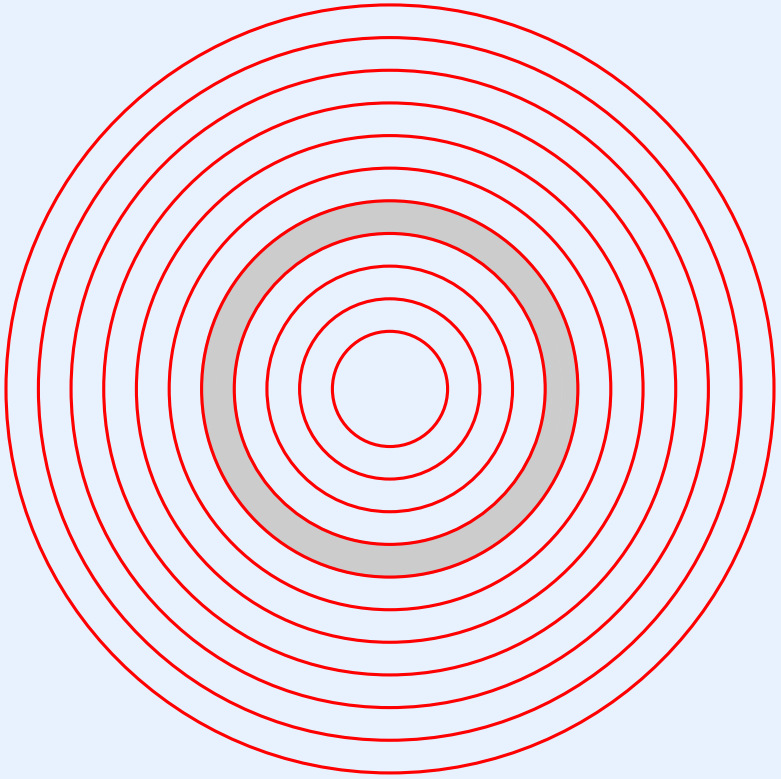
PART 6

Inter-Process Communication

Location Of Inter-process Communication In The Hierarchy



Inter-process Communication

- Used for
  - Exchange of (nonshared) data
  - Coordination
- General technique: *message passing*

Two Approaches To Message Passing

- Approach #1
  - Message passing is one of many services
  - Messages are separate from I/O and process synchronization services
  - Implemented using lower-level mechanisms, such as semaphores
- Approach #2
  - The entire operating system is *message-based*
  - Messages, not function calls, provide the fundamental building block
  - Messages, not semaphores, used for process synchronization

Design Of A Message Passing Facility

- To understand the issue, begin with a trivial message passing facility
- Allow a process to send a message directly to another process
- In principle, the design should be straightforward
- In practice, many design decisions arise

Message Passing Design Decisions

- Are messages fixed or variable size?
- How many messages outstanding at a given time?
- Where are messages stored?
- How is a recipient specified?
- Does a receiver know the sender’s identity?
- Are replies supported?
- Is the interface synchronous or asynchronous?

Synchronous vs. Asynchronous Interface

- Synchronous interface
  - Blocks until operation performed
  - Easy to understand / program
  - Extra processes can be used to obtain asynchrony

Synchronous vs. Asynchronous Interface (continued)

- Asynchronous interface
  - Starts an operation
  - Allows initiating process to continue execution
  - Notification
    - Arrives when operation completes
    - May entail abnormal control (e.g., software interrupt)
  - Polling can be used to determine status

Why Is A Message Passing Facility Difficult To Design?

- Interacts with
  - Process coordination subsystem
  - Memory management subsystem
- Affects user's perception of system

Xinu Inter-process Message Passing

- Simple, low-level mechanism
- Direct process-to-process communication
- One-word messages
- One-message buffer
- Synchronous, buffered reception
- Asynchronous transmission and “reset” operation

Xinu Inter-process Message Passing (continued)

- Three functions

```
send(msg, pid);

msg = receive();

msg = recvclr();
```

- Only *receive* blocks
- Message stored in receiver's process table

Xinu Inter-process Message Passing (continued)

- First-message semantics
  - First message sent to a process is stored until it has been received
  - Subsequent attempts to send fail
- Typical idiom

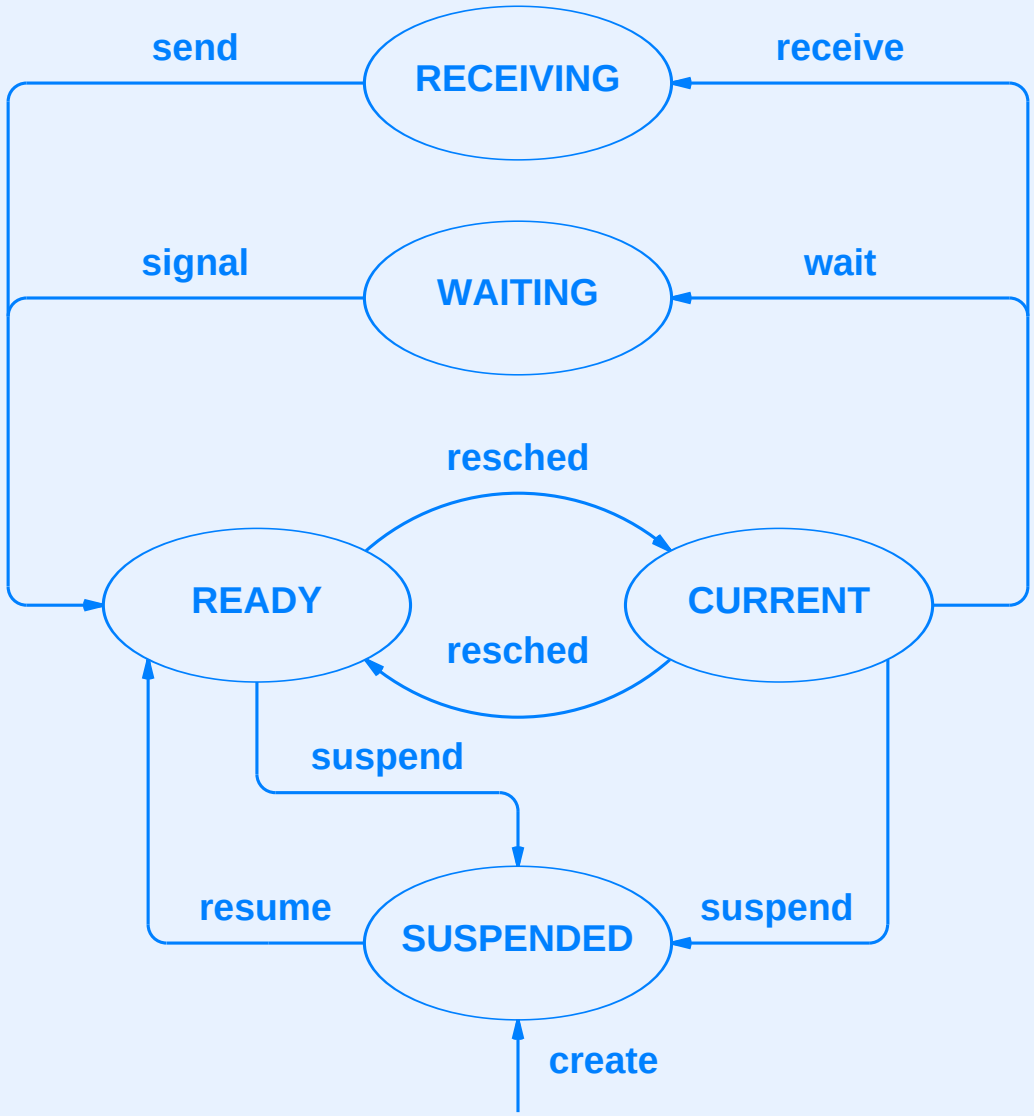
```
recvclr();  /* prepare to receive a message */
... /* allow other processes to send messages */
msg = receive();
```

- *Receive* returns first message that was sent

New Process State Needed

- While receiving a message, a process is not
  - Executing
  - Ready
  - Suspended
  - Waiting on a semaphore
- Therefore, a new state is needed for message passing
- Named *RECEIVING*
- Entered when *receive* called

State Transitions With Message Passing



Xinu Code For Message Reception

```
/* receive.c - receive */

#include <xinu.h>

/*------------------------------------------------------------------------
 *  receive  -  wait for a message and return the message to the caller
 *------------------------------------------------------------------------
 */
umsg32  receive(void)
{
        intmask mask;                   /* saved interrupt mask         */
        struct  procent *prptr;         /* ptr to process' table entry  */
        umsg32  msg;                    /* message to return            */

        mask = disable();
        prptr = &proctab[currpid];
        if (prptr->prhasmsg == FALSE) {
                prptr->prstate = PR_RECV;
                resched();              /* block until message arrives  */
        }
        msg = prptr->prmsg;             /* retrieve message             */
        prptr->prhasmsg = FALSE;        /* reset message flag           */
        restore(mask);
        return msg;
}
```

Xinu Code For Message Transmission (part 1)

```
/* send.c - send */

#include <xinu.h>

/*------------------------------------------------------------------------
 *  send  -  pass a message to a process and start recipient if waiting
 *------------------------------------------------------------------------
 */
syscall send(
          pid32         pid,            /* ID of recipient process      */
          umsg32        msg             /* contents of message          */
        )
{
        intmask mask;                   /* saved interrupt mask         */
        struct  procent *prptr;         /* ptr to process' table entry  */

        mask = disable();
        if (isbadpid(pid)) {
                restore(mask);
                return SYSERR;
        }

        prptr = &proctab[pid];
        if ((prptr->prstate == PR_FREE) || prptr->prhasmsg) {
                restore(mask);
                return SYSERR;
        }
```

Xinu Code For Message Transmission (part 2)

```
        prptr->prmsg = msg;             /* deliver message              */
        prptr->prhasmsg = TRUE;         /* indicate message is waiting  */

        /* if recipient waiting or in timed-wait make it ready */

        if (prptr->prstate == PR_RECV) {
                ready(pid, RESCHED_YES);
        } else if (prptr->prstate == PR_RECTIM) {
                unsleep(pid);
                ready(pid, RESCHED_YES);
        }
        restore(mask);          /* restore interrupts */
        return OK;
}
```

Xinu Code For Clearing Messages

```
/* recvclr.c - recvclr */

#include <xinu.h>

/*------------------------------------------------------------------------
 *  recvclr  -  clear incoming message, and return message if one waiting
 *------------------------------------------------------------------------
 */
umsg32  recvclr(void)
{
        intmask mask;                   /* saved interrupt mask         */
        struct  procent *prptr;         /* ptr to process' table entry  */
        umsg32  msg;                    /* message to return            */

        mask = disable();
        prptr = &proctab[currpid];
        if (prptr->prhasmsg == TRUE) {
                msg = prptr->prmsg;     /* retrieve message             */
                prptr->prhasmsg = FALSE;/* reset message flag           */
        } else {
                msg = OK;
        }
        restore(mask);
        return msg;
}
```

Summary

- Inter-process communication
  - Implemented by message passing
  - Can be synchronous or asynchronous
- Synchronous interface is the simplest
- Xinu uses synchronous reception and asynchronous transmission