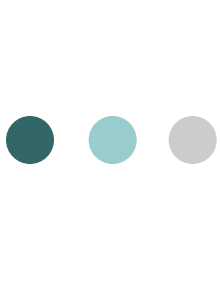
CSCI3180 Principles of Programming Languages

The Administrator and Worker Paradigm and SIMPL Library

Tutorial 5



Introduction

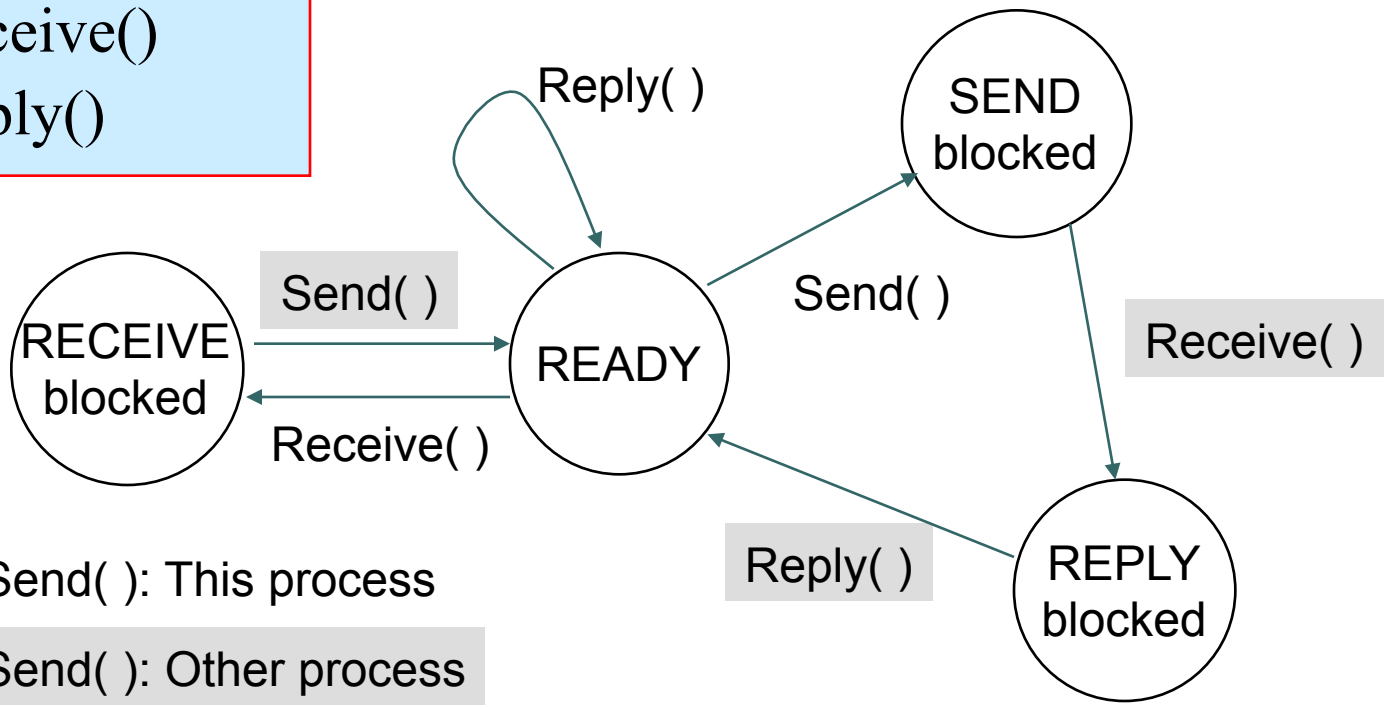
- Concurrent programming
  - Several sequential processes are executing in parallel, and cooperating with other processes.
  - They must communicate and synchronize.
  - Low-level concurrent constructs include: parbegin-parend, semaphores, mutexes, message passing, and remote procedure calls.

The Message Passing System

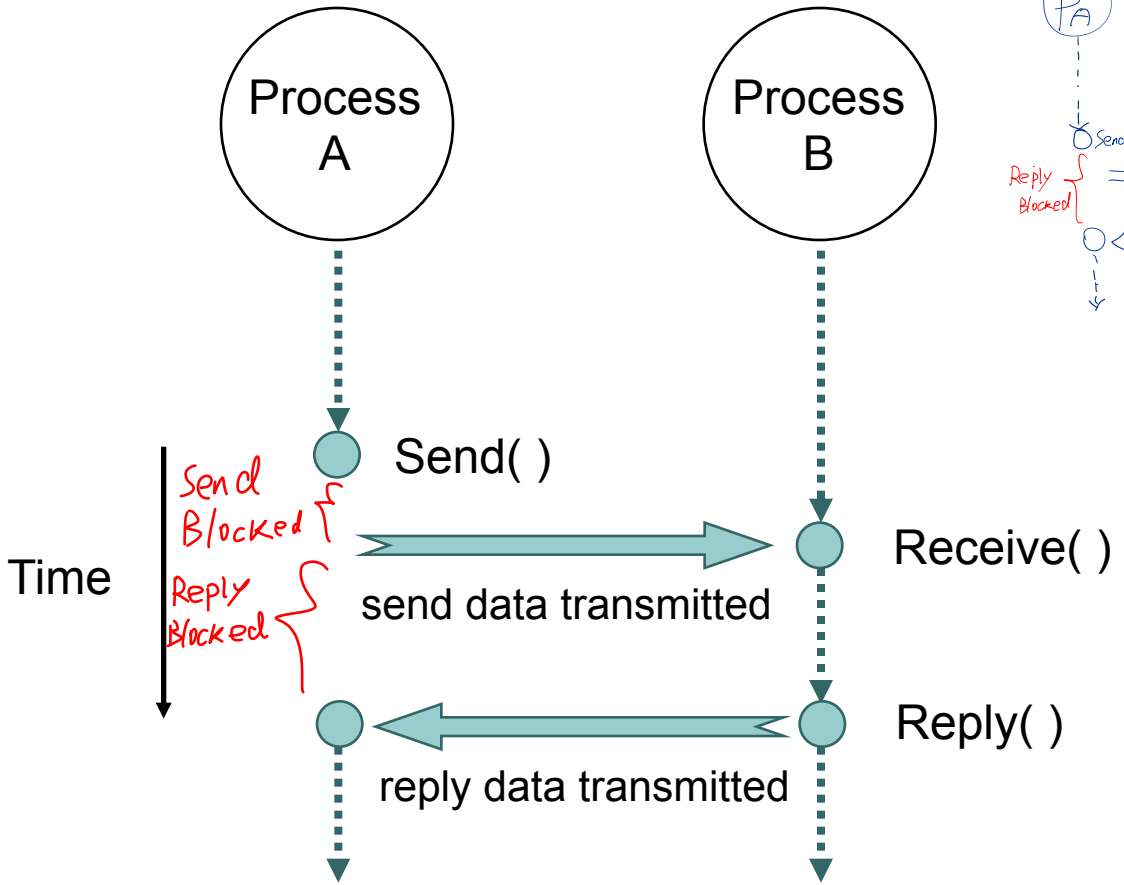
- With carefully designed semantics, message passing can be used for process synchronization.
- The message passing system consists of a blocking Send(), a blocking Receive(), and a non-blocking Reply().

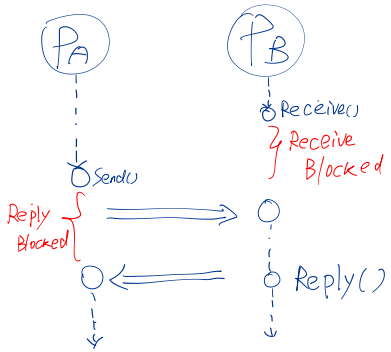
Send/Receive/Reply

- Messaging:
  - Send()
  - Receive()
  - Reply()



A Simple Sequence of Events





More about Message Passing

- Note how message passing not only allows processes to pass data to each other, but also provides a means of synchronizing the execution of several cooperating processes.

Administrator and Worker Paradigm

- The message passing model just described supports a new paradigm for concurrent programming: the Administrator-and-Worker paradigm.
- Two types of processes: administrators and workers.

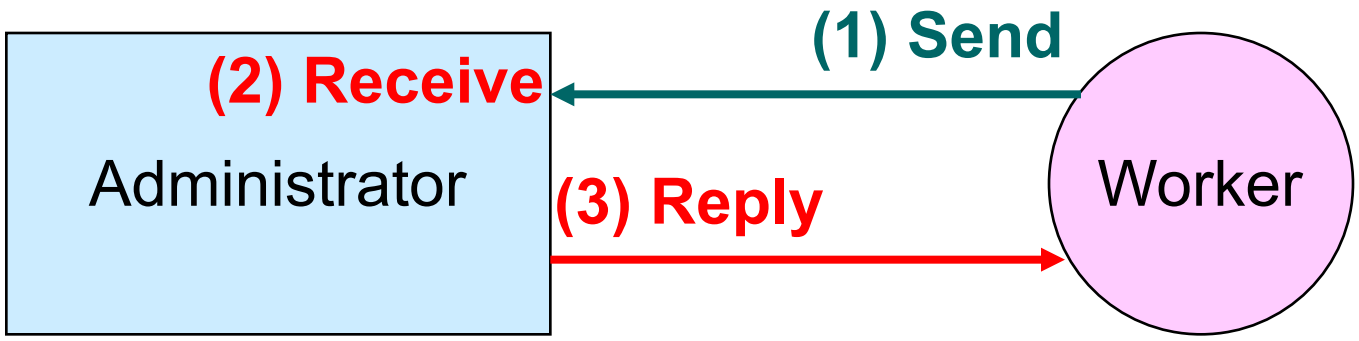
Administrator

- An administrator owns one or more worker processes.
- Usually, an administrator is used to maintain a critical resource
  - e.g. memory, display, keyboard, etc.
- It is mainly responsible for
  - Receiving requests from clients
  - Queuing up the requests
  - Delegating jobs to its worker processes.

Worker

- A worker performs the actual computation that its administrator assigned.
- It is dedicated for a special purpose
  - e.g. painting the screen
- It has to report availability to its administrator.

Administrator and Worker Cooperation



Administrator's action

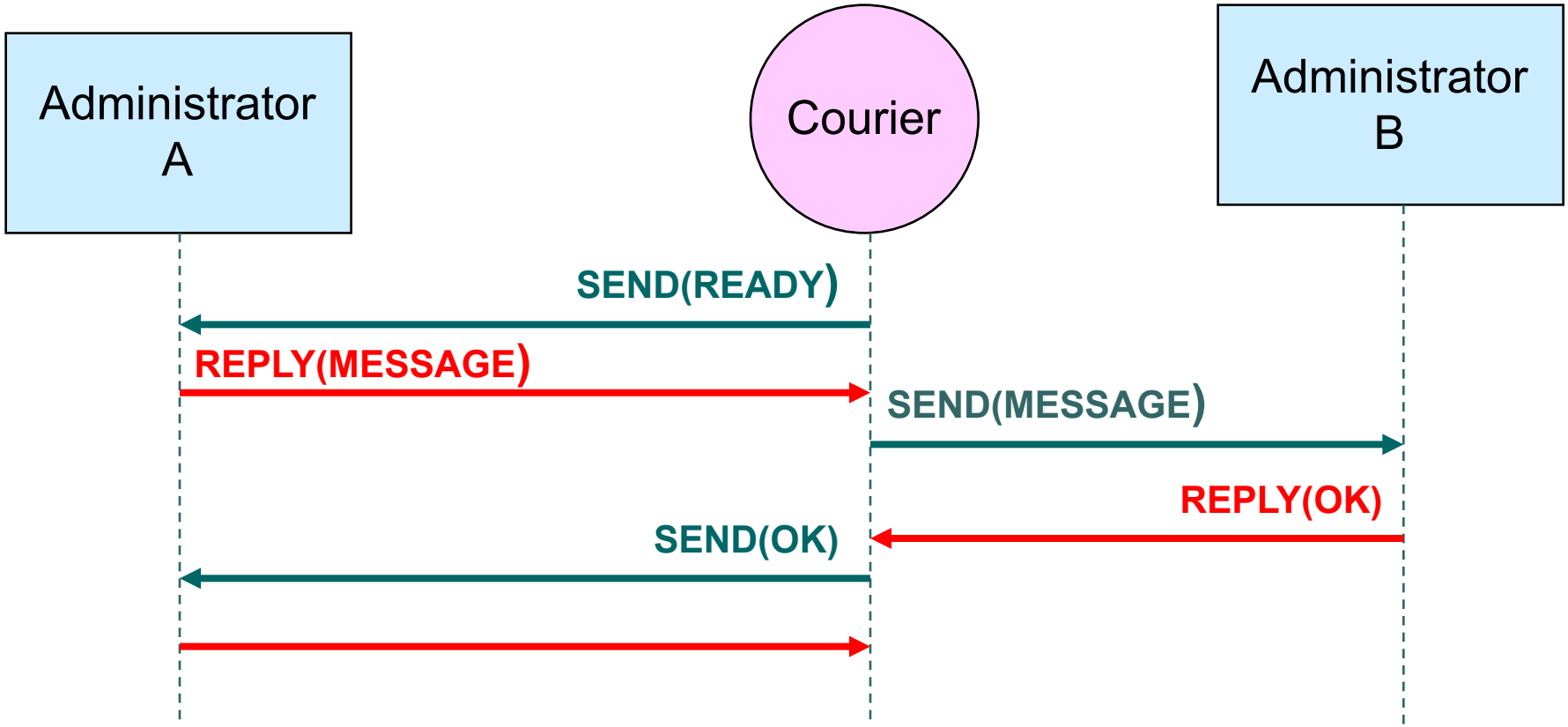
Worker's action

Courier 快递员

- In a program, there can be *more than one* administrators.
- Two administrators cannot communicate each other directly!
- A courier is a special type of worker processes that sends messages on behalf of its administrator to another administrator.

Cooperation Between Two Administrators

- Relay messages from one Administrator to another



Implementation

- C Language
- GNU/LINUX with GCC compiler
- Concurrent Programming
  - Synchronous Interprocess Messaging Project for LINUX (SIMPL)

- SIMPL provides Send/Receive/Reply messaging
  - first popularized in commercial Real-Time Operating System (RTOS), such as QNX

SIMPL Setup

- LINUX Only!
  - We have linux6 to linux9
  - Connection method is the same as for sparc machines
- Create directory fifo/
  - e.g. in your home directory
- Decompress SIMPL library to simpl/
  - can be downloaded from course web page

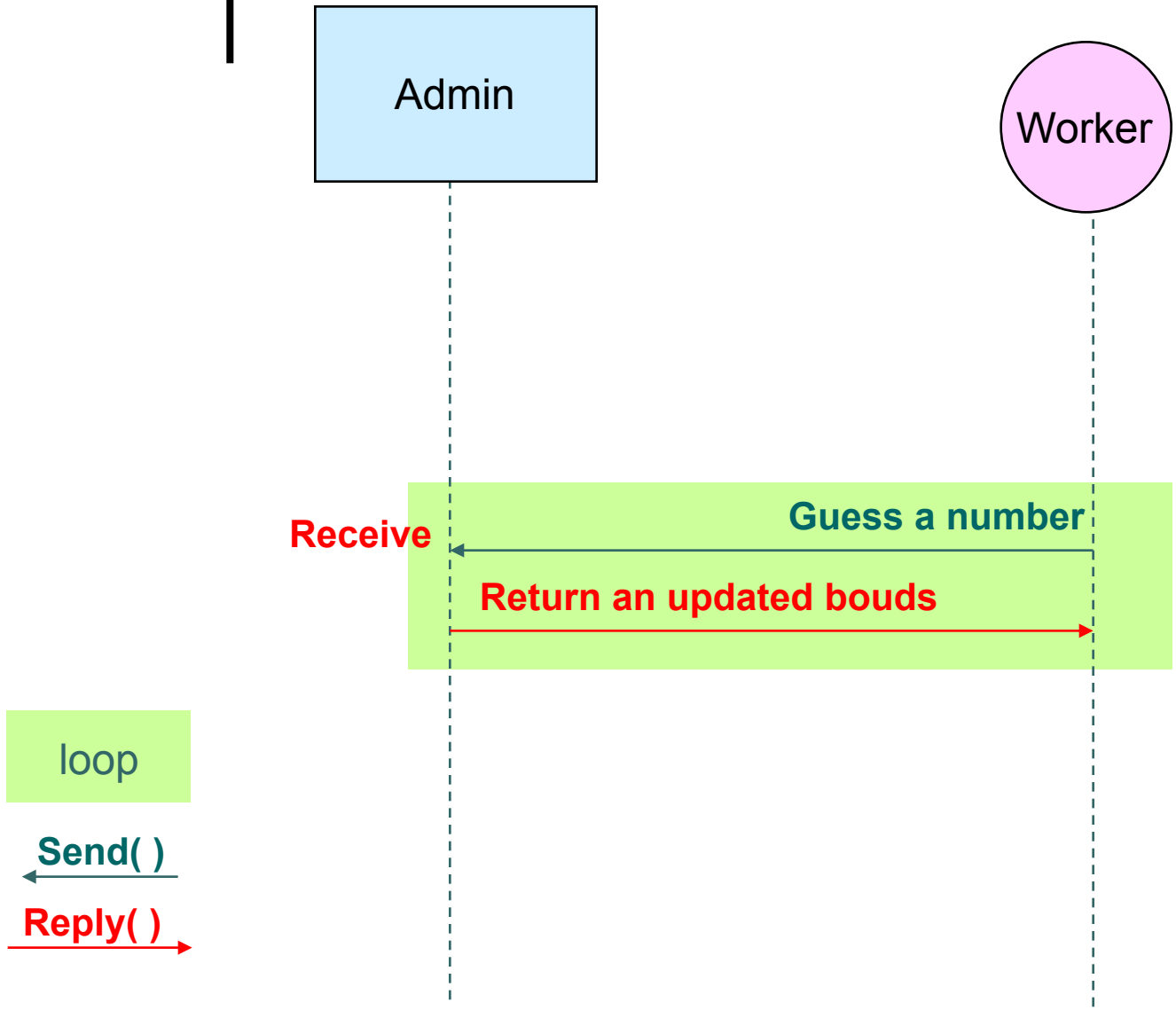
SIMPL Setup

- Set paths in your shell environment
  - e.g. in your .cshrc file
  - setenv FIFO_PATH $HOME/fifo
  - setenv SIMPL_HOME $HOME/simpl
- Include header file "simpl.h" in your source files
- Use the makefile provided to compile

Sample Code: Number Guessing

- A *very simple* example
- Administrator randomly picks a number from 0 to 99
- Every worker continuously guessing the number by randomly picking a number from the bounds
  - the bounds are updated for each guess

Admin and Worker



Attaching Process

```
int name_attach(char* name,
                void(*exitFunc)())
```

- Register a process's name in the namespace
- Required by every process that expects to send/receive messages from any other process
- It returns 0 on success or -1 on failure

Locating a Process

```
int name_locate(char* name)
```

- Identify the receiver before sending a message
- Returns
  - Success: the unique ID of the receiver
  - Failure: -1

if successfully located, return the user's id

NN大佬

Detaching process

```
int name_detach(void)
```

- Remove a process's (previously registered) name from the namespace:
- It returns 0 on success or -1 on failure

Blocking Message Send

File Descriptor of the receiver

```
int Send(int fd, void *out, void *in,
        unsigned outSize, unsigned inSize)
```

- Send a message to fd pointed to by out with size outSize.
- The fd is the receiver ID obtained from name_locate()
- It expects a reply message from fd to be placed in memory pointed to by in with size no larger than inSize.
- Returns
  - Success: n, size of the reply message
  - Failure: -1

Blocking Message Receive

&fromWhom &msg

```
int Receive(char **ptr, void *inArea,
        unsigned maxBytes)
```

max message size

- Receive a message in a memory area pointed to by inArea and no larger than maxBytes.
- The *ptr is a record to uniquely identifies the sender and is used for Reply()
- The record *ptr is destroyed after Reply()
- Returns
  - Success: n, size of the received message
  - Failure: -1

Non-blocking Message Reply

&reply

```
int Reply(char *ptr, void *outArea,
        unsigned outSize)
```

- Reply a message to a blocked sender (designated by ptr) pointed to by outArea with size outSize.
- It returns 0 on success or -1 on failure

Administrator Template

```
int main(...) {
  char* fromWhom = NULL; MESSAGE msg, reply; // ...
  if (name_attach("Admin", NULL) == -1)
    die(ATTACH_ERR); // ...
  while (...) {
    // ...
    if (Receive(&fromWhom, &msg, sizeof(msg)) == -1)
      die(RECEIVE_ERR);
    // ...
    if (Reply(fromWhom, &reply, sizeof(reply)) == -1)
      die(REPLY_ERR);
    // ...
  } // ...
  if (name_detach() == -1) die(DETACH_ERR);
  return 0;
}
```

Predefined message structure

Blocked when waiting for incoming message

Remember to detach name

Worker Template

```
int main(...) {
  int fd; MESSAGE msg, reply; // ...
  if (name_attach("Worker", NULL) == -1)
    die(ATTACH_ERR); // ...
  if ((fd = name_locate("Admin")) == -1)
    die(LOCATE_ERR); // ...
  while (...) {
    // ...
    if (Send(fd, &msg, &reply, sizeof(msg),
          sizeof(reply)) == -1) die(SEND_ERR);
    // ...
  } // ...
  if (name_detach() == -1) die(DETACH_ERR);
  return 0;
}
```

Predefined message structure

Blocked when waiting for reply

Remember to detach name

Shortcomings of the Sample

- When one of the worker wins, the administrator quits immediately
- Other workers fail to send message

- Solutions
  - Fixed number of workers

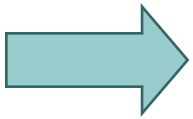
    ➔ Always wait for all
  - Variable number of workers

    ➔ Register each worker and inform them when the game is over

Modify Message Structure

- Add additional field in MESSAGE to indicate the type

```
typedef struct {
    int lowerBound;
    int upperBound;
    int guess;
} MESSAGE;
```



```
typedef struct {
    int type;
    int lowerBound;
    int upperBound;
    int guess;
} MESSAGE;
```

- e.g. 1 → Join, 2 → Guess

Register Workers