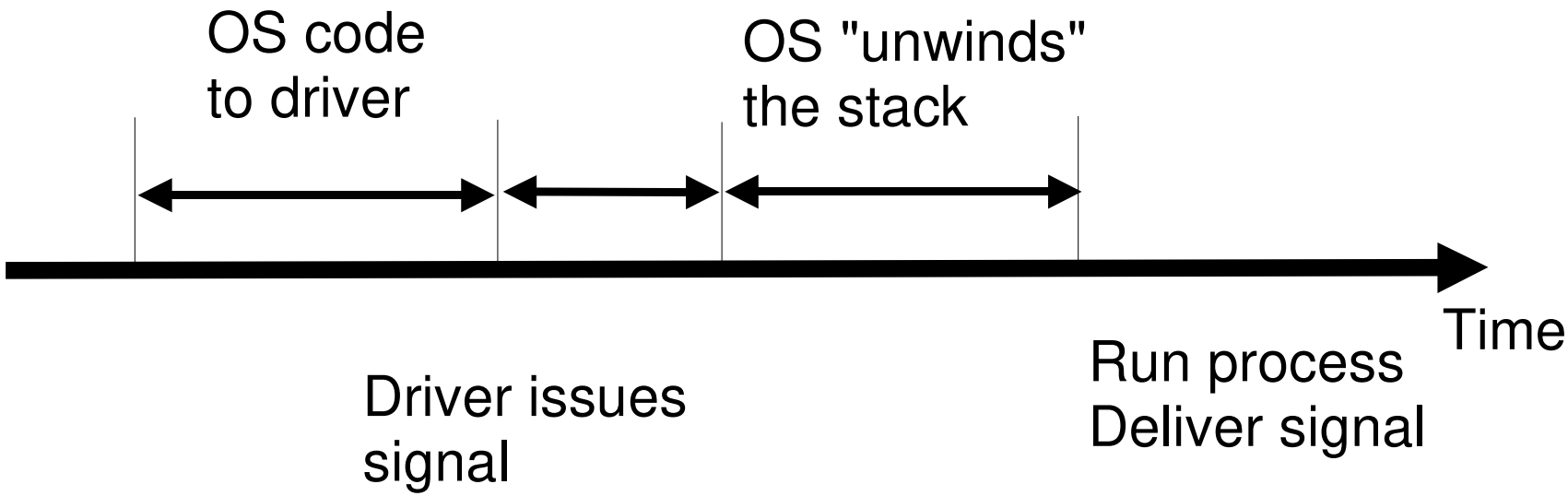



```
IRQ
Jump to IRQ handler
jump to device handler
```

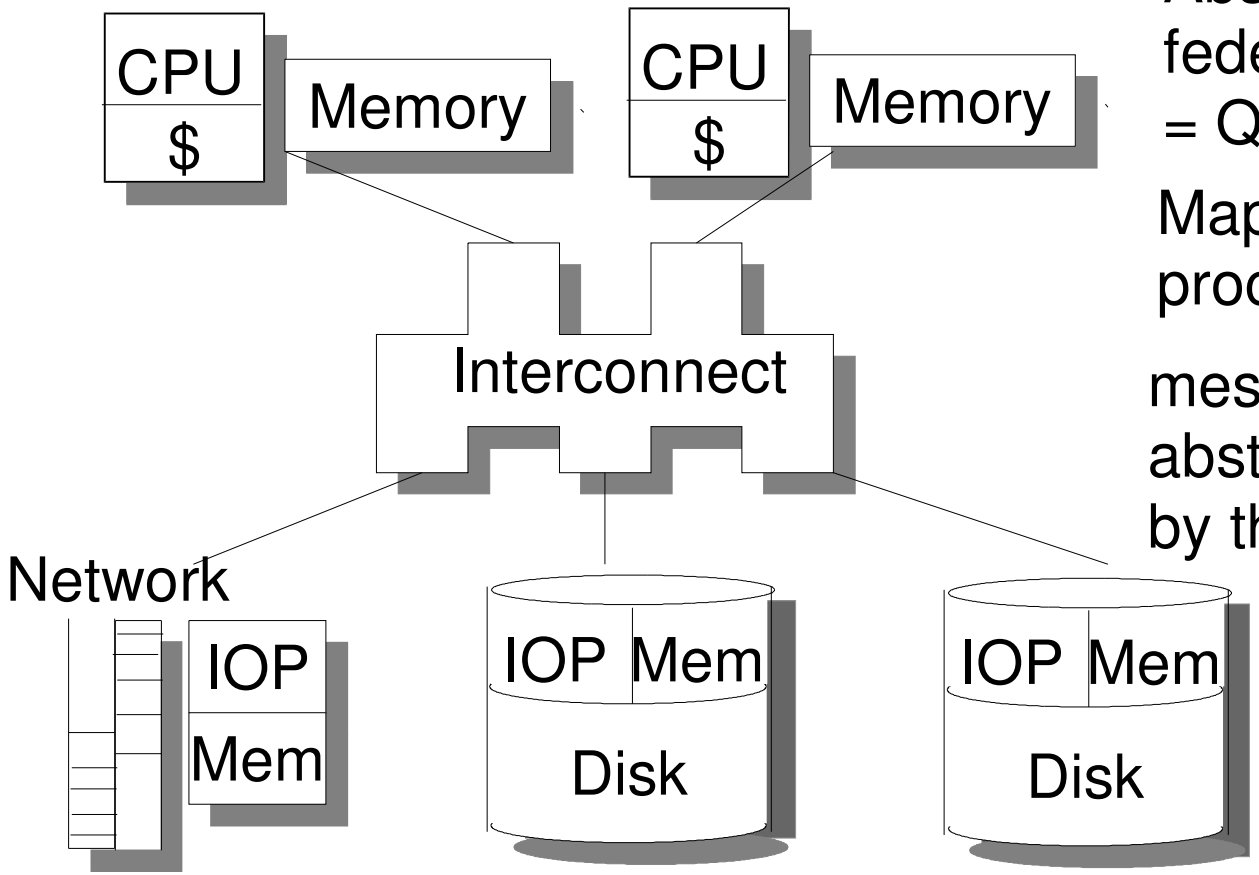
Sun Ultra–1
Myricom LANai 4.1

```
Driver polls lanai clock
Driver stores clock
```

Going through the scheduler



QNX to federated architecture

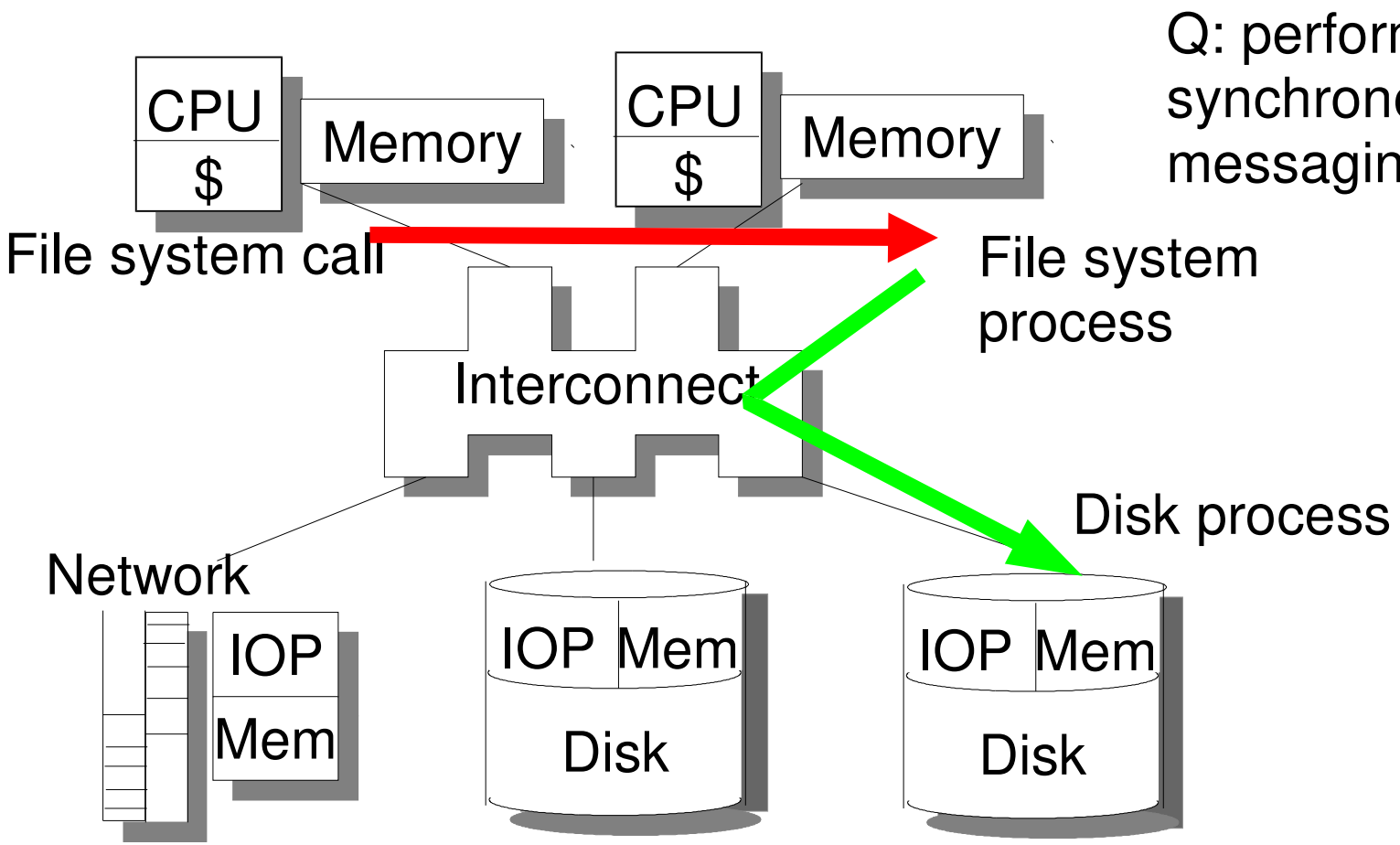


Abstraction of a federated machine = QNX system?

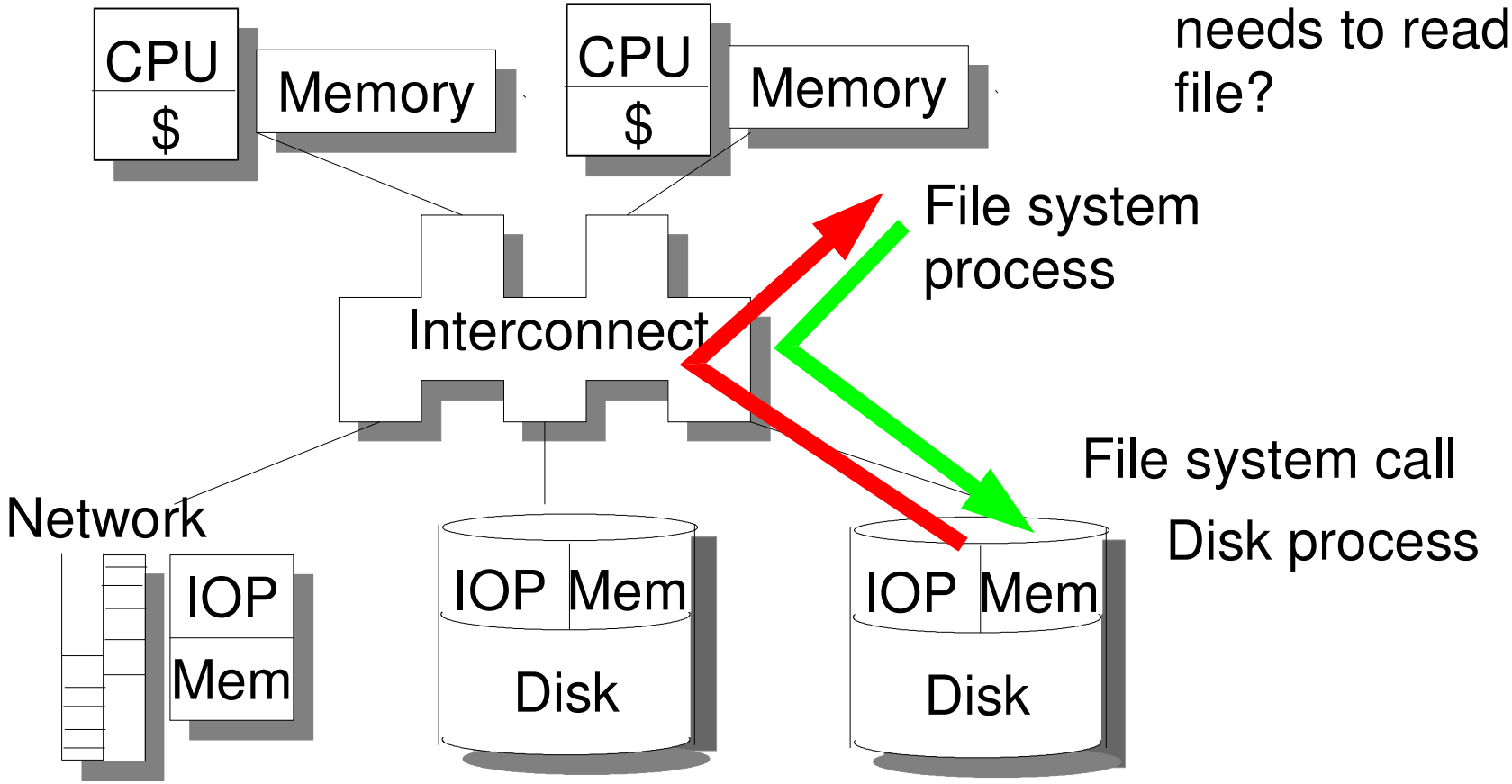
Map µ–kernels to all processors in system

messaging, scheduling abstractions provided for by the system

QNX to federated architecture



QNX to federated architecture



Device performance?

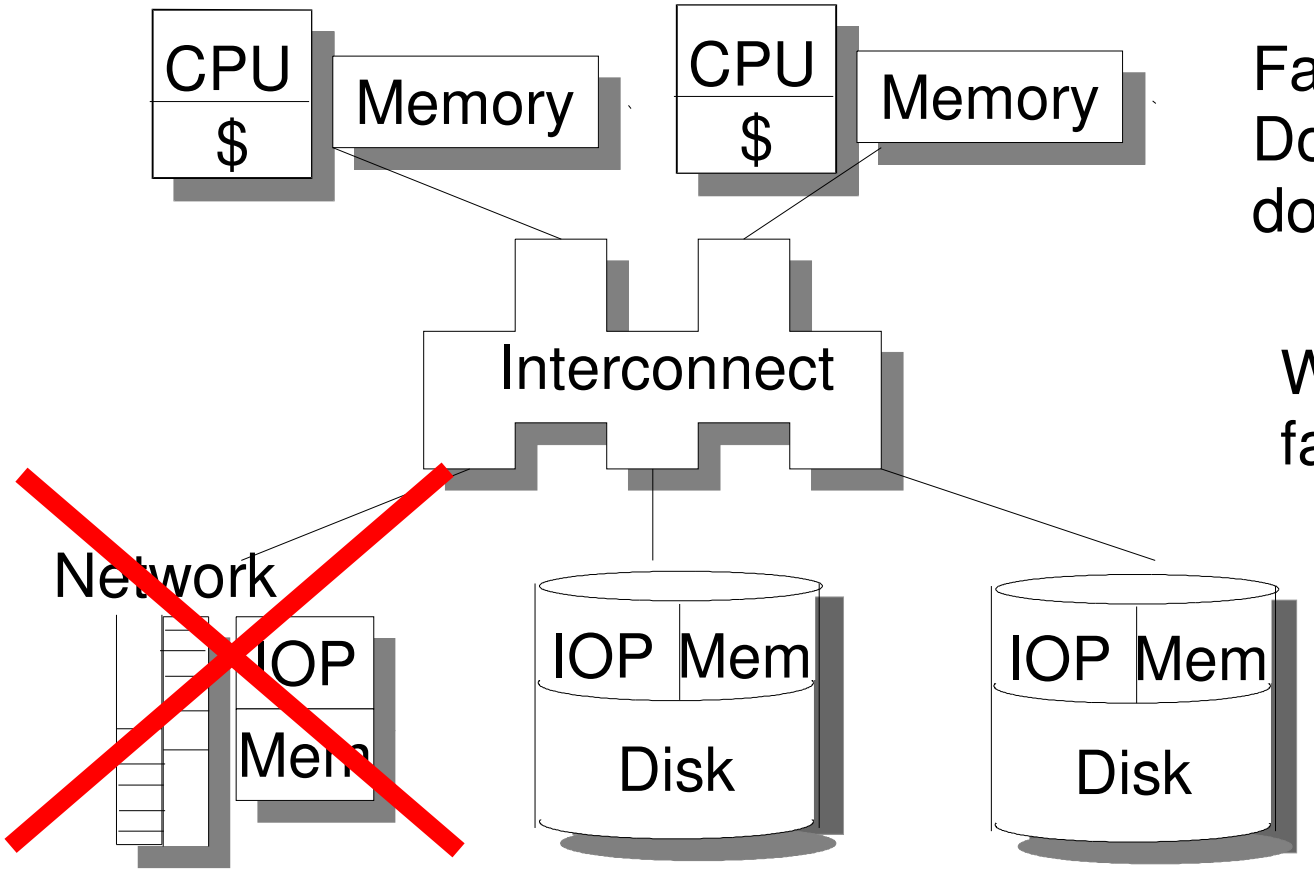
Nodes must possess an MMU?

- How to implement process abstraction w/o?
- Are different ISA's a problem?
  - endian problems?

What about shared memory?

- Mmap, sysV shared memory?

Fault Models



Faulty module Does NOT bring down system

What if a kernel faults?

µ–kernel right abstraction?

Shared memory is harder in hardware

Messaging is easier in hardware

- Betrer match to hardware resources?
- Harder to lay out data structures
- easier to pass control

Pipes vs. messaging

Pipes vs. Messages

Pipe is an ordered sequence of bytes

Messaging: sequence of atomic data

- ordered or unordered?

Pipes more generic but also

- heavier burden on higher layers
- Wasting resources, hardware already moves data in message units

Pipes vs. Messaging

Pipe logic requires a select of all pipes.
How to manage N–to–1 queue abstraction?
Logic to reconstruct incomming messages do to byte stream abstraction,

```
while (msg_not_all_here) {
   any = select(FD_READ, ...  );
   next_fd = fd_low;
   while (FD_ISSET(next_fd)) {
      bytes[fd] += read(fd,buffer[next_fd],maxlen);
      if (bytes[fd] > minMsgSize ) {
         if (messages passed checks ...) {
         }
   }
}
```

Messaging vs. Pipes

reconstruction

merging (n–to–1 queue semantics)

ordering and loss semantics?

```
if (msgid = recv(buf, len) ) {
   check message
   do processing
}
```

Inferno

Touted as network infrastructure OS

Main Abstractions

- Single namespace
  - standard read/write calls translated into messaging
- Typesafe language (Limbo)
  - Channel (pipe?) as a primitive datatype
- Virtual Machine (Dis)

Language/VM based OS

Language provides protection, Not AS

- E.g. Spin OS

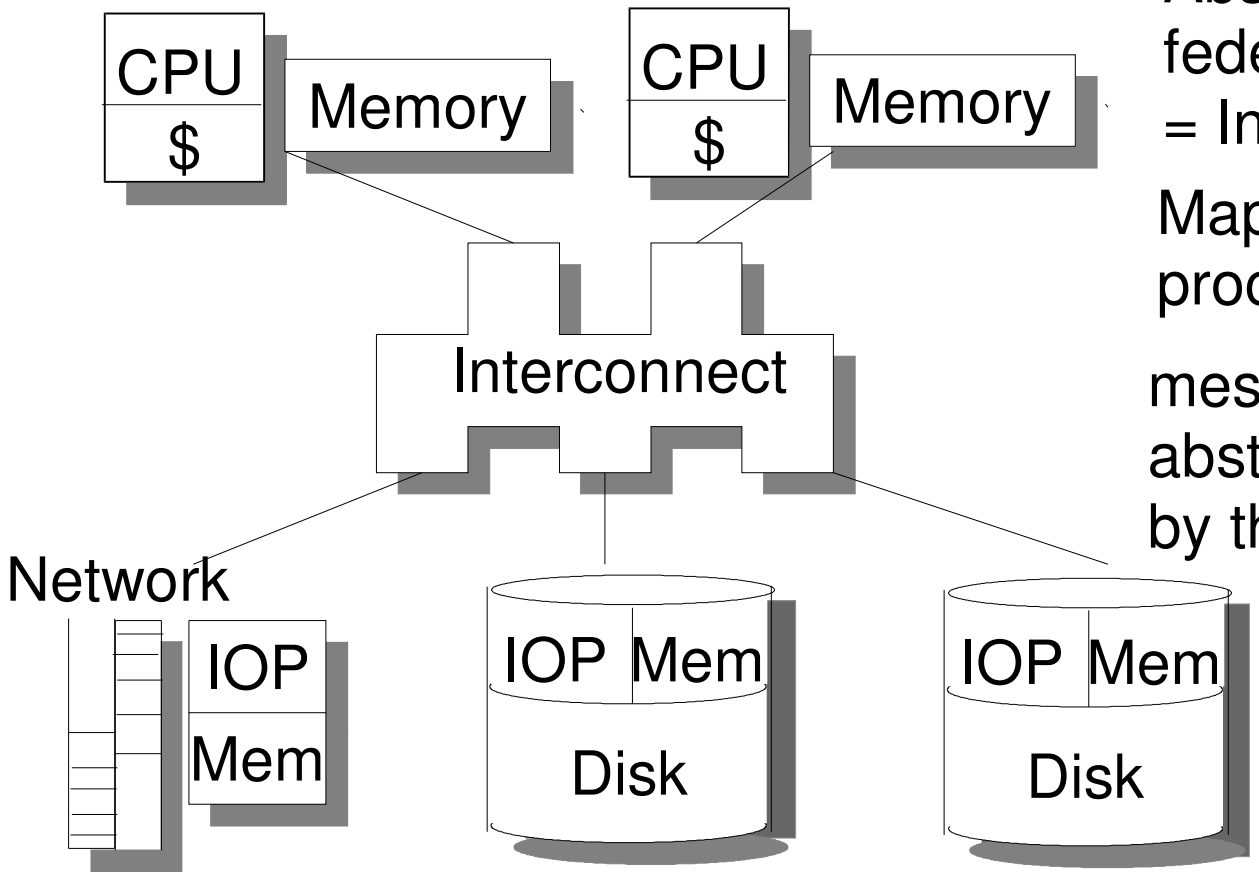
VM based OS uses a Virtual Machine to provide protection

- Java, Dis
- Multiple languages to the VM?

How to reclaim resources from a failed thread?

- (e.g. sockets,time)

Inferno to federated arch.



Abstraction of a federated machine = Inferno system?

Map Dis VM to all processors in system

messaging, namespace abstractions provided for by the system