Other Topics

An Advanced Introduction to Unix/C Programming

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What to cover

- Read/Write/Execute
- Signals
- Fork
- Shared Memory
- Message Queues
- Unix File System
- Threads
- Semaphores / Mutex
- Client/Server Networking

d rwx rwx rwx

rwx	rwx	rwx
user	group	world

d rwx rwx rwx

File Mode Bits	
Bit	Meaning
d	Directory
r	Read Access
w	Write Access
x	Execute

RWX Groupings	
First rwx	User Group Access (owner of file)
Second rwx	Group Access (if in group, have access)
Third rwx	World Access (everyone on system)

For Files:

r – You can read the file
w – You can modify the file
x – You run execute (run) file

For Directories:

r – You can see the file name in the directory.
w – You can add, remove, and rename the file in the directory.
x – You can use the directory name in a file path and change into directory.

d rwx rwx rwx

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% ls –l

```
drwxr-x--- 1 john staff  4096 Dec 24 14:15 my.dir
-rwxr-x--- 1 john staff 16728 Dec 25 15:51 a.out
-rw-r--r-- 1 john staff   232 Dec 24 14:17 continue.c
```

You need r-x access to cd into a directory.

chmod – change file mode bits

% **chmod 644 myfile.txt** ← Sets myfile.txt to rw-r--r—
0x644 = 110 100 100

% **chmod 755 a.out** ← Sets a.out to rwxr-xr-x
0x755 = 111 101 101

% **chmod 775 a.out** ← Sets a.out to rwxrwxr-x
0x775 = 111 111 101

% **chmod 400 id_rsa** ← Sets file id_rsa to be readonly, r--------
0x400 = 100 000 000

chmod – change file mode bits

Can also use …

chmod ugo +-= rwx filename/directory

where

ugo specifies user, group, other
+-= specifies add (+), subtract (-), set (=)
rwx specifies read, write, execute

% **chmod g+w myfile** ← Adds group write access to file myfile.

% **chmod o-w myfile** ← Remove other (world) write access from myfile.

% **chmod g=rwx myfile** ← Sets group to rwx for file myfile.

Signals

```
signal( SIGALRM, timeout);      ← If alarm goes off, call timeout().
alarm (10);                     ← Alarm will go off in 10 seconds.
// Do something.
alarm(0);                       ← Turn off alarm.


void timeout()
{
    printf("ERROR: Timeout occurred.\n");
}
```

Signals

The signals currently defined by <signal.h> are as follows:

Name	Value	Default	Event
SIGHUP	1	Exit	Hangup (see termio(4I))
SIGINT	2	Exit	Interrupt (^C)
SIGQUIT	3	Core	Quit (see termio(4I))
SIGILL	4	Core	Illegal Instruction
SIGTRAP	5	Core	Trace or Breakpoint Trap
SIGABRT	6	Core	Abort
SIGEMT	7	Core	Emulation Trap
SIGFPE	8	Core	Arithmetic Exception
SIGKILL	9	Exit	Killed
SIGBUS	10	Core	Bus Error
SIGSEGV	11	Core	Segmentation Fault
SIGSYS	12	Core	Bad System Call
SIGPIPE	13	Exit	Broken Pipe
SIGALRM	14	Exit	Alarm Clock
SIGTERM	15	Exit	Terminated
SIGUSR1	16	Exit	User Signal 1
SIGUSR2	17	Exit	User Signal 2
SIGCHLD	18	Ignore	Child Status Changed
SIGPWR	19	Ignore	Power Fail or Restart
SIGWINCH	20	Ignore	Window Size Change

There are more signals defined too…

Program can ignore or handle signals:

```
sigset(SIGINT, SIG_IGN);
sigset(SIGHUP, SIG_IGN);
signal(SIGSYS, error_seen);
signal( SIGTERM, error_seen);
signal( SIGPWR, error_seen);
signal( SIGILL, error_seen);
signal( SIGFPE, error_seen);
signal( SIGBUS, error_seen);
signal( SIGSEGV, error_seen);
signal( SIGUSR1, SIG_IGN);
signal( SIGUSR2, error_seen);

// Program continues on …
```

fork

- When a process calls fork, it is deemed the parent process and the newly created process is its child.
- After the fork, the parent and child process don't know if they are the parent or child until the process id returned from the fork call is checked.
- fork() call from the parent process will return the process id of the child.
- fork() call from the child process will return 0. (The age of the child is zero.)
- After the fork, both processes resume execution starting at the fork call.
- Based on the return value, the parent and child can perform different functions.

fork example

```
switch (pid = fork()) {
        case -1:
                printf("----> ERROR: Unable to create child process.\n");
                exit(0);
        case 0:
                go_do_child_stuff();
                break;
        default:
                printf("PARENT started CHILD process id %d\n”, pid);
                break;
        }
        … Parent process continues
```

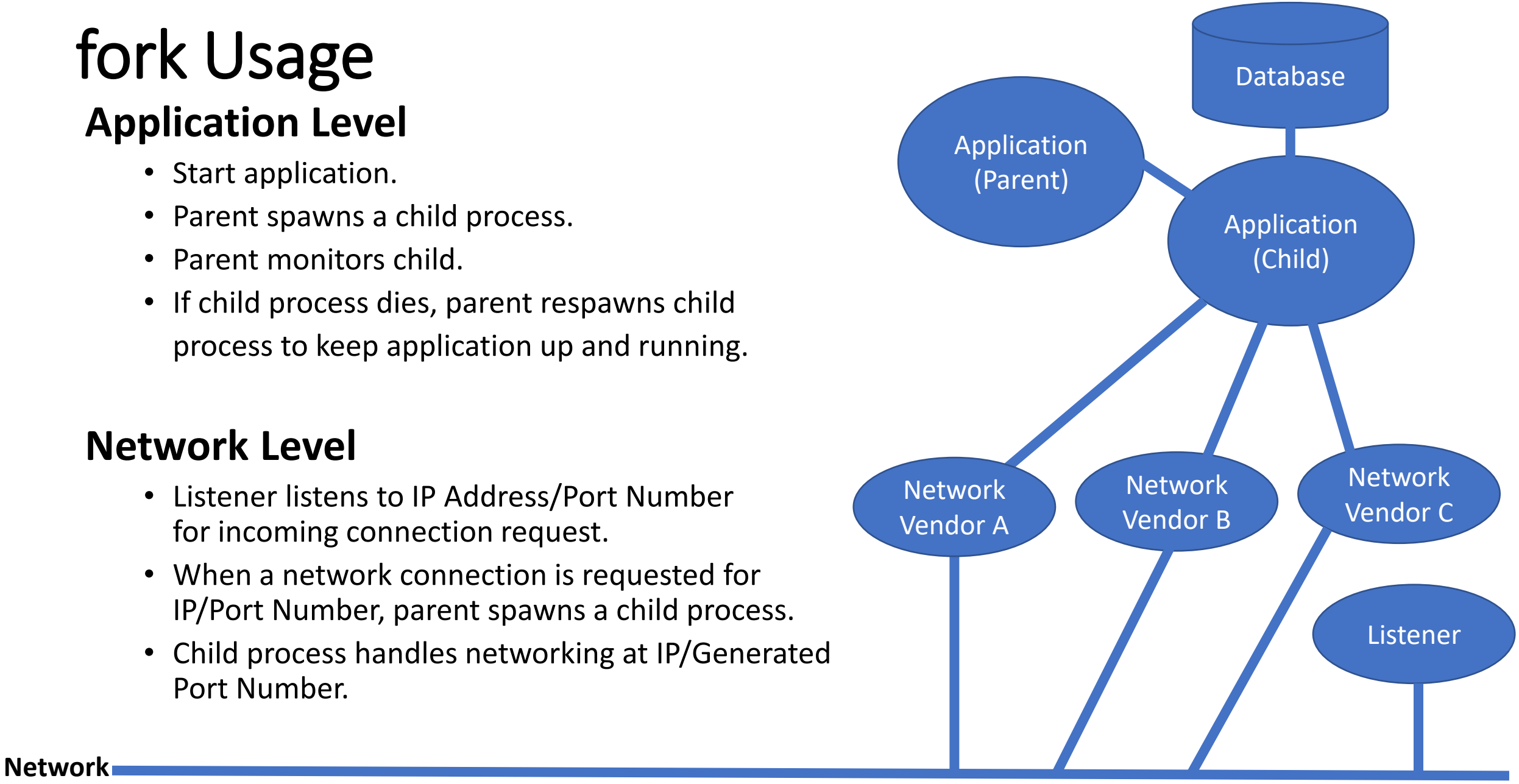
fork Usage

Application Level

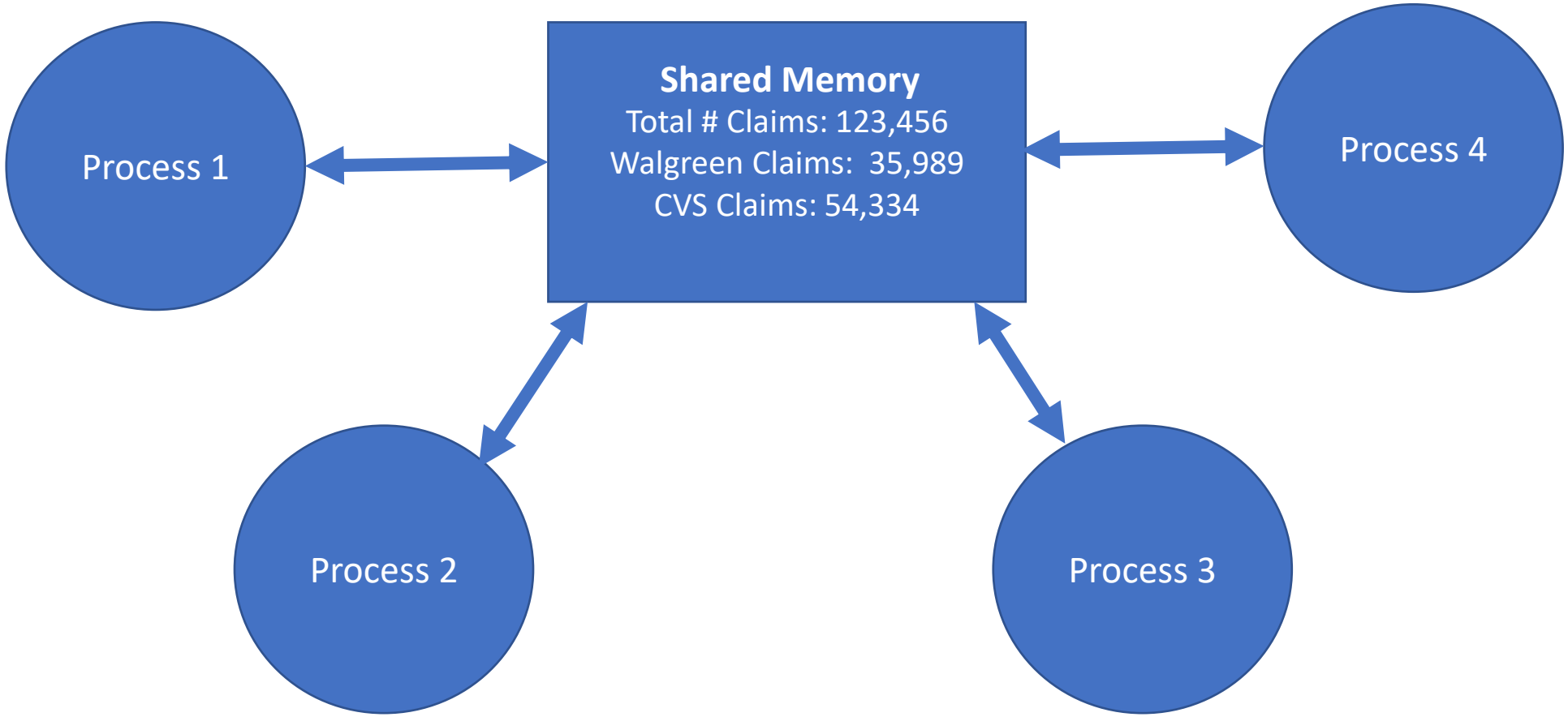
- Start application.
- Parent spawns a child process.
- Parent monitors child.
- If child process dies, parent respawns child process to keep application up and running.

Network Level

- Listener listens to IP Address/Port Number for incoming connection request.
- When a network connection is requested for IP/Port Number, parent spawns a child process.
- Child process handles networking at IP/Generated Port Number.



Shared Memory



Shared Memory Calls - shmget

NAME

shmget - get shared memory segment identifier

SYNOPSIS

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

int shmget(key_t key, size_t size, int shmflg);
```

RETURN VALUES

Upon successful completion, a non-negative integer representing a shared memory identifier is returned. Otherwise, -1 is returned and errno is set to indicate the error.

shmat – Shared Memory Attach

NAME

shmop, shmat, shmdt - shared memory operations

SYNOPSIS

```
#include <sys/types.h>
#include <sys/shm.h>

void *shmat(int shmid, const void *shmaddr, int shmflg);
int shmdt(const void *shmaddr);
```

RETURN VALUES

Upon successful completion, shmat() returns the data segment start address of the attached shared memory segment. Otherwise, SHM_FAILED (-1) is returned, the shared memory segment is not attached, and errno is set to indicate the error.

Create Shared Memory Segment

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

#define SHM_SIZE 1024
```

```
int main()
{
    key_t key = 1234;
    int shmid;
    // Create shared memory.
    // Tricky Note: IPC_CREAT = 0x200 hex, 0644 is octal.
    if ((shmid = shmget(key, SHM_SIZE, 0644 | IPC_CREAT)) == -1)
    {
        printf("ERROR: shmget failed.\n");
        exit(1);
    }
    return 0;
}
```

Copy b.c to b1.c, b2.c, b3.c. Update memory.

```
#define SHM_SIZE 1024
// Usage: b “text to write into shared memory”
int main(int argc, char *argv[])
{
   key_t key = 1234;
   int shmid;
   char *shm_ptr;
   int mode;

// Get shared memory.
   if ((shmid = shmget(key, SHM_SIZE, 0644)) == -1) {
      printf("ERROR: shmget failed.\n"); exit(1);
   }
// Attach to shared memory. shmat returns pointer.
   shm_ptr = shmat(shmid, (void *)0, 0);
   if (shm_ptr == (char *)(-1)) {
      printf("ERROR: shmat failed.\n"); exit(1);
   }
```

```
   // Read from shared memory.
   printf("Read from shared memory: \"%s\"\n",
shm_ptr);

   // Write to shared memory.
   printf("Write to shared memory: \"%s\"\n",
argv[1]);
   strncpy(shm_ptr, argv[1], SHM_SIZE);

   // Read from shared memory.
   printf("Read from shared memory: \"%s\"\n",
shm_ptr);

   // Detach from shared memory.
   if (shmdt(shm_ptr) == -1) {
      printf("ERROR: shmdt failed.\n"); exit(1);
   }
   return 0;
}
```

Delete Shared Memory

```
#define SHM_SIZE 1024

int main(int argc, char *argv[])
{
    key_t key = 1234;
    int shmid;

if ((shmid = shmget(key, SHM_SIZE, 0644)) == -1) {          // Get shared memory id.
        printf("ERROR: shmget failed.\n");
        exit(1);
    }
    shmctl(shmid, IPC_RMID, NULL);                          // Delete shared memory.
    return 0;
}
```

Sample Run for Shared Memory

```
john@oho:~/SHM$ b1 "Hello World"
ERROR: shmget failed.

john@oho:~/SHM$ create_shm

john@oho:~/SHM$ b1 "Hello World"
Read from shared memory: ""
Write to shared memory: "Hello World"
Read from shared memory: "Hello World“

john@oho:~/SHM$ b2 "This is a test"
Read from shared memory: "Hello World"
Write to shared memory: "This is a test"
Read from shared memory: "This is a test"
```

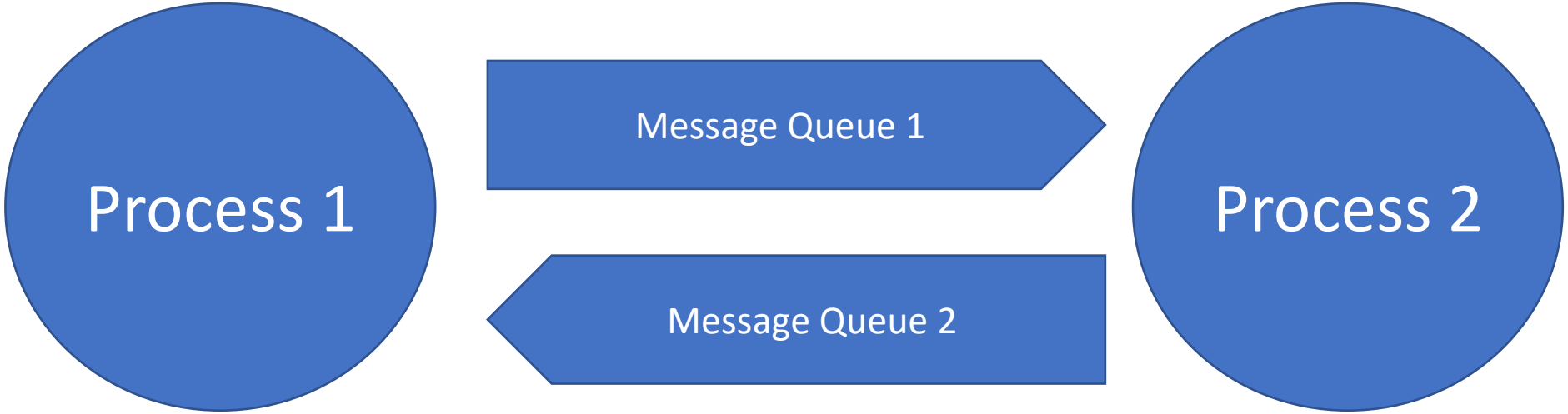
```
john@oho:~/SHM$ b3 "Shared Memory Works!"
Read from shared memory: "This is a test"
Write to shared memory: "Shared Memory Works!"
Read from shared memory: "Shared Memory Works!“

john@oho:~/SHM$ delete_shm

john@oho:~/SHM$ b1 "Hello again"
ERROR: shmget failed.

john@oho:~/SHM$ ls
b.c  b1  b1.c  b2  b2.c  b3  b3.c  create_shm  create_shm.c
delete_shm  delete_shm.c
```

Message Queues



msgget

NAME
msgget - get message queue

SYNOPSIS
#include <sys/msg.h>
int msgget(key_t key, int msgflg);

DESCRIPTION
The msgget() argument returns the message queue identifier associated with key.

% more c.c

```
#include <stdio.h>
#include <sys/msg.h>

int main()
{
      int    mq;

      mq = msgget(1000, 0666|IPC_CREAT);          ← Creates the message queue 1000.

      printf("message queue 1000 created.\n");
}
```

msgsnd / msgrcv

NAME

msgsnd - message send operation

SYNOPSIS

```
#include <sys/msg.h>
int msgsnd(int msqid, const void *msgp,  size_t  msgsz,  int msgflg);
```

DESCRIPTION

The msgsnd() function is used to send a message to the queue associated with the message queue.

NAME

msgrcv - message receive operation

SYNOPSIS

```
#include <sys/msg.h>
ssize_t msgrcv(int msqid, void *msgp, size_t msgsz, long int msgtyp, int msgflg);
```

DESCRIPTION

The msgrcv() function reads a message from the queue associated with the message queue identifier specified by msqid and places it in the user-defined buffer pointed to by msgp.

msgsnd

```
% cat s.c
#include <stdio.h>
#include <sys/msg.h>

struct my_message {
        long    mtype;
        char    mtext[100];
} my_msg;

int main()
{
        int     mq;
        int     return_val = 0;

        mq = msgget(1000, 0666);

        my_msg.mtype = 100;
        strcpy(my_msg.mtext, "Hello!");

    if ((return_val = msgsnd(mq, &my_msg,
                        sizeof(struct my_message), 0666)) < 0) {
        printf("msgsnd failed.\n");
    }
    if ((return_val = msgsnd(mq, &my_msg,
                        sizeof(struct my_message), 0666)) < 0) {
        printf("msgsnd failed.\n");
    }

    my_msg.mtype = 200;
    strcpy(my_msg.mtext, "Bye!");

    if ((return_val = msgsnd(mq, &my_msg,
                        sizeof(struct my_message), 0666)) < 0) {
        printf("msgsnd failed.\n");
    }

    printf("msgsnd worked.\n");
}
```

msgrcv – mtype = 100

```
% cat r100.c
#include <stdio.h>
#include <sys/msg.h>

struct my_message {
        long    mtype;
        char    mtext[100];
} my_msg;

int main()
{
        int     mq;
        int     return_val = 0;

        mq = msgget(1000, 0666);
        if ((return_val = msgrcv(mq, &my_msg, sizeof(struct my_message), 100, 0666)) < 0) {          // Return message with type = 100
          printf("msgrcv failed.\n");
        }

        printf("msgrcv: my_msg.mtype = %d, my_msg.mtext = %s\n", my_msg.mtype, my_msg.mtext);
        printf("msgrcv worked.\n");
}
```

msgrcv – mtype = 200

```
% cat r200.c
#include <stdio.h>
#include <sys/msg.h>
struct my_message {
        long    mtype;
        char    mtext[100];
} my_msg;

int main()
{
        int     mq;
        int     return_val = 0;

        mq = msgget(1000, 0666);
        if ((return_val = msgrcv(mq, &my_msg, sizeof(struct my_message), 200, 0666)) < 0) {       // mtype = 200
          printf("msgrcv failed.\n");
        }

        printf("msgrcv: my_msg.mtype = %d, my_msg.mtext = %s\n", my_msg.mtype, my_msg.mtext);
        printf("msgrcv worked.\n");
}
```

msgget, msgsnd, msgget Example

% c
message queue 1000 created.

% s **← Puts {100, “Hello!”}, {100, “Hello!”}, {200, “Bye!”} on queue.**
msgsnd worked.

%r100
msgrcv: my_msg.mtype = 100, my_msg.mtext = Hello!
msgrcv worked.

%r200
msgrcv: my_msg.mtype = 200, my_msg.mtext = Bye!
msgrcv worked.

%r100
msgrcv: my_msg.mtype = 100, my_msg.mtext = Hello!
msgrcv worked.

%r100 **← No more 100 message types on queue. r100 blocks/waits for next 100 type.**
^C
%r200 **← No more 200 message types on queue. r200 blocks/waits for next 200 type.**
^C

Message Queues

Message queues are used to send incoming transactions from the Network Vendor process to the Application Process.

Separate message queues are used to send responses from the Application to the Network Vendor process.