

CSE344 SYSTEMS PROGRAMMING 2024 – FINAL PROJECT REPORT

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1. *Introduction*

The project aims to simulate an automated pide (Turkish flatbread) delivery system using a client-server architecture. The system manages client orders through concurrent processing of orders, cooking by cooks, and delivery by delivery personnel.

2. System Architecture

- **Server (server.c):**
 - Utilizes multi-threading (pthread) for concurrent order handling.
 - Manages cooks and delivery persons as threads within defined thread pools.
 - Implements socket communication to receive orders from a client generator (client.c).
 - Handles order preparation, cooking, and delivery using synchronization mechanisms (mutex, condition variables).

```

for (int i = 0; i < cook_pool_size; i++) {
    cooks[i].id = i;
    cooks[i].busy = 0;
    pthread_create(&cooks[i].thread, NULL, cook_function, &cooks[i]);
}

for (int i = 0; i < delivery_pool_size; i++) {
    delivery_persons[i].id = i;
    delivery_persons[i].busy = 0;
    delivery_persons[i].delivery_count = 0;
    pthread_create(&delivery_persons[i].thread, NULL, delivery_function, &delivery_persons[i]);
}

while (1) {
    client_socket = accept(server_socket, (struct sockaddr *)&client_addr, &client_len);
    if (client_socket < 0) {
        perror("Error accepting client");
        continue;
    }
}

```

- **Client Generator (client.c):**

- Simulates multiple clients generating orders with specified coordinates.
- Communicates with the server via TCP sockets to submit orders.

```

server_addr.sin_family = AF_INET;
server_addr.sin_port = htons(port);
inet_pton(AF_INET, ip_address, &server_addr.sin_addr);

if (connect(client_gen_socket, (struct sockaddr *)&server_addr, sizeof(server_addr)) < 0) {
    perror("Error connecting to server");
    close(client_gen_socket);
    exit(1);
}

for (int i = 0; i < number_of_clients; i++) {
    int client_socket;

    client_socket = socket(AF_INET, SOCK_STREAM, 0);
    if (client_socket < 0) {
        perror("Error creating socket");
        exit(1);
    }

    if (connect(client_socket, (struct sockaddr *)&server_addr, sizeof(server_addr)) < 0) {
        perror("Error connecting to server");
        close(client_socket);
        exit(1);
    }

    int x = rand() % p;
    int y = rand() % q;
    snprintf(buffer, MAX_BUFFER, "Order from client %d at location (%d, %d)", i, x, y);
    if (write(client_socket, buffer, strlen(buffer)) < 0) {
        perror("Error writing to socket");
        close(client_socket);
        exit(1);
    }
}

```

3. *Functionality and Implementation Details*

- **Order Management:**
 - Orders are received and stored in a queue.
 - Cooks asynchronously prepare orders, simulate cooking, and notify completion.
 - Delivery personnel deliver prepared orders to specified client locations.
- **Concurrency Control:**
 - Ensures thread safety with mutex locks and condition variables to manage shared data (orders, cooks, delivery persons).
 - Prevents race conditions during order processing and delivery assignment.

```
pthread_mutex_unlock(&orders_mutex);

for (int i = 0; i < delivery_person->delivery_count; i++) {
    deliver_order(&orders[delivery_person->deliveries[i]]);
}

pthread_mutex_lock(&orders_mutex);
delivery_person->delivery_count = 0;
delivery_person->busy = 0;
pthread_cond_broadcast(&orders_cond);
pthread_mutex_unlock(&orders_mutex);
} else {
    pthread_cond_wait(&orders_cond, &orders_mutex);
    pthread_mutex_unlock(&orders_mutex);
}
```

- **Error Handling and Shutdown:**
 - Implements signal handling (SIGINT) for graceful shutdown.
 - Logs events and maintains consistency in handling orders and connections.

```
// handle sigint signal using sigaction
struct sigaction act;
act.sa_handler = handle_sigint;
act.sa_flags = 0;
if ((sigemptyset(&act.sa_mask) == -1) || (sigaction(SIGINT, &act, NULL) == -1)) {
    perror("Failed to set SIGINT signal handler");
    return 1;
}
```

```
void handle_sigint(int sig) {
    printf("Pide shop is shutting down...\n");
    log_event("Pide shop is shutting down");
    fclose(log_file);
    exit(0);
}
```

When Ctrl^C is pressed, on server side, it is shutting down:

```
ra@ra-Aspire-F5-573G:~/Desktop/final$ ./server 9090 6 8 1
PideShop active, waiting for connection...
^CPide shop is shutting down...
ra@ra-Aspire-F5-573G:~/Desktop/final$
```

On client side, the order is cancelled (could not implement fully):

```
ra@ra-Aspire-F5-573G:~/Desktop/final$ ./client 172.16.1.0 9090 10 30 40
PID 31112...
...
^COrder cancelled.
```

Additionally log file is created to keep track of the state and delivery time of the orders.

```

[2024-06-15 09:00:00] Received order from client: Order 0 at location (14, 13)
[2024-06-15 09:00:00] Cooker 0 is preparing order 0
[2024-06-15 09:00:00] Received order from client: Order 1 at location (26, 14)
[2024-06-15 09:00:00] Cooker 1 is preparing order 1
[2024-06-15 09:00:00] Received order from client: Order 2 at location (25, 22)
[2024-06-15 09:00:00] Cooker 2 is preparing order 2
[2024-06-15 09:00:00] Received order from client: Order 3 at location (11, 1)
[2024-06-15 09:00:00] Cooker 3 is preparing order 3
[2024-06-15 09:00:07] Delivery person 4 is carrying orders: 0
[2024-06-15 09:00:07] Delivery person 1 is carrying orders: 1
[2024-06-15 09:00:07] Delivery person 3 is carrying orders: 3
[2024-06-15 09:00:07] Delivery person 0 is carrying orders: 2
[2024-06-15 09:00:08] Delivered 0 to location (14, 13)
[2024-06-15 09:00:08] Delivered 1 to location (26, 14)
[2024-06-15 09:00:08] Delivered 3 to location (11, 1)
[2024-06-15 09:00:08] Delivered 2 to location (25, 22)
[2024-06-15 09:00:08] Received order from client: Order 0 at location (0, 0)
[2024-06-15 09:00:08] Cooker 2 is preparing order 0
[2024-06-15 09:00:12] Pide shop is shutting down

```

4. Testing Details and Test Cases & Running Results

Testing Details:

- It can be tested on the same machine or different machines.
- Before testing, server's ip address should be looked up to connect to the server.
- "ip a" command can be used to spot the ip address of a machine over a network.

```

ra@ra-Aspire-F5-573G:~/Desktop/final$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp4s0f1: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc fq_codel state DOWN group default qlen 1000
    link/ether a8:1e:84:82:56:0e brd ff:ff:ff:ff:ff:ff
3: wlp3s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 2c:50:67:c1:b6:d1 brd ff:ff:ff:ff:ff:ff
    inet 172.16.1.0/22 brd 172.16.3.255 scope global dynamic noprefixroute wlp3s0
        valid_lft 2646sec preferred_lft 2646sec
    inet6 fe80::ce7a:f46f:8dd7:3d64/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
ra@ra-Aspire-F5-573G:~/Desktop/final$

```

Inet address should be used to connect client to server.

- When testing it with 2 different machines, they both need to connect to the same network.

- Exact correct IP address and same port must be used to establish connection successfully.

Testing commands:

- When running client side, both ip and port should be used to establish connection to the server.
- When running server side, just port is enough.

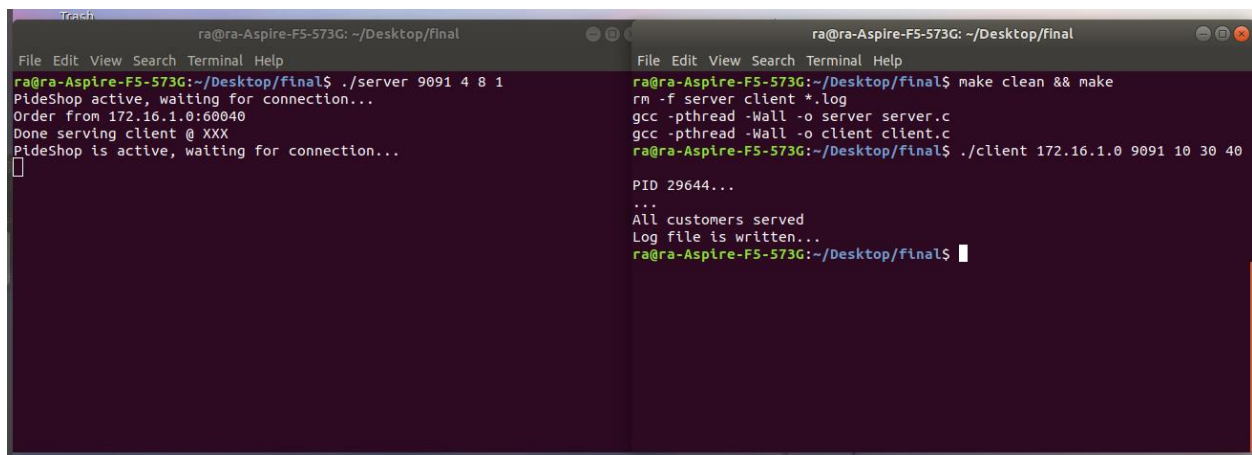
Example test commands:

```
ra@ra-Aspire-F5-573G:~/Desktop/final$ ./server 9091 4 8 1
```

```
ra@ra-Aspire-F5-573G:~/Desktop/final$ ./client 172.16.1.0 9091 10 30 40
```

Test Cases & Running Results:

- On the same machine:



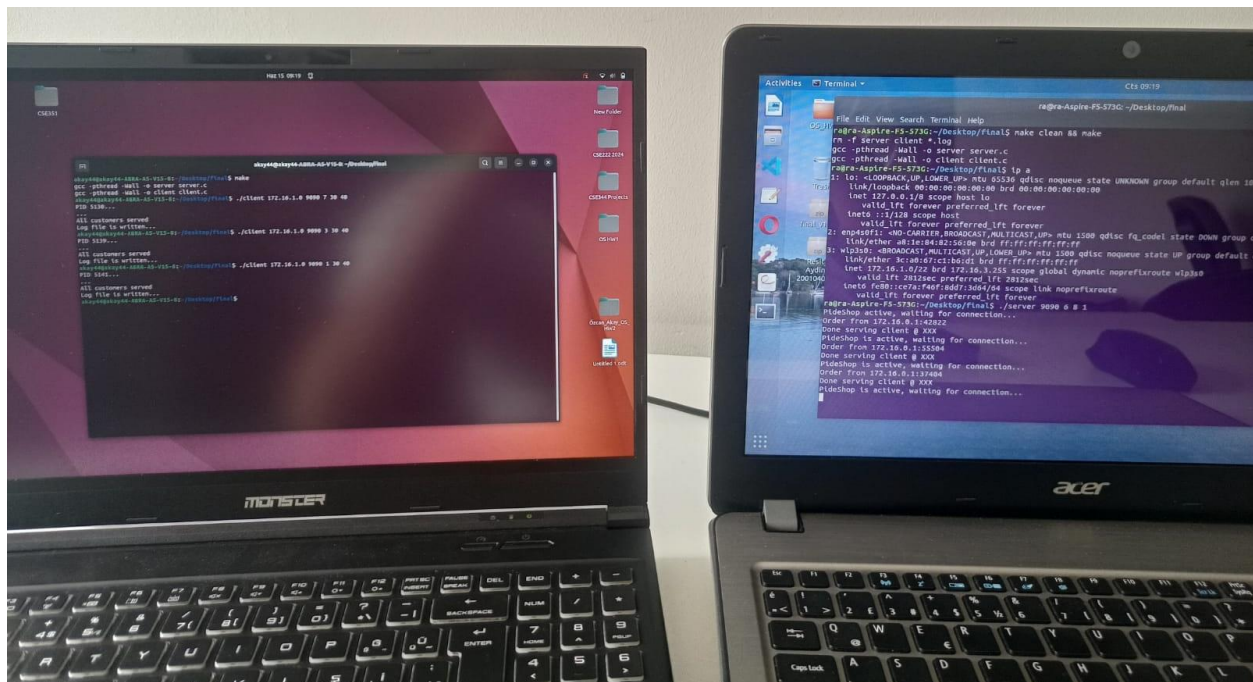
```
ra@ra-Aspire-F5-573G: ~/Desktop/final
File Edit View Search Terminal Help
ra@ra-Aspire-F5-573G:~/Desktop/final$ ./server 9091 4 8 1
PidShop active, waiting for connection...
Order from 172.16.1.0:60040
Done serving client @ XXX
PidShop is active, waiting for connection...
█

ra@ra-Aspire-F5-573G: ~/Desktop/final
File Edit View Search Terminal Help
ra@ra-Aspire-F5-573G:~/Desktop/final$ make clean && make
rm -f server client *.log
gcc -pthread -Wall -o server server.c
gcc -pthread -Wall -o client client.c
ra@ra-Aspire-F5-573G:~/Desktop/final$ ./client 172.16.1.0 9091 10 30 40
PID 29644...
...
All customers served
Log file is written...
ra@ra-Aspire-F5-573G:~/Desktop/final$
```

Log file:


```
Open ▾ pideshop.log ~/Desktop/final Save ≡ [X] [O] [D]
[2024-06-15 09:04:36] Received order from client: Order 0 at location (8, 13)
[2024-06-15 09:04:36] Received order from client: Order 1 at location (24, 7)
[2024-06-15 09:04:36] Received order from client: Order 2 at location (27, 21)
[2024-06-15 09:04:36] Cooker 1 is preparing order 0
[2024-06-15 09:04:36] Received order from client: Order 3 at location (23, 4)
[2024-06-15 09:04:36] Received order from client: Order 4 at location (27, 20)
[2024-06-15 09:04:36] Received order from client: Order 5 at location (7, 4)
[2024-06-15 09:04:36] Cooker 3 is preparing order 1
[2024-06-15 09:04:36] Received order from client: Order 6 at location (1, 9)
[2024-06-15 09:04:36] Received order from client: Order 7 at location (14, 13)
[2024-06-15 09:04:36] Received order from client: Order 8 at location (0, 0)
[2024-06-15 09:04:36] Cooker 0 is preparing order 2
[2024-06-15 09:04:36] Received order from client: Order 9 at location (3, 37)
[2024-06-15 09:04:36] Cooker 2 is preparing order 3
[2024-06-15 09:04:36] Cooker 1 is preparing order 4
[2024-06-15 09:04:43] Delivery person 1 is carrying orders: 0
[2024-06-15 09:04:43] Delivery person 3 is carrying orders: 1
[2024-06-15 09:04:43] Cooker 0 is preparing order 5
[2024-06-15 09:04:43] Delivery person 2 is carrying orders: 2
[2024-06-15 09:04:43] Cooker 3 is preparing order 6
[2024-06-15 09:04:43] Cooker 2 is preparing order 7
[2024-06-15 09:04:43] Delivery person 6 is carrying orders: 3
[2024-06-15 09:04:44] Delivered 0 to location (8, 13)
[2024-06-15 09:04:44] Delivered 1 to location (24, 7)
[2024-06-15 09:04:44] Delivered 2 to location (27, 21)
[2024-06-15 09:04:44] Delivered 3 to location (23, 4)
[2024-06-15 09:04:50] Cooker 1 is preparing order 8
[2024-06-15 09:04:50] Delivery person 4 is carrying orders: 4
[2024-06-15 09:04:50] Cooker 0 is preparing order 9
[2024-06-15 09:04:50] Delivery person 6 is carrying orders: 5
[2024-06-15 09:04:50] Delivery person 7 is carrying orders: 6
[2024-06-15 09:04:50] Delivery person 0 is carrying orders: 7
[2024-06-15 09:04:51] Delivered 4 to location (27, 20)
[2024-06-15 09:04:51] Delivered 5 to location (7, 4)
[2024-06-15 09:04:51] Delivered 6 to location (1, 9)
[2024-06-15 09:04:51] Delivered 7 to location (14, 13)
[2024-06-15 09:04:57] Delivery person 6 is carrying orders: 8
[2024-06-15 09:04:57] Delivery person 5 is carrying orders: 9
[2024-06-15 09:04:58] Delivered 8 to location (0, 0)
[2024-06-15 09:04:58] Delivered 9 to location (3, 37)
[2024-06-15 09:04:58] Received order from client: Order 0 at location (0, 0)
[2024-06-15 09:04:58] Cooker 1 is preparing order 0
[2024-06-15 09:05:05] Delivery person 1 is carrying orders: 0
[2024-06-15 09:05:06] Delivered 0 to location (0, 0)
```

- On two different machines



As we see it works properly across different machines, also the program can handle subsequent clients gracefully.

Log file:

```
Open  pideshop.log  
~/Desktop/final  
[2024-06-15 09:18:16] Received order from client: Order 0 at location (1, 29)  
[2024-06-15 09:18:16] Cooker 0 is preparing order 0  
[2024-06-15 09:18:16] Received order from client: Order 1 at location (15, 24)  
[2024-06-15 09:18:16] Cooker 1 is preparing order 1  
[2024-06-15 09:18:16] Received order from client: Order 2 at location (22, 36)  
[2024-06-15 09:18:16] Cooker 2 is preparing order 2  
[2024-06-15 09:18:16] Received order from client: Order 3 at location (11, 34)  
[2024-06-15 09:18:16] Cooker 3 is preparing order 3  
[2024-06-15 09:18:16] Received order from client: Order 4 at location (25, 38)  
[2024-06-15 09:18:16] Cooker 4 is preparing order 4  
[2024-06-15 09:18:16] Received order from client: Order 5 at location (1, 36)  
[2024-06-15 09:18:16] Cooker 5 is preparing order 5  
[2024-06-15 09:18:16] Received order from client: Order 6 at location (4, 35)  
[2024-06-15 09:18:23] Cooker 0 is preparing order 6  
[2024-06-15 09:18:23] Delivery person 0 is carrying orders: 0  
[2024-06-15 09:18:23] Delivery person 2 is carrying orders: 1  
[2024-06-15 09:18:23] Delivery person 4 is carrying orders: 2  
[2024-06-15 09:18:23] Delivery person 5 is carrying orders: 3  
[2024-06-15 09:18:23] Delivery person 1 is carrying orders: 4  
[2024-06-15 09:18:23] Delivery person 3 is carrying orders: 5  
[2024-06-15 09:18:24] Delivered 0 to location (1, 29)  
[2024-06-15 09:18:24] Delivered 1 to location (15, 24)  
[2024-06-15 09:18:24] Delivered 2 to location (22, 36)  
[2024-06-15 09:18:24] Delivered 3 to location (11, 34)  
[2024-06-15 09:18:24] Delivered 4 to location (25, 38)  
[2024-06-15 09:18:24] Delivered 5 to location (1, 36)  
[2024-06-15 09:18:30] Delivery person 5 is carrying orders: 6  
[2024-06-15 09:18:31] Delivered 6 to location (4, 35)  
[2024-06-15 09:18:31] Received order from client: Order 0 at location (0, 0)  
[2024-06-15 09:18:34] Received order from client: Order 1 at location (13, 9)  
[2024-06-15 09:18:34] Cooker 3 is preparing order 0  
  
[2024-06-15 09:18:34] Cooker 3 is preparing order 0  
[2024-06-15 09:18:34] Received order from client: Order 2 at location (15, 4)  
[2024-06-15 09:18:34] Received order from client: Order 3 at location (13, 12)  
[2024-06-15 09:18:34] Cooker 4 is preparing order 1  
[2024-06-15 09:18:41] Cooker 3 is preparing order 2  
[2024-06-15 09:18:41] Delivery person 5 is carrying orders: 0  
[2024-06-15 09:18:41] Cooker 5 is preparing order 3  
[2024-06-15 09:18:41] Delivery person 2 is carrying orders: 1  
[2024-06-15 09:18:42] Delivered 0 to location (0, 0)  
[2024-06-15 09:18:42] Delivered 1 to location (13, 9)  
[2024-06-15 09:18:48] Delivery person 0 is carrying orders: 2  
[2024-06-15 09:18:48] Delivery person 7 is carrying orders: 3  
[2024-06-15 09:18:49] Delivered 2 to location (15, 4)  
[2024-06-15 09:18:49] Delivered 3 to location (13, 12)  
[2024-06-15 09:18:49] Received order from client: Order 0 at location (0, 0)  
[2024-06-15 09:18:53] Received order from client: Order 1 at location (10, 33)  
[2024-06-15 09:18:53] Cooker 1 is preparing order 0  
[2024-06-15 09:19:00] Cooker 1 is preparing order 1  
[2024-06-15 09:19:00] Delivery person 6 is carrying orders: 0  
[2024-06-15 09:19:01] Delivered 0 to location (0, 0)  
[2024-06-15 09:19:07] Delivery person 0 is carrying orders: 1  
[2024-06-15 09:19:08] Delivered 1 to location (10, 33)  
[2024-06-15 09:19:08] Received order from client: Order 0 at location (0, 0)  
[2024-06-15 09:19:50] Pide shop is shutting down
```

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