CSCE 451/851
Introduction to Operating Systems

Interprocess Communications (Message Passing)

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Message Passing

- Two fundamental communication & synchronization paradigms
  - » Shared memory
    - ❖ Efficient, familiar
    - ❖ Not always available
    - ❖ Potentially insecure
  - » Message passing
    - ❖ Awkward, less standardized
    - ❖ Extensible to communication in distributed systems
    - ❖ Syntax:

```
send(process : process_id, message : string)
receive(process : process_id, var message : string)
```

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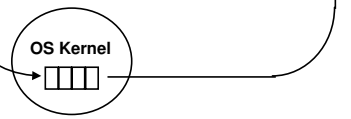
Message Passing Example
Ye Olde Producer/Consumer System

```
process producer
begin
  loop
    <produce a char "c">
    send(consumer, c)
  end loop
end producer
```

```
process consumer
begin
  loop
    receive(producer, mesg)
    <consume message "mesg">
  end loop
end consumer
```



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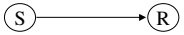
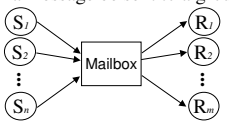
Issues
Naming communicants

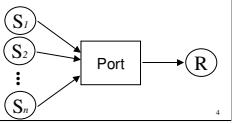
- How do processes refer to each other?
  - » Does a sender explicitly name a receiver?



  - » Can a message be sent to a group?



  - » Implementation considerations
    - ❖ Synchronization among receivers



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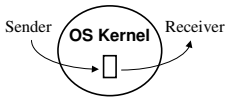
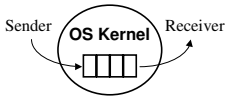
Issues

Synchronization semantics

- When does a send/receive operation terminate?
  - » Blocking
    - ❖ sender waits until its message is received
    - ❖ receiver waits if no message is available



  - » Non-blocking
    - ❖ send operation "immediately" returns
    - ❖ receive operation returns if no message is available



  - » Variants
    - ❖ `send()/receive()` with *timeout*

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Semantics of Message Passing

`send(recvr,mesg)`

Synchronization

Naming	**Blocking**	**Nonblocking**
Explicit	Send message to *recvr*. Wait until message is accepted.	Send message to *recvr*.
Implicit	Broadcast message to all receivers. Wait until message is accepted by all.	Broadcast message to all receivers.

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Semantics of Message Passing

`receive(sender,mesg)`

Naming \ Synchronization	Blocking	Nonblocking
Explicit	Wait for a message from *sender*	If there is a message from *sender* then receive it, else continue
Implicit	Wait for a message from any sender	If there is a message from any sender then receive it, else continue

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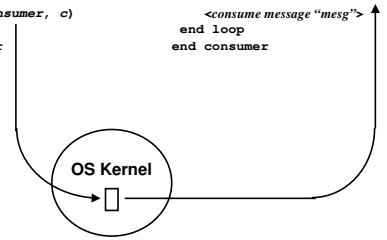
Producer/Consumer Example

Direct naming, blocking synchronization

```
process producer
begin
  loop
    <produce a char "c">
    send(consumer, c)
  end loop
end producer
```

```
process consumer
begin
  loop
    receive(producer, mesg)
    <consume message "mesg">
 end loop
end consumer
```



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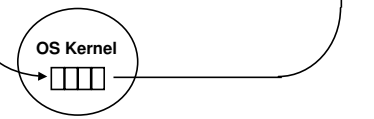
Producer/Consumer Example

Direct naming, non-blocking synchronization

```
process producer
begin
  loop
    <produce a char "c">
    send(consumer, c)
  end loop
end producer
```

```
process consumer
begin
  receive(producer, mesg)
  loop
    while (mesg ° NULL) do
      receive(producer, mesg)
    end while
    <consume message "mesg">
 end loop
end consumer
```



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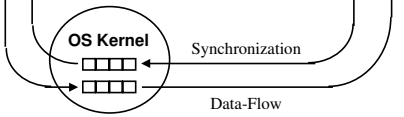
Producer/Consumer Example

With non-blocking send, blocking receive

```
process producer
begin
 loop
   <produce a char "c">
   receive(consumer,mesg)
   send(consumer, c)
 end loop
end producer
```

```
process consumer
begin
  for i := 1 to n do
     send(producer,NULL)
  end for
  loop
    receive(producer,mesg)
    <consume message "mesg">
    send(producer,NULL)
  end loop
end consumer
```



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Producer/Consumer Example

With blocking send/receive

```
process producer
begin
 loop
   <produce a char "c">
   send(bufferManager, c)
 end loop
end producer
```

```
process consumer
begin
 loop
   send(bufferManager,request)
   receive(bufferManager,mesg)
   <consume message "mesg">
 end loop
end consumer
```

```
process bufferManager
var buff : array [0..n-1] of char
    nextIn,nextOut : 0..n-1 := 0
    fullCount      : 0..n   := 0

begin
  loop
    if (fullCount < n) then
      receive(producer, mesg)
      buff[nextIn] := mesg
      nextIn    := nextIn+1 mod n
      fullCount := fullCount + 1
    end if

    if (fullCount > 0) then
      receive(consumer, request)
      send(consumer, buff[nextOut])
      nextOut   := nextOut+1 mod n
      fullCount := fullCount - 1
    end if
  end loop
end bufferManager
```

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Realizing Parallel Execution

Buffered, asynchronous communication

```
process bufferManager
var buff : array [0..n-1] of
char
    nextIn,nextOut : 0..n-1 := 0
    fullCount      : 0..n   := 0
begin
  loop
    case select() of
      producer :
        deposit()
        if (fullCount = n) then
          remove()
        end if
      consumer :
        remove()
        if (fullCount = 0) then
          deposit()
        end if
    end case
  end loop
end bufferManager
```

```
procedure deposit()
begin
  receive(producer, mesg)
  buff[nextIn] := mesg
  nextIn    := nextIn+1 mod n
  fullCount := fullCount + 1
end deposit

procedure remove()
begin
  receive(consumer, request)
  send(consumer,buff[nextOut])
  nextOut   := nextOut+1 mod n
  fullCount := fullCount - 1
end remove
```

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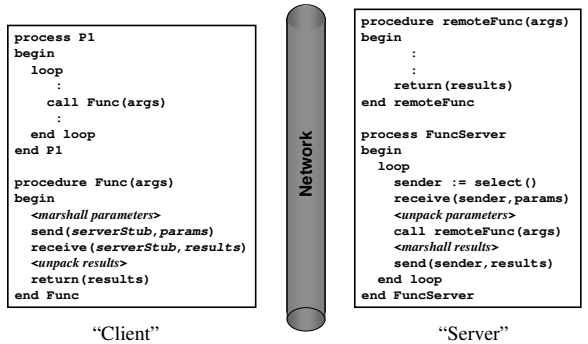
Remote Procedure Call
Emulating shared memory via message passing



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Remote Procedure Call
Issues

- How does a client locate a server?
- What types of parameters can be passed?
- What parameter passing paradigms are easy/hard?
- How does one deal with errors & server failures?

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