How to communicate between processes/threads?

Prof. Yung-Pin Cheng

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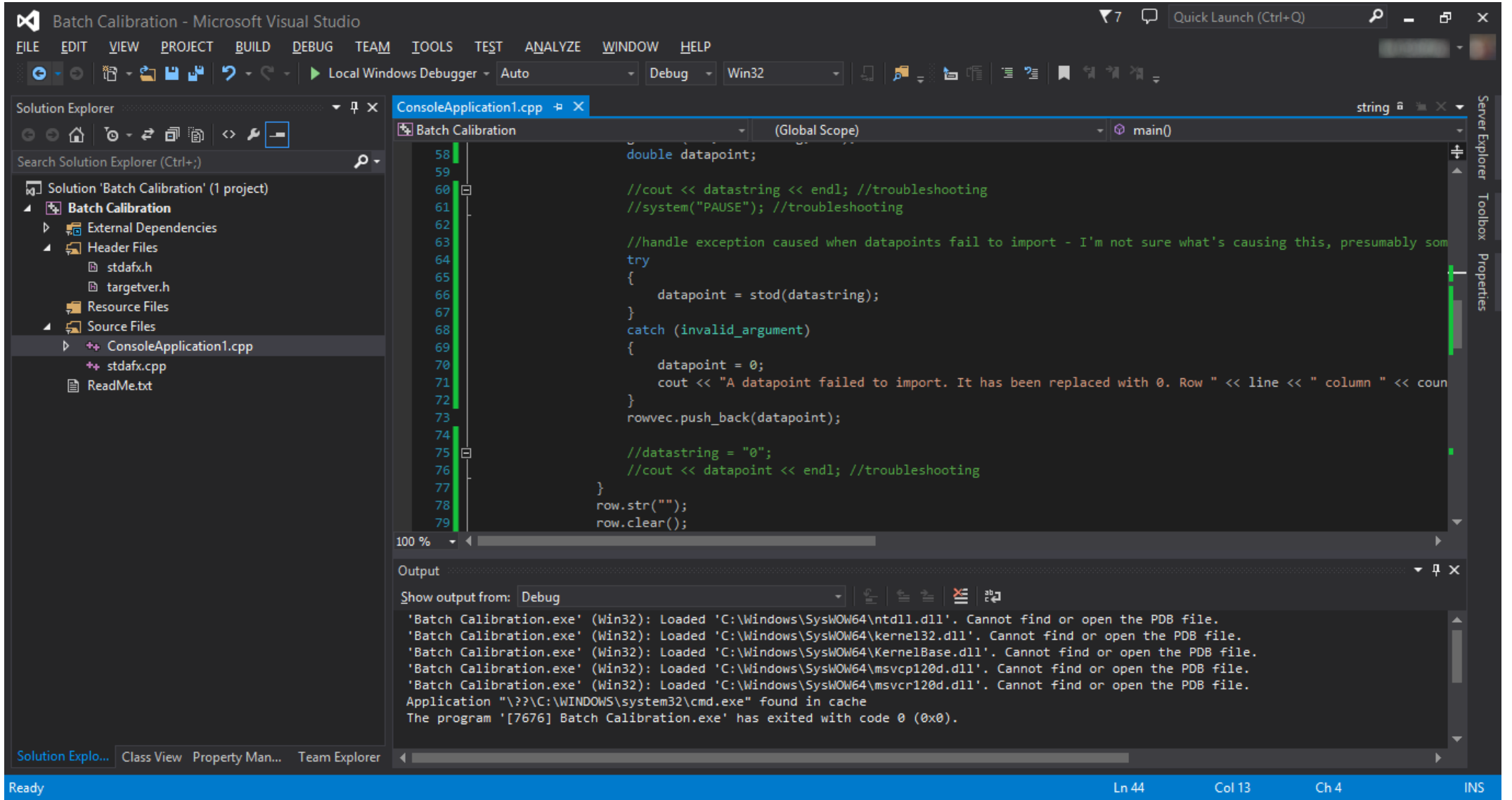
Timing to communicate between processes and threads?

- In practice, always packing your code (assume large enough) into a monolithic chunk of program (i.e., an .exe) is not a good choice in many cases.

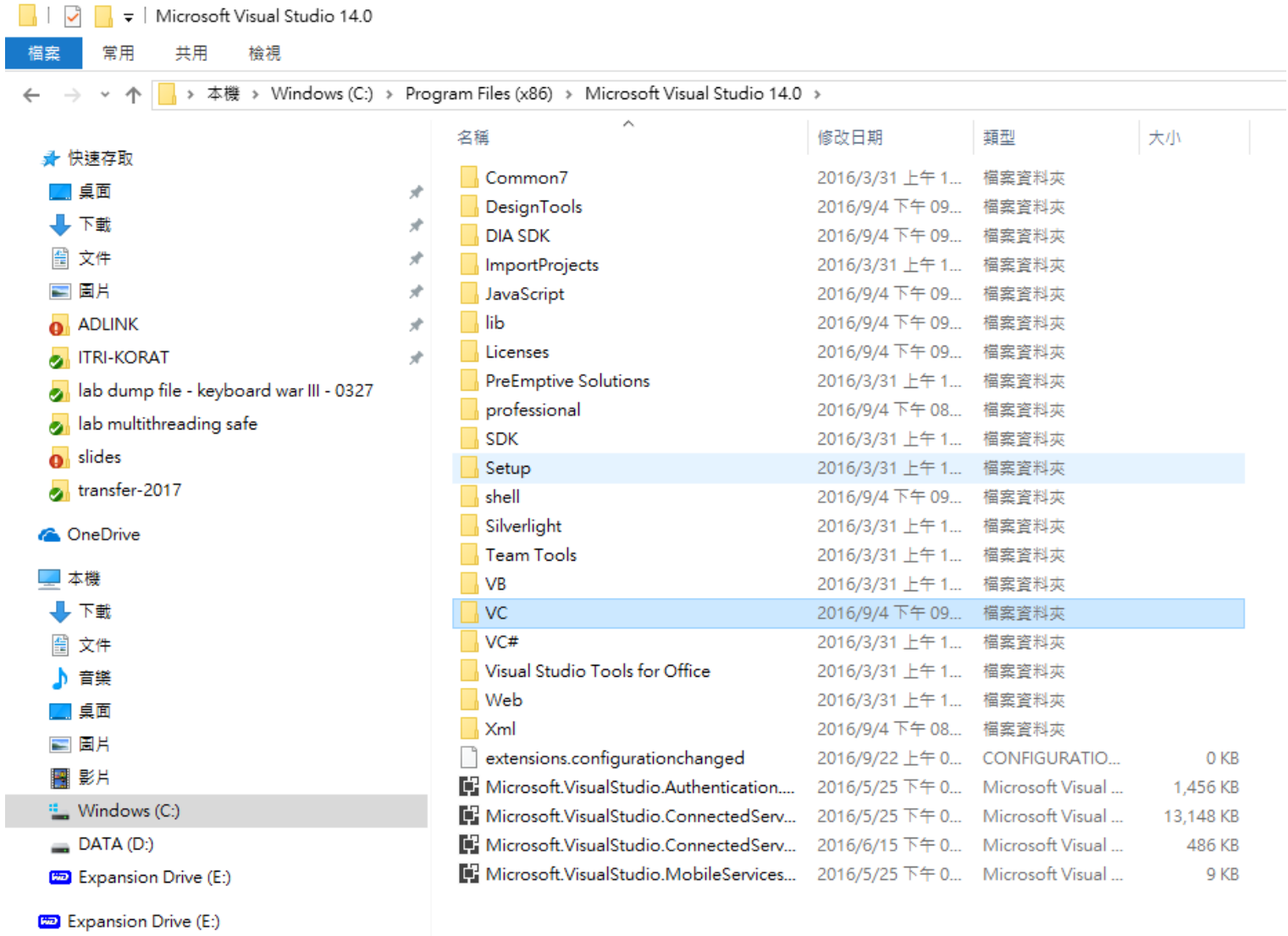
Visual Studio



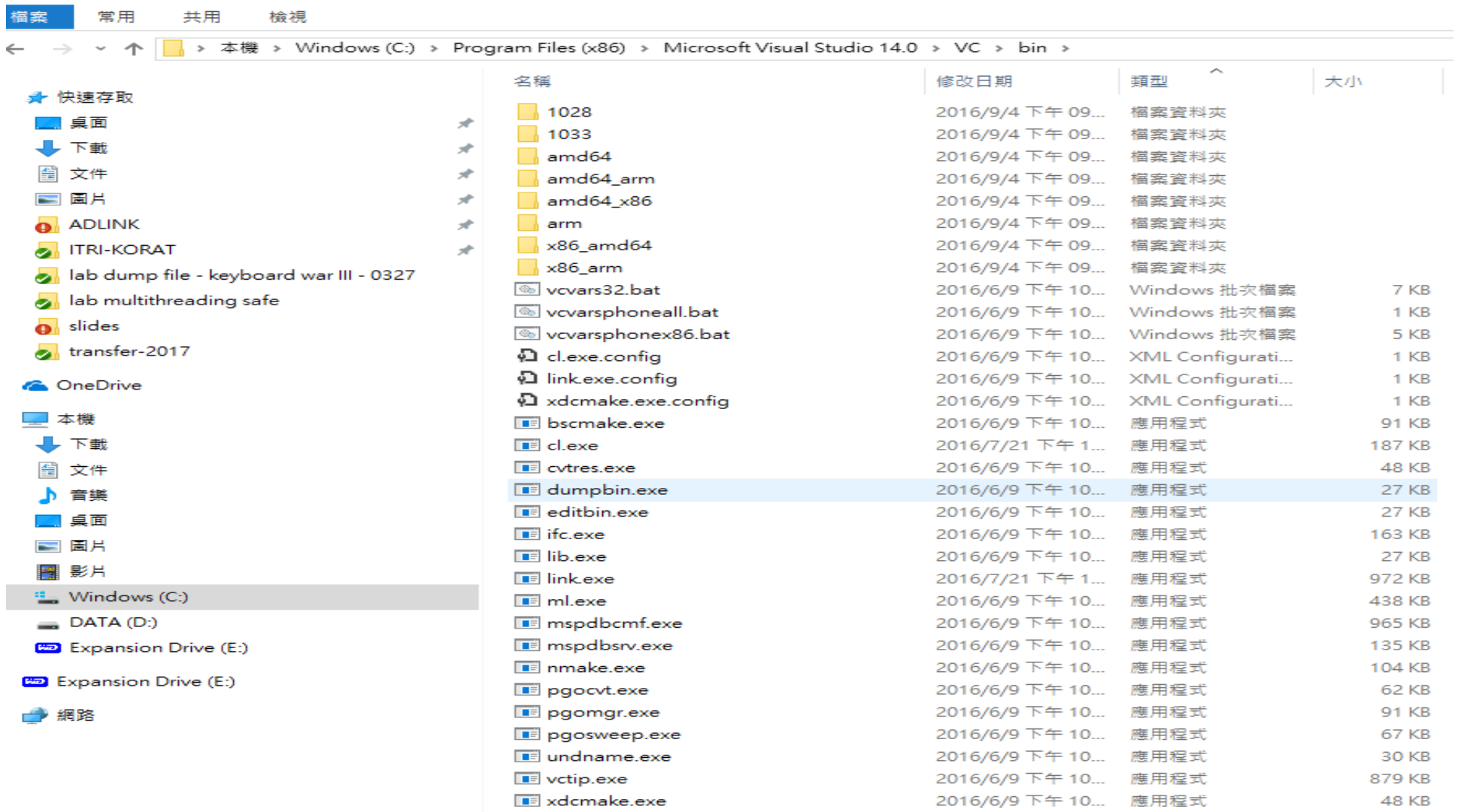
Visual Studio

- You may think Visual Studio is a big .exe
- Actually its code only contains GUI + editor
- When you hit “build” it actually pass the your compiler options/linking options to Cl.exe, link.exe

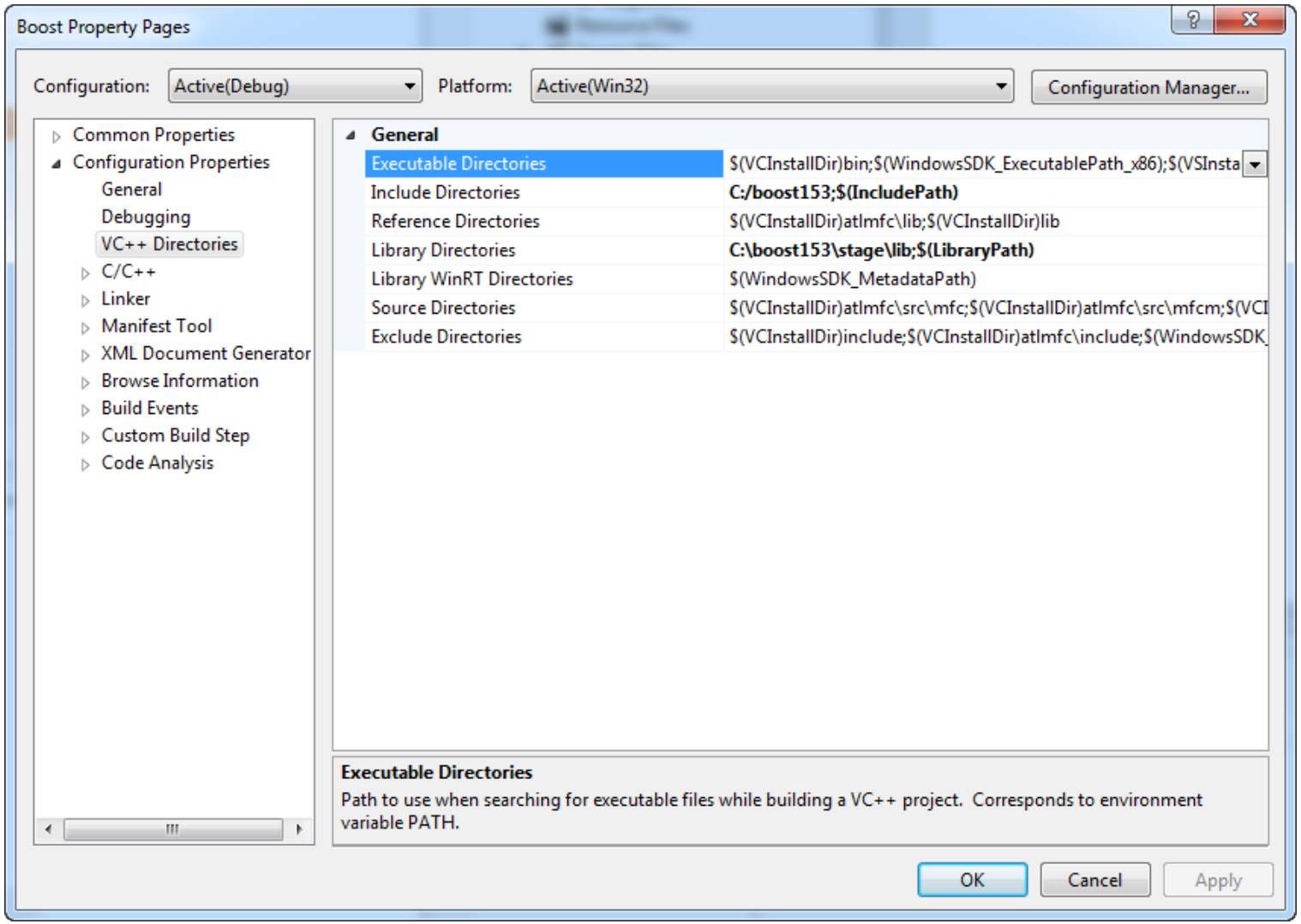
Visual Studio



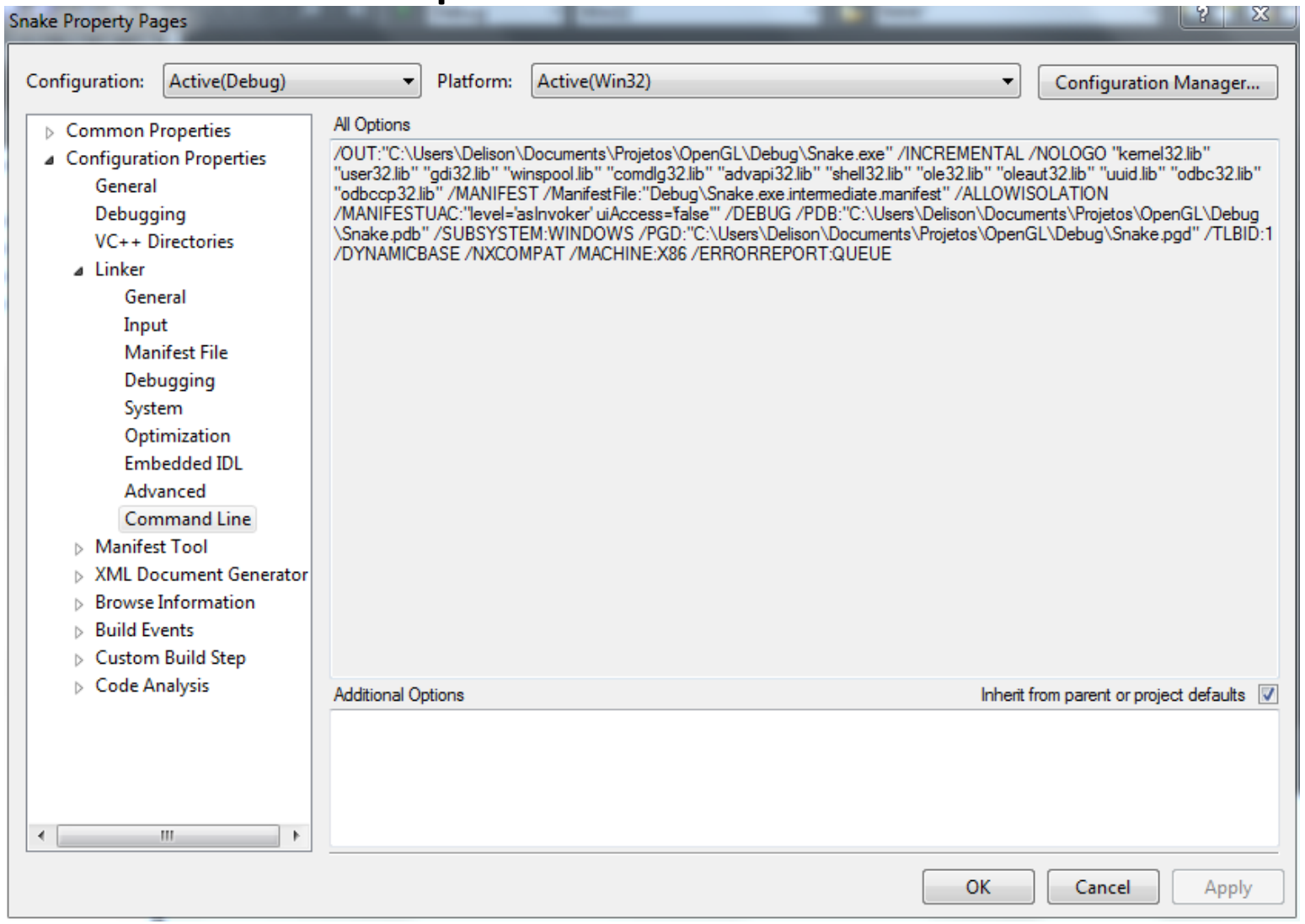
Visual Studio



Compiler/Linker Options in Visual Studio



Command Line options



Why?

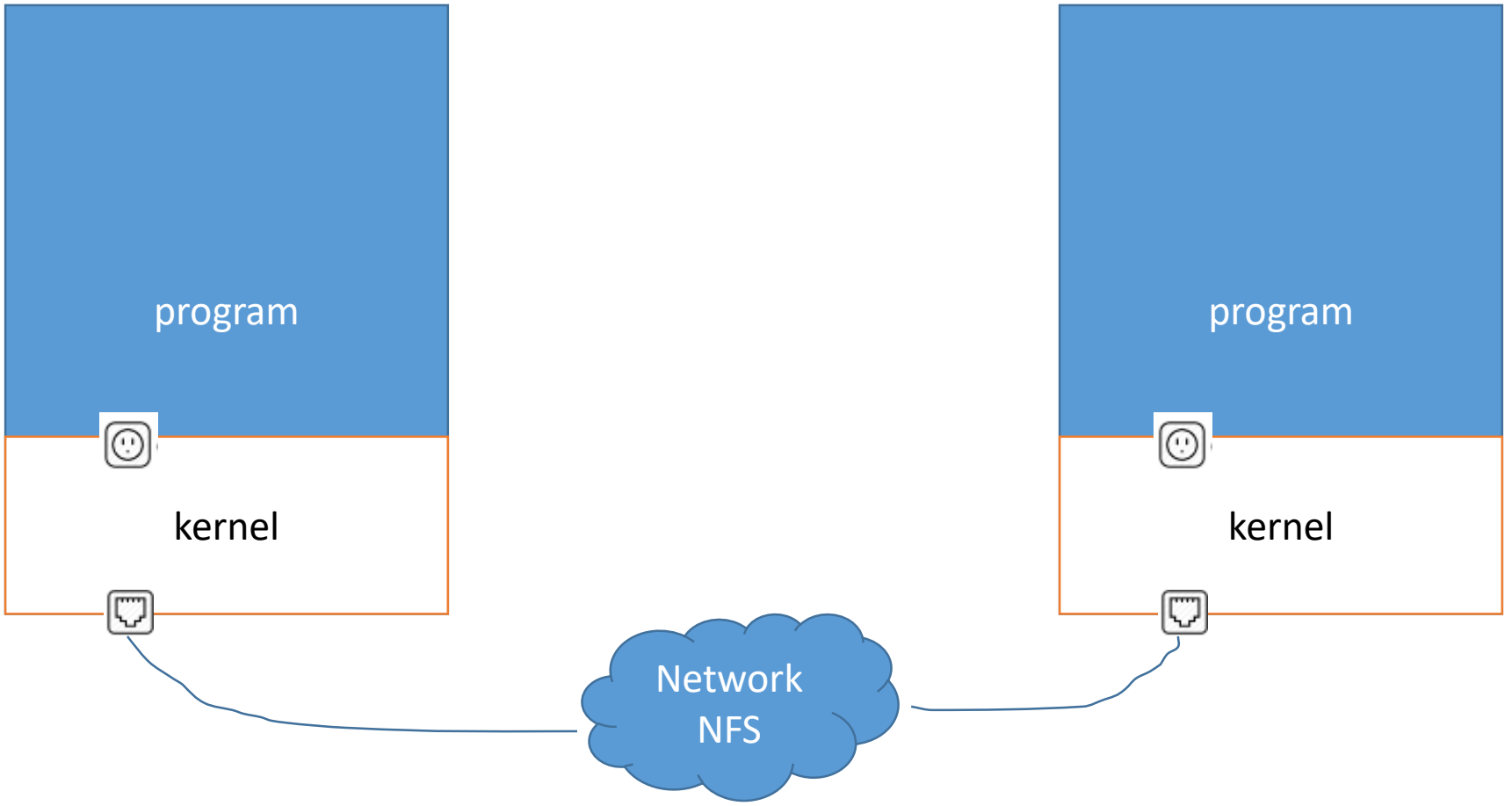
- A large program is usually hard to maintain and extend.
- If you include C compiler code in Visual Studio, every time C compiler code change, all Visual Studio code (million lines) need to be recompiled, debugged, and tested.
- So, divide a large-scale program into several small programs is a common design when performance issues are not compromised. This is called decoupling.
- Each program is self-contained, smaller, and more manageable.

To break or not to break !!
That is the question.

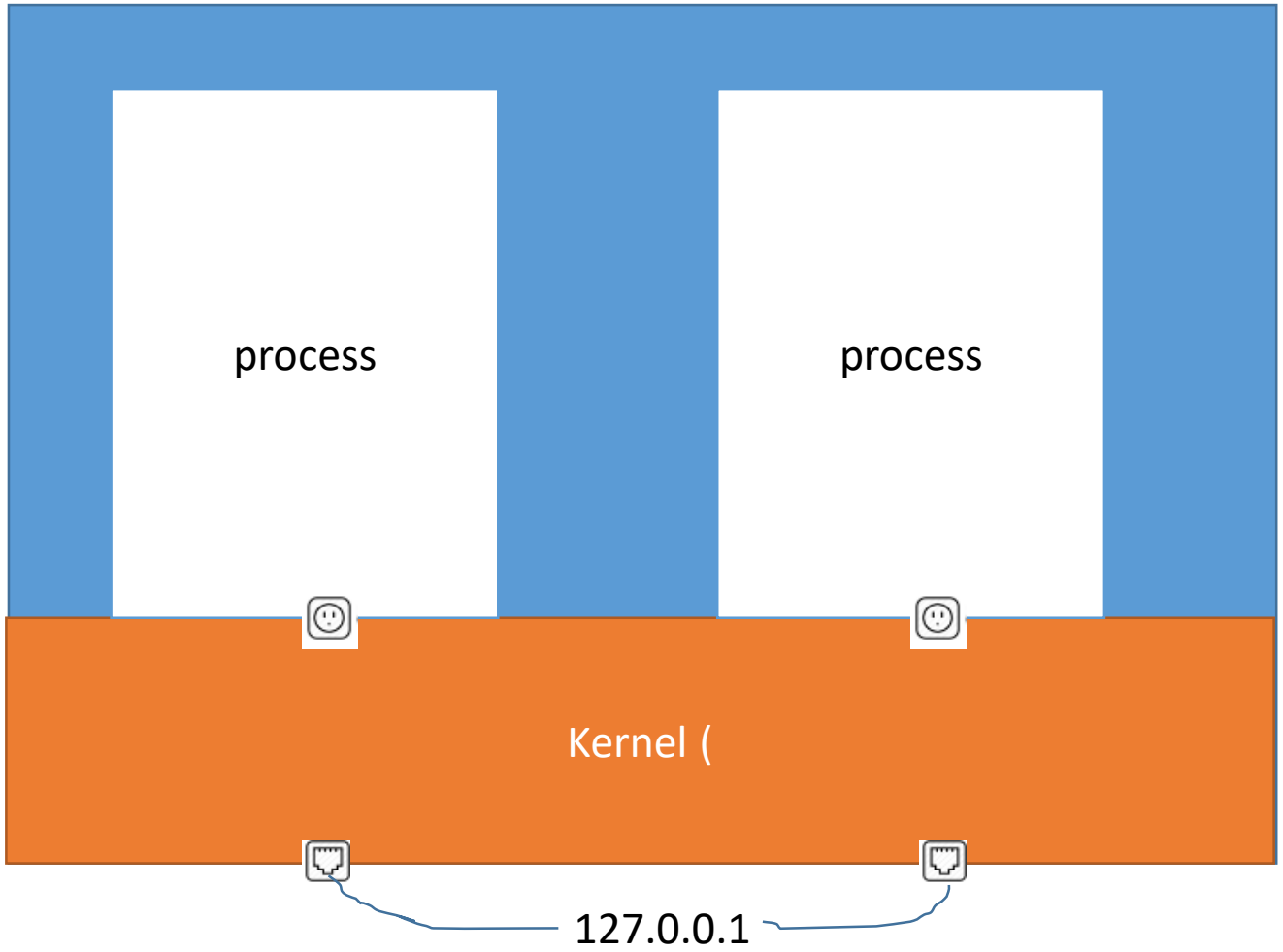
Break it !!

- In case you break it. You will find you often need to make two programs (processes) communicate.

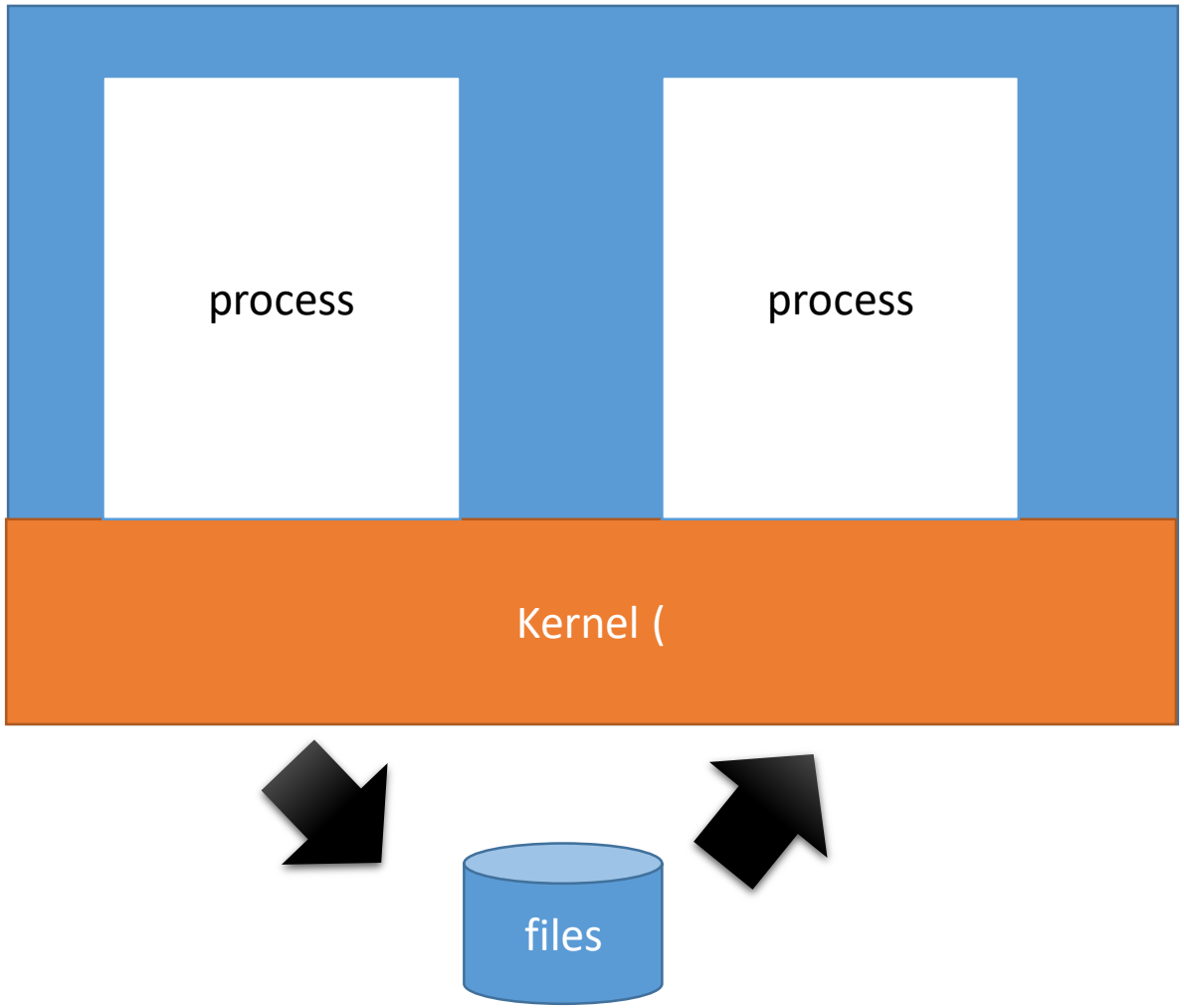
Cross Computer Communication - Socket



Programs in the same computer - socket



Programs in the same computer – files

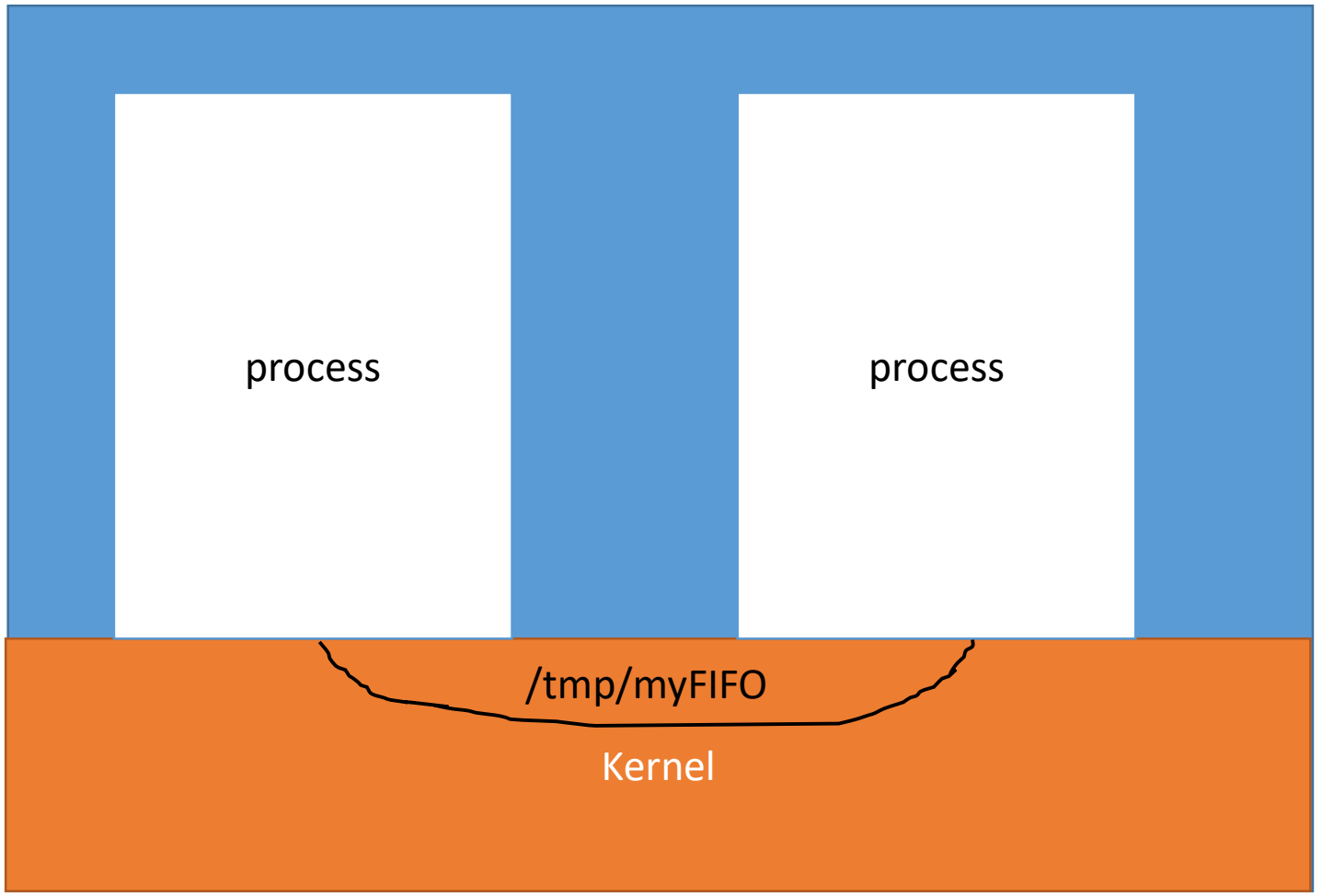


Synchronization by files

- You may want to have a program read the file at then have a program to write (append?) at the same time. Message is passed by file.
- Don’t try it !! However, you are welcome to try it to understand why

- If you really want to pass info by files
  - Use other communication technique to notify another program that the file is ready for reading or ready for writing
  - Make sure you flush the file before doing so

Programs in the same computer – named pipes



Linux named pipe

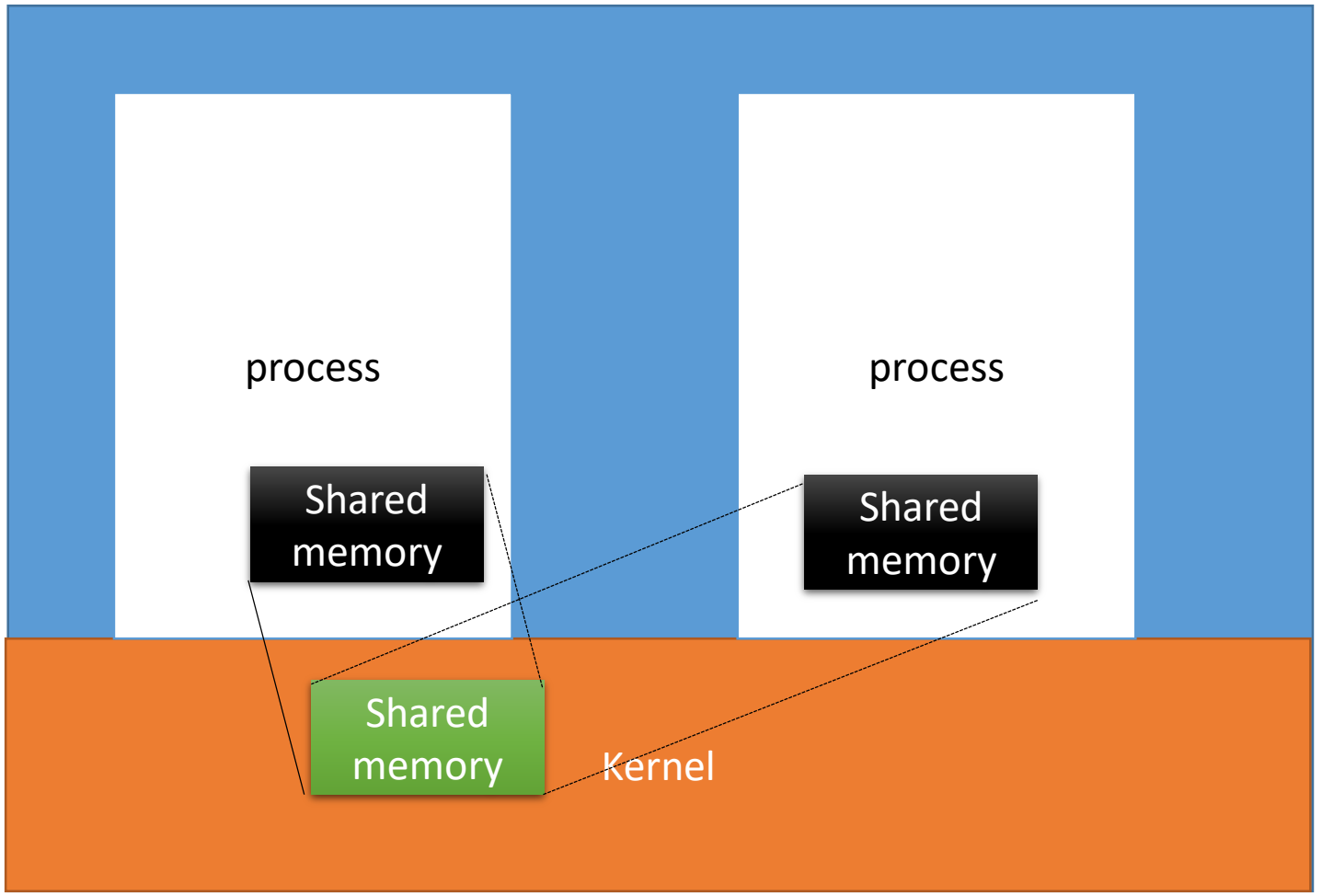
writer.c

```c
#include <fcntl.h>
#include <sys/stat.h>
#include <sys/types.h>
#include <unistd.h>

int main()
{
    int fd;
    char * myfifo = "/tmp/myfifo";

    /* create the FIFO (named pipe) */
    mkfifo(myfifo, 0666);

    /* write "Hi" to the FIFO */
    fd = open(myfifo, O_WRONLY);
    write(fd, "Hi", sizeof("Hi"));
    close(fd);

    /* remove the FIFO */
    unlink(myfifo);

    return 0;
}
```

reader.c

```c
#include <fcntl.h>
#include <stdio.h>
#include <sys/stat.h>
#include <unistd.h>

#define MAX_BUF 1024

int main()
{
    int fd;
    char * myfifo = "/tmp/myfifo";
    char buf[MAX_BUF];

    /* open, read, and display the message from the FIFO */
    fd = open(myfifo, O_RDONLY);
    read(fd, buf, MAX_BUF);
    printf("Received: %s\n", buf);
    close(fd);

    return 0;
}
```

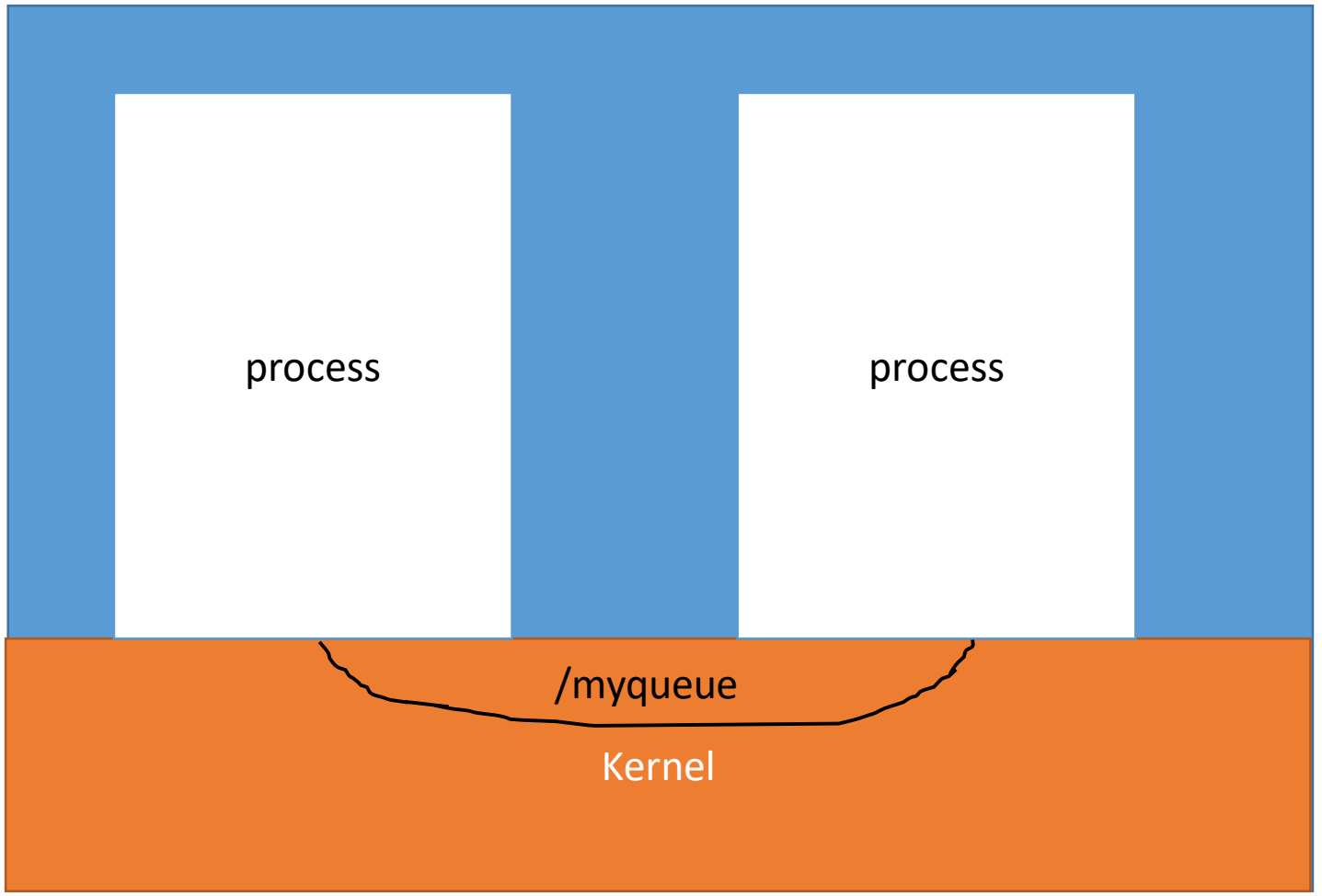
Programs in the same computer – shared memory



Shared memory

- In time-sharing multitasking, process address space are protected by hardware to prevent memory from messed up by another process
- However, you can request an area of shared memory from O.S.
- O.S. setup the physical frame and make page table of p1 and p2 point to the same physical frame
- Once you do so, you begins to risk yourself in race

Programs in the same computer – message queue



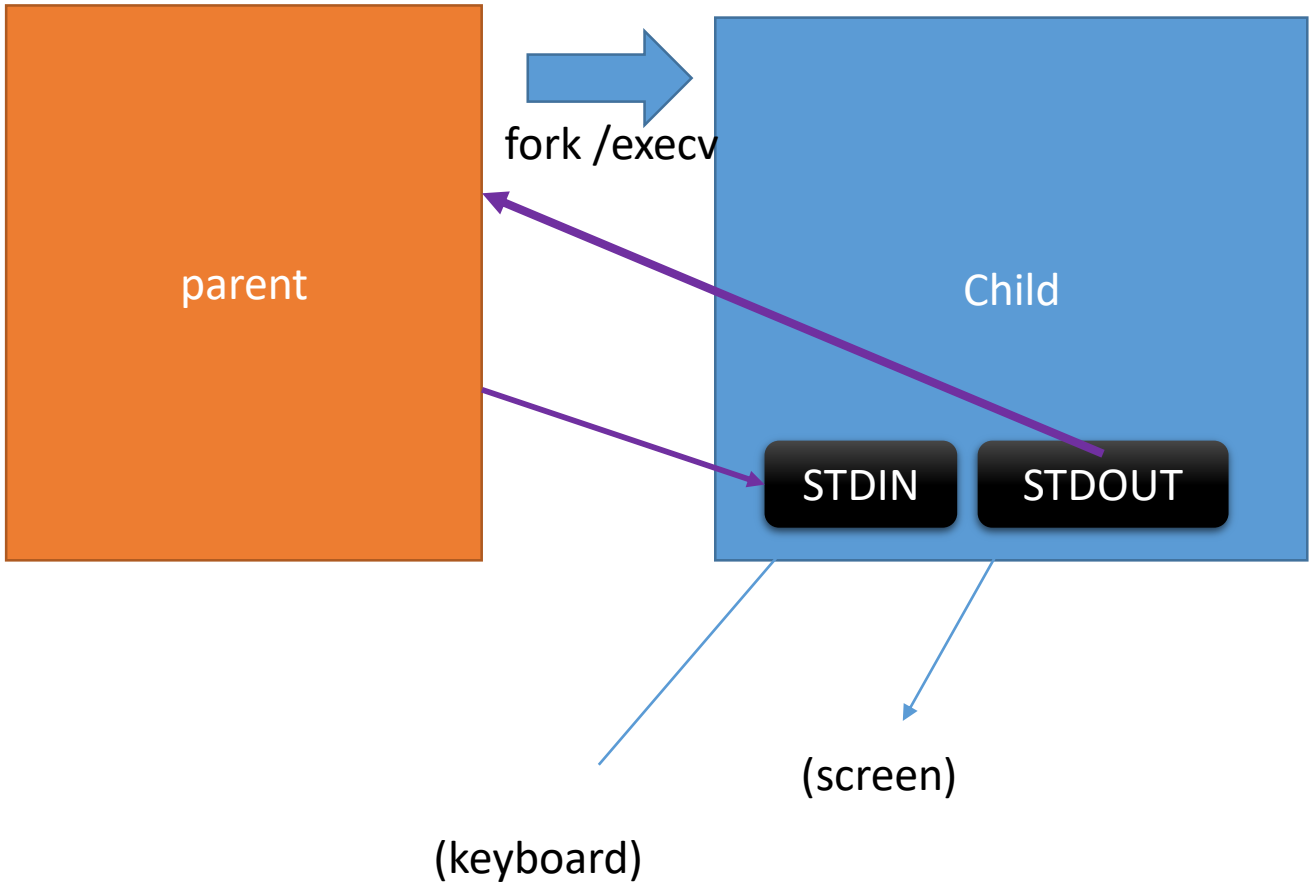
```c
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <sys/stat.h>
#include <sys/types.h>
#include <mqueue.h>

#include "common.h"


int main(int argc, char **argv)
{
    mqd_t mq;
    char buffer[MAX_SIZE];

    /* open the mail queue */
    mq = mq_open(QUEUE_NAME, O_WRONLY);
    CHECK((mqd_t)-1 != mq);


    printf("Send to server (enter \"exit\" to stop it):\n");

    do {
        printf("> ");
        fflush(stdout);

        memset(buffer, 0, MAX_SIZE);
        fgets(buffer, MAX_SIZE, stdin);

        /* send the message */
        CHECK(0 <= mq_send(mq, buffer, MAX_SIZE, 0));

    } while (strncmp(buffer, MSG_STOP, strlen(MSG_STOP)));

    /* cleanup */
    CHECK((mqd_t)-1 != mq_close(mq));
```

```c
int main(int argc, char **argv)
{
    mqd_t mq;
    struct mq_attr attr;
    char buffer[MAX_SIZE + 1];
    int must_stop = 0;

    /* initialize the queue attributes */
    attr.mq_flags = 0;
    attr.mq_maxmsg = 10;
    attr.mq_msgsize = MAX_SIZE;
    attr.mq_curmsgs = 0;

    /* create the message queue */
    mq = mq_open(QUEUE_NAME, O_CREAT | O_RDONLY, 0644, &attr);
    CHECK((mqd_t)-1 != mq);

    do {
        ssize_t bytes_read;

        /* receive the message */
        bytes_read = mq_receive(mq, buffer, MAX_SIZE, NULL);
        CHECK(bytes_read >= 0);

        buffer[bytes_read] = '\0';
        if (! strncmp(buffer, MSG_STOP, strlen(MSG_STOP)))
        {
            must_stop = 1;
        }
        else
        {
            printf("Received: %s\n", buffer);
        }
    } while (!must_stop);
```

Pipe vs Message Queue

- Pipes are flat, much like a stream, to impose a message structure you would have to implement a protocol on both sides, message queues are message oriented already, no care has to be taken to get, say, the fifth message in the queue.
- Pipes aren't limited in size, message queues are.
- Pipes can be integrated in systems using file descriptors, message queues have their own set of functions, though linux supports select(), poll(), epoll() and friends on the mqd_t.
- Pipes, once closed, require some amount of cooperation on both sides to reestablish them, message queues can be closed and reopened on either side without the coorporation of the other side.

Programs in the same computer – I/O redirect



Thread to Thread -

- As described in previous slide
- Threads can share static variables in data
- Threads can share referenced object in heap