**SERVER:**

#include <iostream>

#include <iomanip>

#include <cstdlib>

#include <unistd.h>

#include <stdio.h>

#include <sys/socket.h>

#include <stdlib.h>

#include <netinet/in.h>

#include <string.h>

#include <arpa/inet.h>

#include <vector>

#include <cstdlib>

#include <ctime>

#define PORT 8080

using namespace std;

// function for string delimiter

vector<string> split(string s, string delimiter) {

size\_t pos\_start = 0, pos\_end, delim\_len = delimiter.length();

string token;

vector<string> res;

while ((pos\_end = s.find (delimiter, pos\_start)) != string::npos) {

token = s.substr (pos\_start, pos\_end - pos\_start);

pos\_start = pos\_end + delim\_len;

res.push\_back (token);

}

res.push\_back (s.substr (pos\_start));

return res;

}

int main(int argc, char \*argv[])

{

// /\* deal with input arguments\*/

// std::cout << "print arguments:\nargc == " << argc << '\n';

// for(int ndx{}; ndx != argc; ++ndx) {

// std::cout << "argv[" << ndx << "] == " << argv[ndx] << '\n';

// }

// std::cout << "argv[" << argc << "] == "

// << static\_cast<void\*>(argv[argc]) << '\n';

srand((unsigned int)time(NULL)); // avoid always same output of rand()

float server\_local\_clock = rand() % 10; // range from 0 to 9

vector<float> clients\_local\_clocks;

printf("Sever starts. Server pid is %d \n", getpid());

printf("Server local clock is %f \n\n", server\_local\_clock);

// Socket Cite: https://www.geeksforgeeks.org/socket-programming-cc/?ref=lbp

int server\_socket\_fd, new\_socket, valread;

vector<int> client\_sockets;

vector<string> client\_ips;

vector<int> client\_ports;

struct sockaddr\_in server\_address;

server\_address.sin\_family = AF\_INET; // IPv4

server\_address.sin\_addr.s\_addr = INADDR\_ANY; // localhost

server\_address.sin\_port = htons( PORT ); // 8080

int opt = 1; // for setsockopt

// Creating socket file descriptor (IPv4, TCP, IP)

if ((server\_socket\_fd = socket(AF\_INET, SOCK\_STREAM, 0)) == 0)

{

perror("Server: socket failed");

exit(EXIT\_FAILURE);

}

// Optional: it helps in reuse of address and port. Prevents error such as: “address already in use”.

if (setsockopt(server\_socket\_fd, SOL\_SOCKET, SO\_REUSEADDR | SO\_REUSEPORT,

&opt, sizeof(opt)))

{

perror("Server: setsockopt");

exit(EXIT\_FAILURE);

}

// Forcefully attaching socket to the port 8080

if (bind(server\_socket\_fd, (struct sockaddr \*)&server\_address,

sizeof(server\_address))<0)

{

perror("Server: bind failed");

exit(EXIT\_FAILURE);

}

// Putting the server socket in a passive mode, waiting for the client to approach the server to make a connection

// The backlog=7, defines the maximum length to which the queue of pending connections for sockfd may grow.

// If a connection request arrives when the queue is full, the client may receive an error with an indication of ECONNREFUSED.

if (listen(server\_socket\_fd, 7) < 0)

{

perror("Server: listen");

exit(EXIT\_FAILURE);

}

printf("Server: server is listening ...\n\nYou can open one or multiple new terminal windows now to run ./client\n");

int clients\_ctr = 0;

// Setting up buffer for receiving msg

char recv\_buf[65536];

memset(recv\_buf, '\0', sizeof(recv\_buf));

int in\_client\_enough = 0;

while ( in\_client\_enough == 0) { // block on accept() until positive fd or error

struct sockaddr\_in client\_addr;

socklen\_t length = sizeof(client\_addr);

// Extracting the first connection request on the queue of pending connections for the listening socket (server\_socket\_fd)

// Creates a new connected socket, and returns a new file descriptor referring to that socket

if ((new\_socket = accept(server\_socket\_fd, (struct sockaddr \*)&client\_addr,

(socklen\_t\*)&length))<0)

{

perror("Server: accept");

exit(EXIT\_FAILURE);

}

clients\_ctr ++;

printf("\nYou have connected %d client(s) now.", clients\_ctr);

// converting the network address structure src in the af address family into a character string.

char client\_ip[INET\_ADDRSTRLEN] = "";

inet\_ntop(AF\_INET, &client\_addr.sin\_addr, client\_ip, INET\_ADDRSTRLEN);

printf("Server: new client accepted. client ip and port: %s:%d\n", client\_ip, ntohs(client\_addr.sin\_port));

// store new client connection into array

client\_sockets.push\_back(new\_socket);

client\_ips.push\_back(client\_ip);

client\_ports.push\_back(ntohs(client\_addr.sin\_port));

printf("current connected clients amount is %d \n", int(client\_sockets.size()) );

cout << "Do you have enought clients? (please input '1' for yes, '0' for no):" ;

cin >> in\_client\_enough;

if (in\_client\_enough == 0){

cout << "OK. Please continute opening one or multiple new terminal windows to run ./client\n" << endl;

}else if (in\_client\_enough != 1){

cout << "Unrecognized input has been considered as 0. You can create one more client.\n" << endl;

in\_client\_enough = 0;

}

}

printf("\nClients creation finished! There are totally %d connected clients.\n", int(client\_sockets.size()) );

printf("Asking all clients to report their local clock value ... \n\n\n");

for (int i = 0; i < client\_sockets.size(); i++){

// sending a message to client

const char \*msg = "Hello from server, please tell me your local clock value.";

send(client\_sockets[i] , msg , strlen(msg) , 0 );

printf("Server: sent to client(%s:%d): '%s'\n", client\_ips[i].c\_str(), client\_ports[i], msg);

// receiving

while(recv(client\_sockets[i], recv\_buf, sizeof(recv\_buf), 0) > 0 ){

printf("Server: recv from client(%s:%d): '%s' \n", client\_ips[i].c\_str(), client\_ports[i], recv\_buf);

// convert char array to string

string recv\_msg = string(recv\_buf);

if (recv\_msg.find("Hello from client, my local clock value is") != string::npos){

string substr\_after\_last\_space;

vector<string> split\_str = split(recv\_msg, " ");

substr\_after\_last\_space = split\_str[ split\_str.size() - 1 ];

cout << "Server: received client local clock (string) is " << substr\_after\_last\_space << endl;

float substr\_after\_last\_space\_f = stof(substr\_after\_last\_space);

cout << "Server: received client local clock (float) is " << substr\_after\_last\_space\_f << endl;

clients\_local\_clocks.push\_back(substr\_after\_last\_space\_f);

}

memset(recv\_buf, '\0', strlen(recv\_buf));

break;

}

}

printf("\n\n");

// average clock values

float all\_clock\_sum = server\_local\_clock;

for (int i = 0; i < clients\_local\_clocks.size(); i++){

all\_clock\_sum += clients\_local\_clocks[i];

}

float avg\_clock = all\_clock\_sum / (client\_sockets.size() + 1);

// tell clients how to adjust

for (int i = 0; i < client\_sockets.size(); i++){

// prepare msg

float offset = clients\_local\_clocks[i] - avg\_clock;

string operation;

if (offset >= 0){

operation = "minus";

}else{

operation = "add";

offset = 0 - offset;

}

string msg\_str = "From server, your clock adjustment offset is " + operation + " " + to\_string(offset);

char msg\_char\_array[msg\_str.length() + 1];

strcpy(msg\_char\_array, msg\_str.c\_str());

// sending a message to client

send(client\_sockets[i] , &msg\_char\_array , strlen(msg\_char\_array) , 0 );

printf("Server: sent to client(%s:%d): '%s'\n", client\_ips[i].c\_str(), client\_ports[i], msg\_char\_array);

}

// adjust self

server\_local\_clock += avg\_clock - server\_local\_clock;

printf("\n\nServer new local clock is %f \n\n", server\_local\_clock);

printf("Server: server stopped. \n");

close(server\_socket\_fd);

return 0;

}

**CLIENT:**

#include <stdio.h>

#include <sys/socket.h>

#include <arpa/inet.h>

#include <unistd.h>

#include <string.h>

#include <iostream>

#include <stdlib.h> /\* srand, rand \*/

#include <cstdlib>

#include <ctime>

#include <vector>

#define PORT 8080

using namespace std;

// function for string delimiter

vector<string> split(string s, string delimiter) {

size\_t pos\_start = 0, pos\_end, delim\_len = delimiter.length();

string token;

vector<string> res;

while ((pos\_end = s.find (delimiter, pos\_start)) != string::npos) {

token = s.substr (pos\_start, pos\_end - pos\_start);

pos\_start = pos\_end + delim\_len;

res.push\_back (token);

}

res.push\_back (s.substr (pos\_start));

return res;

}

int main(int argc, char const \*argv[])

{

srand((unsigned int)time(NULL)); // avoid always same output of rand()

float client\_local\_clock = rand() % 10; // range from 0 to 9

printf("Client starts. Client pid is %d \n", getpid());

printf("Client local clock is %f \n\n", client\_local\_clock);

int client\_socket\_fd, valread;

char client\_read\_buffer[1024] = {0};

struct sockaddr\_in server\_addr;

server\_addr.sin\_family = AF\_INET;

// server\_addr.sin\_addr.s\_addr = inet\_addr(argv[1]); // hardcode to 127.0.0.1

server\_addr.sin\_port = htons(PORT);

// Creating socket file descriptor (IPv4, TCP, IP)

if ((client\_socket\_fd = socket(AF\_INET, SOCK\_STREAM, 0)) < 0)

{

printf("\n Client: Socket creation error \n");

return -1;

}

// Converting IPv4 and IPv6 addresses from text to binary form,

// from character string src into a network

// address structure in the af address family, then copies the

// network address structure to dst.

if(inet\_pton(AF\_INET, "127.0.0.1", &server\_addr.sin\_addr)<=0)

{

printf("\nClient: Invalid address/ Address not supported \n");

return -1;

}

// Connecting server, return 0 with success, return -1 with error

if (connect(client\_socket\_fd, (struct sockaddr \*)&server\_addr, sizeof(server\_addr)) < 0)

{

printf("\nClient: Connection Failed \n");

return -1;

}

char server\_ip[INET\_ADDRSTRLEN]="";

inet\_ntop(AF\_INET, &server\_addr.sin\_addr, server\_ip, INET\_ADDRSTRLEN);

printf("Client: connected server(%s:%d). \n", server\_ip, ntohs(server\_addr.sin\_port));

printf("\n\n");

//

// first round communicattion

//

// receiving form server

valread = read( client\_socket\_fd , client\_read\_buffer, 1024);

printf("Client: read: '%s'\n",client\_read\_buffer );

// convert char array to string

string recv\_msg = string(client\_read\_buffer);

// reply according to what client receive

if (strcmp(client\_read\_buffer, "Hello from server, please tell me your local clock value.") == 0) {

// prepare msg

string msg\_str = "Hello from client, my local clock value is " + to\_string(client\_local\_clock);

char msg\_char\_array[msg\_str.length() + 1];

strcpy(msg\_char\_array, msg\_str.c\_str());

// sending a message to server

send(client\_socket\_fd , &msg\_char\_array , strlen(msg\_char\_array) , 0 );

printf("Client: sent message: '%s'\n", msg\_char\_array);

}

//

// second round communicattion

//

// receiving form server

valread = read( client\_socket\_fd , client\_read\_buffer, 1024);

printf("Client: read: '%s'\n",client\_read\_buffer );

// convert char array to string

recv\_msg = string(client\_read\_buffer);

if (recv\_msg.find("From server, your clock adjustment offset is") != string::npos){ // if latter is a substring of former

string substr\_after\_lastbutone\_space;

string substr\_after\_last\_space;

vector<string> split\_str = split(recv\_msg, " ");

substr\_after\_lastbutone\_space = split\_str[ split\_str.size() - 2 ];

substr\_after\_last\_space = split\_str[ split\_str.size() - 1 ];

cout << "Client: received local clock adjustment offset (string) is " << substr\_after\_lastbutone\_space << " " << substr\_after\_last\_space << endl;

float substr\_after\_last\_space\_f = stof(substr\_after\_last\_space);

cout << "Client: received local clock adjustment offset (float) is " << substr\_after\_lastbutone\_space << " " << substr\_after\_last\_space\_f << endl;

char oper\_char\_array[substr\_after\_lastbutone\_space.length() + 1];

strcpy(oper\_char\_array, substr\_after\_lastbutone\_space.c\_str());

if (strcmp(oper\_char\_array, "add") == 0 ){

client\_local\_clock += substr\_after\_last\_space\_f;

}else if (strcmp(oper\_char\_array, "minus") == 0 ){

client\_local\_clock -= substr\_after\_last\_space\_f;

}

printf("Client local clock is %f \n\n", client\_local\_clock);

}

close(client\_socket\_fd);

return 0;

}