Operating Systems

University at Albany
Department of Computer Science
Chongqing University of Posts and Telecommunications
Computer Science, International College
ICSI 412

Project-2
Assigned: Thursday, April 21th, 2025.
Due: To be determined by your co-instructor.

PURPOSE
Develop a practical understanding of task collaboration using socket programming, semaphores, and multithreading.

OBJECTIVES
Develop a multithreaded client/server application using Linux TCP sockets and the C programming language. Your solution will respond to service requests by clients. Such requests may be either by providing the IP address of the server or the name of the host where the server is executing.

PROBLEM
You are to develop a data processing system to process strings of characters. The solution must replace all instances of lowercase vowels with uppercase ones and append to the last set of strings the sum of all numbers found.

You are to design and implement a client/server application where the server will respond to different client requests by creating two dedicated new processes. One process will read from the socket and will create seven threads. The other process will collect the messages processed by the threads and will write the resulting data to the socket.

THE SERVER
Accepts multiple client requests and for each request creates two *child* processes. These processes are to be named **serverDecoder** and **ServerEncoder**. The **ServerDecoder** will read from the socket, and will create the following seven threads:

1 The **charA** thread will read data provided by the decoder process and will replace all lowercase **a characters only** with its corresponding uppercase A. It will share the data received with the *charE* thread through a queue of messages.

2 The **charE** thread component will scan the data shared and replace all lowercase **e** characters with uppercase E. It will then share the modified data with the *charI* thread through another queue of messages.
3 The **charI** thread component will scan the data shared and replace all lowercase **i** characters with uppercase **I**. It will then share the modified data with the *charO* thread through another queue of messages.
4 The **charO** thread component will scan the data shared and replace all lowercase **o** characters with uppercase **O**. It will then share the modified data with the *charU* thread through another queue of messages.
5 The **charU** thread component will scan the data shared and replace all lowercase **u** characters with uppercase **U**. It will then share the modified data with the *digit* thread through another queue of messages.
6 The **digit** thread component will scan the data shared and compute the sum of all digits found. It will then share the processed data with the *writer* thread through another queue of messages. This thread will also append the total sum of all digits found to the data received. The last sentence of the data processed must include the following: Sum of digits is *Integer returned through the successful execution of the digit thread.*
7 The **writer** thread will share the data received with the **serverEncoder** process.

The **serverEncoder** will share the resulting data with the client through the socket connection.

CLIENT/SERVER IMPLEMENTATION DETAILS

1. You must develop a module that implements a queue of character strings.
2. This structure will be an array of pointers to strings with integers (pointers) to indicate the head and tail of the list.
3. The maximum size of the buffer array will be 10.
4. Threads should terminate when the end of input data is reached.

THE CLIENT

Creates two processes, the **clientEncoder** and the **clientDecoder**. The **clientEncoder** will open input files and will write data to the socket. The **clientDecoder** will read data from the socket and will write the decoded data to a file.

INPUT TEST FILE (*intext.txt*)

You are encouraged to test your solution with large data sets. For testing your prototype, you are to name your input file as *intext.txt* and populate it with text. You are to use the following text during the early stages of your prototype development.

Machine representation of the source code.
Source code represents the part of process that contains the programming

language itself. You may use a text editor to write your source code file. A compiler will be used to produce a machine representation of your source code. Such representation may show your code as hexadecimal or binary formats. The resulting hexadecimal code will contain combinations of numbers such 1 3 5 8 2 4 6 9 12 21 13 31 14 41 15 51 16 61 17 71 18 81 19 91 100 or combinations of characters and numbers such as 1A3B4C0DEFA, for example.

OUTPUT

The final data received by the client must be stored in a file named *result.txt*.

SAMPLE CODE

```
/* Program: server.c
 * A simple TCP server using sockets.
 * Server is executed before Client.
 * Port number is to be passed as an argument.
 *
 * To test: Open a terminal window.
 * At the prompt ($ is my prompt symbol) you may
 * type the following as a test:
 *
 * $ ./server 54554
 * Run client by providing host and port
 *
 *
 */
#include <arpa/inet.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>

void error(const char *msg)
{
    perror(msg);
    exit(1);
}

int main(int argc, char *argv[])
{
     int sockfd, newsockfd, portno;
     socklen_t clilen;
     char buffer[256];
     struct sockaddr_in serv_addr, cli_addr;
     int n;
```

```
    if (argc < 2) {
        fprintf(stderr,"ERROR, no port provided\n");
        exit(1);
    }
    fprintf(stdout, "Run client by providing host and port\n");
    sockfd = socket(AF_INET, SOCK_STREAM, 0);
    if (sockfd < 0)
       error("ERROR opening socket");
    bzero((char *) &serv_addr, sizeof(serv_addr));
    portno = atoi(argv[1]);
    serv_addr.sin_family = AF_INET;
    serv_addr.sin_addr.s_addr = INADDR_ANY;
    serv_addr.sin_port = htons(portno);
    if (bind(sockfd, (struct sockaddr *) &serv_addr,
             sizeof(serv_addr)) < 0)
             error("ERROR on binding");
    listen(sockfd,5);
    clilen = sizeof(cli_addr);
    newsockfd = accept(sockfd,
                (struct sockaddr *) &cli_addr,
                &clilen);
    if (newsockfd < 0)
       error("ERROR on accept");
    bzero(buffer,256);
    n = read(newsockfd,buffer,255);
    if (n < 0)
       error("ERROR reading from socket");
    printf("Here is the message: %s\n",buffer);
    n = write(newsockfd,"I got your message",18);
    if (n < 0)
       error("ERROR writing to socket");
    close(newsockfd);
    close(sockfd);
    return 0;
}

/*
 * Simple client to work with server.c program.
 * Host name and port used by server are to be
 * passed as arguments.
 *
 * To test: Open a terminal window.
 * At prompt ($ is my prompt symbol) you may
 * type the following as a test:
 *
 * $./client 127.0.0.1 54554
 * Please enter the message: Programming with sockets is fun!
 * I got your message
 * $
 *
 */
```

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>

void error(const char *msg)
{
    perror(msg);
    exit(0);
}

int main(int argc, char *argv[])
{
    int sockfd, portno, n;
    struct sockaddr_in serv_addr;
    struct hostent *server;

    char buffer[256];
    if (argc < 3) {
       fprintf(stderr,"usage %s hostname port\n", argv[0]);
       exit(0);
    }
    portno = atoi(argv[2]);
    sockfd = socket(AF_INET, SOCK_STREAM, 0);
    if (sockfd < 0)
        error("ERROR opening socket");
    server = gethostbyname(argv[1]);
    if (server == NULL) {
        fprintf(stderr,"ERROR, no such host\n");
        exit(0);
    }
    bzero((char *) &serv_addr, sizeof(serv_addr));
    serv_addr.sin_family = AF_INET;
    bcopy((char *)server->h_addr,
         (char *)&serv_addr.sin_addr.s_addr,
         server->h_length);
    serv_addr.sin_port = htons(portno);
    if (connect(sockfd,(struct sockaddr *)
&serv_addr,sizeof(serv_addr)) < 0)
        error("ERROR connecting");
    printf("Please enter the message: ");
    bzero(buffer,256);
    fgets(buffer,255,stdin);
    n = write(sockfd,buffer,strlen(buffer));
    if (n < 0)
         error("ERROR writing to socket");
    bzero(buffer,256);
    n = read(sockfd,buffer,255);
```

```
    if (n < 0)
         error("ERROR reading from socket");
    printf("%s\n",buffer);
    close(sockfd);
    return 0;
}
```

DOCUMENTATION

Your program should be developed using GNU versions of the C compiler. It should be layered, modularized, and well commented on. The following is a tentative marking scheme and what is expected to be submitted for this assignment:

1. External Documentation (as many pages necessary to fulfill the requirements listed below.) including the following:
    a. Title page
    b. A table of contents
    c. [20%] System documentation
        i. A high-level data flow diagram for the system
        ii. A list of routines and their brief descriptions
        iii. Implementation details
    d. [5%] Test documentation
        i. How you tested your program
        ii. Testing outputs
    e. [5%] User documentation
        i. Where is your source code located
        ii. How to run your program
        iii. Describe parameter (if any)

2. Source Code
    a. [65%] Correctness
    b. [5%] Programming style
        i. Layering
        ii. Readability
        iii. Comments
        iv. Efficiency

WHAT TO SUBMIT

The following are to be submitted to your co-instructor:

1. Your documentation for project-2. This document must be typeset and saved in MS Word.
2. Copies of all your source code files as well as their executables.
3. Copies of all data used for the testing of your solution.

4. All input files used and their generated output files.

You are to place all files that are related to your solution in a .zip file. Your .zip file must follow the format: *412 Project-2 Your Name*. Marks will be deducted if you do not follow this requirement.