Relazione sul Progetto dell'Esame di

Sistemi Operativi

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1 Primo Esercizio

Simulatore di chiamate a procedura

1.1 Descrizione dell'implementazione

L'obiettivo del primo esercizio é quello di implementare uno scheduler di processi. Quest'ultimo deve permettere all'utente di poter creare, eseguire ed eliminare i processi stessi secondo una politica di prioritá od esecuzioni rimanenti.
Abbiamo organizzato il codice in tre files: due librerie *config.h* e *taskmanager.h* ed un programma, *scheduler.c*. All'interno di *config.h*1 vengono unicamente definite due stringhe utilizzate nella formattazione dell'output. All'interno di *taskmanager.h*2 abbiamo invece definito la `struct` *TaskElement*, ovvero l'elemento ***Task***, descritto da 5 campi fondamentali che rappresentano un processo all'interno della nostra implementazione:

1. *ID* : Un numero intero univoco che viene automaticamente assegnato alla creazione del task.
2. *nameTask* : Nome del task, di massimo 8 caratteri, scelto dall'utente alla creazione.
3. *priority* : Numero intero che rappresenta la prioritá del task.
4. *remainingExe* : Numero intero che rappresenta il numero di esecuzioni rimanenti (burst) del task.
5. **nextTask* : Puntatore al task successivo

Sempre all'interno di *taskmanager.h*2 vi sono le implementazioni delle operazioni che il nostro scheduler sará in grado di effettuare, definite dalle seguenti funzioni:

- `setExeNumber(void)` : Permette l'inserimento del numero di esecuzioni rimanenti n, effettuando i controlli sulla legalitá dell'input ($1 < n < 99$).
- `setPriority(void)` : Permette l'inserimento della prioritá p, effettuando i controlli sulla legalitá dell'input ($1 < p < 9$).
- `setTaskName(Task*)` : Permette l'inserimento del nome del task, effettuando i controlli sulla lunghezza massima della stringa inserita (al massimo 8 caratteri).
- `isEmptyTaskList(Task*)` : Esegue il controllo sulla lista di task, restituendo 0 nel caso sia vuota.
- `selectTask(Task*)` : Restituisce il task con il PID richiesto dall'utente, dopo aver eseguito la ricerca nella lista.
- `modifyPriority(Task*)` : Permette di modificare la prioritá del task selezionato.
- `modifyExecNumb(Task*)` : Permette di modificare il numero di esecuzioni rimanenti del task selezionato.
- `newTaskElement(Task*,int)` : Permette la creazione di un nuovo task, allocandolo in memoria con l'utilizzo di una `malloc`.
- `printTask(Task*)` : Esegue la stampa degli elementi del task coerentemente con la richiesta nella specifica dell'esercizio.
- `printListTask(Task*)` : Esegue la stampa dell'intera lista dei task, richiamando la funzione `printTask`.
- `deleteTask(Task*, Task*)` : Permette l'eliminazione di un task dalla lista, semplicemente collegando il puntatore *nextTask* dell'elemento precedente al task successivo a quello che deve essere eliminato.
- `executeTask(Task*)` : Esegue il task in testa alla coda, eseguendo i controlli sul numero di esecuzioni rimanenti.

Le operazioni legate allo scheduling sono state poi affidate a *scheduler.c*3, il quale contiene le funzioni:

- `getChoice(void)` : Stampa il menu di scelta delle operazioni eseguibili e restituisce la risposta data in input dall'utente.
- `switchPolicy(char)` : Permette di modificare la politica di scheduling, passando da prioritá ad esecuzioni rimanenti.
- `sortListByPriority(Task*)` : Ordina la lista dei task per valori decrescenti della prioritá ($max(p) = 9$).
- `sortListByExecution(Task*)` : Ordina la lista dei task per valori decrescenti del numero di esecuzioni rimanenti ($max(n) = 99$).
- `swapTask(Task*, Task*, Task*)` : Permette l'inversione dell'ordine di due task.
- `main()` : Main del programma.

1.2 Codice

```
#ifndef CONFIG_H_
#define CONFIG_H_

#define POINTSHEAD "
    ..................................................................\n\r"
#define SEPARATOR "+----+----------+----------+--------------------+\n\r"

#endif /* CONFIG_H_ */
```

Listing 1: config.c

```
#include <string.h>
#include <stdio.h>
#include <stdlib.h>

#include "config.h"

typedef struct TaskElement {
  int ID;
  char nameTask[9]; // the ninth element of the name must be
  int priority;
  int remainingExe;
  struct TaskElement *nextTask;
} Task;

int setExeNumber(void);
int setPriority(void);
void setTaskName(Task*);
int isEmptyTaskList(Task*);
Task* selectTask(Task*);
void modifyPriority(Task*);
void modifyExecNumb(Task*);
Task* newTaskElement(Task*, int);
void printTask(Task*);
void printListTasks(Task*);
Task* deleteTask(Task*, Task*);
int executeTask(Task*);

/*
*
* PURPOSE : Setter remainingExe member of struct TaskElement, this function is use by
    newTaskElement
* RETURN : int -> number of remaining execution
*
*/
int setExeNumber() {
  int exeNum = 0;
  do {
    printf("\n\rInsert the number of remaning executions : ");
    scanf("%i", &exeNum);
    if ((exeNum < 0) || (exeNum > 99)) {
      printf("\n\rError! It must be a number between 1 and 99. \n\r");
```

```
41      }
42    } while ((exeNum <= 0) || (exeNum > 99));
43    return exeNum;
44  }
45
46  /*
47  *
48  * PURPOSE : Setter priority member of struct TaskElement, this function is use by
        newTaskElement
49  * RETURN : int -> number of priority
50  *
51  */
52  int setPriority() {
53    int priority = 0;
54    do {
55      printf("\n\rInsert the priority (ascending order): ");
56      scanf("%i", &priority);
57      if (((priority < 0) || (priority > 9))) {
58        printf("\n\rError! It must be a number between 1 and 9\n\r");
59      }
60    } while ((priority < 0) || (priority > 9));
61    return priority;
62  }
63
64  /*
65  *
66  * PURPOSE : Setter name member of struct TaskElement, this function is use by
        newTaskElement
67  * PARAMS : Task* actualTask -> pointer of the task that want to set name
68  * RETURN : void
69  *
70  */
71  void setTaskName(Task *actualTask) {
72    char name[256];
73    do {
74      printf("\n\rName this task (max 8 chars) : ");
75      scanf("%s", name);
76      if (strlen(name)>0 && strlen(name)<=8) {
77        strcpy(actualTask->nameTask, name);
78        for (int i = strlen(name); i<=9 ;i++) {
79          actualTask->nameTask[i] = '\0'; // this for cycle set all character of the name
        task with the null character
80        }
81        return;
82      } else {
83        printf("\n\rThe name of the task must be less than 8");
84      }
85    } while (strlen(name)>8);
86    printf("Something went wrong\n\rThe name of the task it will be setted -default-");
87    strcpy(actualTask->nameTask,"default\0");
88    return;
89  }
90
91  /*
92  *
93  * PURPOSE : Check if the list is empty
94  * PARAMS : Task* firstTask -> pointer of the first (head) task of the list
95  * RETURN : int -> return 0 if the list is empty, return 1 if the list is not empty
96  *
97  */
98  int isEmptyTaskList(Task *firstTask) {
99    return !(firstTask->ID);
100 }
101
102 /*
103 *
104 * PURPOSE : It ask the ID of the Task and finds the Task with that ID
105 * PARAMS : Task* firstTask -> pointer of the first (head) task of the list
106 * RETURN : Task* -> return the pointer of the task found
107 *
108 */
109 Task* selectTask(Task* firstTask) {
110   int id;
```

```
111   printf("Select the task...\nInsert the ID : ");
112   scanf("%d", &id);
113   while (firstTask->ID != id) {
114     firstTask = firstTask->nextTask;
115     if (firstTask == NULL) {
116       printf("\n\rError! No tasks with this ID!\n\r");
117       return firstTask;
118     }
119   }
120   return firstTask;
121 }
122 
123 /*
124 *
125 * PURPOSE : Modify the priority of the task
126 * PARAMS : Task* thisTask -> pointer of the task to change
127 * RETURN : void
128 *
129 */
130 void modifyPriority(Task *thisTask) {
131   thisTask = selectTask(thisTask);
132   if (thisTask == NULL) {
133     return;
134   }
135   thisTask->priority = setPriority();
136   return;
137 }
138 
139 /*
140 *
141 * PURPOSE : Modify the execution number of the task
142 * PARAMS : Task* thisTask -> pointer of the task to change
143 * RETURN : void
144 *
145 */
146 void modifyExecNumb(Task *thisTask) {
147   thisTask = selectTask(thisTask);
148   if (thisTask == NULL) {
149     return;
150   }
151   thisTask->remainingExe = setExeNumber();
152   return;
153 }
154 
155 /*
156 *
157 * PURPOSE : Allocate a new item in the list
158 * PARAMS : Task* actualTask -> pointer of the last task of the list
159 * PARAMS : int idT -> the id of the new task
160 * RETURN : Task* -> pointer of the new last task of the list
161 *
162 */
163 Task* newTaskElement(Task *actualTask, int idT) {
164   actualTask->ID = idT;
165   setTaskName(actualTask);
166   actualTask->priority = setPriority();
167   actualTask->remainingExe = setExeNumber();
168   (*actualTask).nextTask = malloc(sizeof(Task));
169   return (*actualTask).nextTask;
170 }
171 
172 /*
173 *
174 * PURPOSE : Print a single Task
175 * PARAMS : Task* thisTask -> pointer of the task to print
176 * RETURN : void
177 *
178 */
179 void printTask(Task *thisTask) {
180   printf("| %d  + %d          + %s         + %d                  | \n\r",
181       thisTask->ID, thisTask->priority , thisTask->nameTask,
182       thisTask->remainingExe);
183   printf(SEPARATOR);
```

```
184 }
185
186 /*
187 *
188 * PURPOSE : Print the list of the task
189 * PARAMS : Task* first -> printing start from this task
190 * RETURN : void
191 *
192 */
193 void printListTasks(Task *first) {
194   printf(SEPARATOR);
195   printf("| ID + PRIORITY + TASK NAME + REMAINING EXEC |\n\r");
196   printf(SEPARATOR);
197   Task* tmp = first;
198   while (tmp->ID != 0) {
199     printTask(tmp);
200     tmp = (*tmp).nextTask;
201   }
202 }
203
204 /*
205 *
206 * PURPOSE : Delete a Task
207 * PARAMS : Task* first -> pointer of the first task of the list
208 * PARAMS : Task* thisTask -> pointer of the task to delete
209 * RETURN : Task* -> return the pointer of the first task of the list
210 *
211 */
212 Task* deleteTask(Task *first, Task *thisTask) {
213   if (thisTask != NULL) {
214     Task *tmpTask = first;
215     if (thisTask == first) {
216       tmpTask = thisTask->nextTask;
217       thisTask->ID = thisTask->priority = thisTask->remainingExe = 0;
218       strcpy(thisTask->nameTask, "\0");
219       thisTask->nextTask = NULL;
220       return tmpTask;
221     } else {
222       while (tmpTask->nextTask == NULL) {
223         if (tmpTask->nextTask == thisTask) {
224           tmpTask->nextTask = thisTask->nextTask;
225           thisTask->ID = thisTask->priority = thisTask->remainingExe =
226               0;
227           strcpy(thisTask->nameTask, "\0");
228           thisTask->nextTask = NULL;
229           return first;
230         }
231         tmpTask = tmpTask->nextTask;
232       }
233     }
234   }
235   printf("There is no task to delete!\n\r");
236   return first;
237 }
238
239 /*
240 *
241 * PURPOSE : Execute a Task
242 * PARAMS : Task* thisTask -> pointer of the task to execute
243 * RETURN : Task* -> return the number of the remaining execution
244 *
245 */
246 int executeTask(Task *thisTask) {
247   if (thisTask != NULL) {
248     thisTask->remainingExe -= 1;
249     return thisTask->remainingExe;
250   } else if (thisTask->remainingExe == 0) {
251     printf("This task has no more executions to be done\n\r");
252     return 0;
253   }
254   printf("There is no task to execute!\n\r");
255   return 0;
256 }
```

Listing 2: Task Manager

```c
#include <string.h>
#include <stdio.h>
#include <stdlib.h>
#include "taskmanager.h"

int getChoice(void);
char switchPolicy(char pol);
Task* sortListByPriority(Task*);
Task* sortListByExecution(Task*);
Task* swapTask(Task*, Task*, Task*);

int main() {
  int idTraker = 1;
  int flag = 1;
  char policy = 'p';
  Task *firstTask = malloc(sizeof(Task));
  Task *lastTask = NULL; // the last Task is always empty
  printf(POINTSHEAD);
  printf("                This is a process scheduler\n\r");
  printf(POINTSHEAD);
  while (flag == 1) {
    Task *tmpTask;
    switch (getChoice()) {
    case 0:
      printf("Bye!\n\r");
      return 0;
    case 1:
      if (firstTask->ID == 0) {
        lastTask = newTaskElement(firstTask, idTraker);
      } else {
        lastTask = newTaskElement(lastTask, idTraker);
        if (policy == 'p') {
          firstTask = sortListByPriority(firstTask);
        } else if (policy == 'e') {
          firstTask = sortListByExecution(firstTask);
        }
      }
      idTraker += 1;
      break;
    case 2:
      printf("\n\rHow many execution do you want to do: ");
      scanf("%d", &flag);
      while (flag != 0) {
        if (executeTask(firstTask) == 0) {
          firstTask = deleteTask(firstTask, firstTask);
        }
        flag -= 1;
      }
      flag = 1;
      printf("\n\r");
      break;
    case 3:
      if (!isEmptyTaskList(firstTask)) {
        tmpTask = selectTask(firstTask);
        if (executeTask(tmpTask) == 0) {
          firstTask = deleteTask(firstTask, tmpTask);
        }
      }
      break;
    case 4:
      firstTask = deleteTask(firstTask, selectTask(firstTask));
      break;
    case 5:
      modifyPriority(firstTask);
      if (policy == 'p') {
        firstTask = sortListByPriority(firstTask);
      }
      break;
    case 6:
      policy = switchPolicy(policy);
```

```
71        if (policy == 'p') {
72          firstTask = sortListByPriority(firstTask);
73        } else if (policy == 'e') {
74          firstTask = sortListByExecution(firstTask);
75        }
76        break;
77      case 7:
78        modifyExecNumb(firstTask);
79        if (policy == 'e') {
80          firstTask = sortListByExecution(firstTask);
81        }
82        break;
83      default:
84        flag = 0;
85        break;
86      }
87      if (!isEmptyTaskList(firstTask)) {
88        printf("\n\rScheduling Policy: ");
89        if (policy == 'p') {
90          printf("PRIORITY \n\r");
91        } else if (policy == 'e') {
92          printf("REMAINING EXECUTIONS \n\r");
93        }
94        printListTasks(firstTask);
95      } else {
96        printf("\n\rList is empty! Please insert a task first...\n\r");
97      }
98    }
99    return 0;
100 }
101
102 /*
103 *
104 * PURPOSE : Print menu and get the choice
105 * RETURN : int -> choice of the menu
106 *
107 */
108 int getChoice() {
109   printf("\n\rPlease select an option:\n\r");
110   printf(" 0) Exit\n\r 1) Create a new task\n\r 2) Execute the task on the top of the
        list\n\r");
111   printf(
112       " 3) Execute a task\n\r 4) Delete a task\n\r 5) Modify the PRIORITY of a task\n\r")
        ;
113   printf(
114       " 6) Switch policy (default : PRIORITY)\n\r 7) Modify the REMAINING EXECUTIONS of a
        task");
115   int res = 0;
116   printf("\n\r> ");
117   scanf("%i", &res);
118   return res;
119 }
120
121 /*
122 *
123 * PURPOSE : Switch the policy of the scheduler
124 * PARAMS : char pol -> actual policy of the scheduler
125 * RETURN : char -> new policy of the scheduler
126 *
127 */
128 char switchPolicy(char pol) {
129   printf("\n\rYou switched the policy of scheduling from ");
130   if (pol == 'p') {
131     printf("PRIORITY to REMAINING EXECUTIONS\n\r");
132     return 'e';
133   } else if (pol == 'e') {
134     printf("REMAINING EXECUTIONS to PRIORITY \n\r");
135     return 'p';
136   }
137   return 'p';
138 }
139
140 /*
```

```
141 *
142 * PURPOSE : Sort list by priority (highest priority, task most important)
143 * PARAMS : Task* headTask -> pointer of the first task of the list
144 * RETURN : Task* -> new pointer of first (head) task
145 *
146 */
147 Task* sortListByPriority(Task *headTask) {
148   Task *tempTask = headTask;
149   Task *previousTempTask = tempTask;
150   int flag = 0;
151   while (!flag) {
152     flag = 1;
153     tempTask = headTask;
154     previousTempTask = tempTask;
155     while (tempTask->ID != 0) {
156       if (tempTask->priority < tempTask->nextTask->priority) {
157         if (tempTask == headTask) {
158           headTask = swapTask(headTask, tempTask, tempTask->nextTask);
159         } else {
160           previousTempTask = swapTask(previousTempTask, tempTask,
161               tempTask->nextTask);
162         }
163         flag = 0;
164       }
165       previousTempTask = tempTask;
166       tempTask = tempTask->nextTask;
167     }
168   }
169   return headTask;
170 }
171
172 /*
173 *
174 * PURPOSE : Sort list by priority (lowest remaining execution, task most important)
175 * PARAMS : Task* headTask -> pointer of the first task of the list
176 * RETURN : Task* -> new pointer of first (head) task
177 *
178 */
179 Task* sortListByExecution(Task* headTask) {
180   Task *tempTask = headTask;
181   Task *previousTempTask = tempTask;
182   int flag = 0;
183   while (!flag) {
184     flag = 1;
185     tempTask = headTask;
186     previousTempTask = tempTask;
187     while (tempTask->ID != 0) {
188       if ((tempTask->remainingExe > tempTask->nextTask->remainingExe)
189           && (tempTask->nextTask->remainingExe != 0)) {
190         if (tempTask == headTask) {
191           headTask = swapTask(headTask, headTask, headTask->nextTask);
192         } else {
193           previousTempTask = swapTask(previousTempTask, tempTask,
194               tempTask->nextTask);
195         }
196         flag = 0;
197       }
198       previousTempTask = tempTask;
199       tempTask = tempTask->nextTask;
200     }
201   }
202   return headTask;
203 }
204
205 /*
206 *
207 * PURPOSE : Swap two task
208 * PARAMS : Task* previousTask -> pointer of the first task of the list
209 * PARAMS : Task* taskSwap1 -> pointer of first task to swap
210 * PARAMS : Task* taskSwap2 -> pointer of second task to swap
211 * RETURN : Task* -> pointer of the previous task
212 *
213 */
```

```
214 Task* swapTask(Task *previousTask, Task *taskSwap1, Task *taskSwap2) {
215   if (previousTask != taskSwap1) {
216     previousTask->nextTask = taskSwap2;
217     taskSwap1->nextTask = taskSwap2->nextTask;
218     taskSwap2->nextTask = taskSwap1;
219     return previousTask;
220   }
221   taskSwap1->nextTask = taskSwap2->nextTask;
222   taskSwap2->nextTask = taskSwap1;
223   return taskSwap2;
224 }
```

Listing 3: scheduler.c

2 Secondo Esercizio

Esecutore di comandi

2.1 Descrizione dell'implementazione

L'obiettivo del secondo esercizo é quello di creare un esecutore di comandi `UNIX` che scriva, sequenzialmente o parallelamente, l'output dell'esecuzione su di un file.
Tutte le funzionalitá del programma sono incluse all'interno della libreria *functions.h*5 e fanno uso a loro volta della libreria *unistd.h*. La funzione `initDataFolder()` si occupa di creare la cartella ed inserirvi il file di output. Essa viene generata all'interno della directory *"../commandexe/data/[pid]"* dove il *pid* é il process ID del chiamante in questione, ritornato dal `getpid()`. Il comando inserito dall'utente viene poi eseguito attraverso una `popen()`, la quale apre uno stream di scrittura/lettura su di una pipe, inserendovi l'output del comando. La funzione `execCommandAndLog(char,int)` genera due *char[]*, rispettivamente il *path* ed il *filename*, quest'ultimo viene nominato attraverso il pid e l'indice di esecuzione, come richiesto dalla specifica di implementazione. Viene poi eseguito il comando ed il log dell'output: l'esecuzione viene affidata ancora una volta ad una `popen()` mentre la scrittura dell'output viene eseguita mediante le usuali funzioni dello `stdin` attraverso il descrittore di file generato precedentemente. Il codice viene eseguito nel *cmd.c*4, all'interno del quale vi é un ciclo while che itera fino a quando non viene inserita la stringa vuota dall'utente.

2.2 Codice

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include "functions.h"

#define MAX_CMD_LEN 100

int main() {
  int k = 1;
  initDataFolder();
  while (1) {
    char cmd[MAX_CMD_LEN] = "";
    printf("\nEnter the %d-cmd: ", k);

    //read chars until \n
    scanf("%[^\n]", cmd);
    getchar();
    printf("Cmd entered : %s\n", cmd);
    if (strlen(cmd) == 0) {
      printf("Bye!\n");
      exit(1);
    }
    execCommandAndLog(cmd, k);
    k = k + 1;
  }

  return (0);
}
```

Listing 4: cmd.c

```c
/*
*
* PURPOSE : Create the data folder to store outputs
*
* RETURN : void
*
*/
int initDataFolder() {
  char cmd[30];
  FILE *fp;
  sprintf(cmd, "%s%i", "mkdir -p ../commandexe/data/", getpid());
  fp = popen(cmd, "r");
```

```
13    if (fp == NULL) {
14      printf("[Error] - Error initialing process folder\n");
15      exit(1);
16    }
17    return 0;
18  }
19
20  /*
21  *
22  * PURPOSE : Function that execute the c command and log the output in ../commandexe/data
        /[pid]/out.[index]
23  *
24  * PARAMS : char* -> command string
25  * PARAMS : int -> index of out.[index] log
26  * RETURN : int -> 0
27  *
28  */
29  int execCommandAndLog(char* c, int index) {
30    FILE *fp;
31    char path[1035];
32    char filename[7];
33
34    sprintf(filename, "data/%i/%s.%i", getpid(), "out", index);
35    FILE *f = fopen(filename, "w");
36    if (f == NULL) {
37      printf("[Error] - Error opening file!\n");
38      exit(1);
39    }
40
41    // command open to read
42    sprintf(c, "%s %s", c, "2>&1");
43    fp = popen(c, "r");
44
45    if (fp == NULL) {
46      fprintf(f, "[Error] - Error executing the command\n");
47    }
48
49    // read the output a line at a time - output it.
50    while (fgets(path, sizeof(path) - 1, fp) != NULL) {
51      fprintf(f, "%s", path);
52    }
53
54    // closing files
55    pclose(fp);
56    fclose(f);
57
58    return 0;
59  }
```

Listing 5: functions.h

3 Terzo Esercizio

Message passing

3.1 Descrizione dell'implementazione

3.2 Codice

```
#define DEBUG 1 //debug mode
#define CMD_PIPE_NAME "data/pipe" //path to store the main named pipe
#define PIPES_PATH "data/" //path to store clients pipes
#define MAX_MSG_LEN 100
#define MAX_PID_LEN 100
```

Listing 6: config.h

```
/*
*
* PURPOSE : Show menu options
*
* RETURN : void
*
*/
void menu(){
    int menuChoice;

    printf("Menu 1\n");
    printf("~~~~~~~~~~\n");
    printf("1. Connect to server.\n");
    printf("2. Get clients connected to server.\n");
    printf("3. Write to client/s.\n");
    printf("4. Disconnect from server.\n");
    printf("5. Exit.\n");
    scanf("%d", &menuChoice);
    printf("\n");
    switch ( menuChoice ){
        case 1:
            connect();
            break;
        case 2:
            getClientsID();
            break;
        case 3:
            sendMessage();
            break;
        case 4:
            disconnect();
            break;
        case 5:
            disconnect();
            clientExit();
            break;
        default:
            printf("Please.. is not a joke. \n");
    }

    printf("\n");
    menu();
}

/*
*
* PURPOSE : Connect to server
*
* RETURN : void
*
*/
void connect(){
    if(connected == 1){
        printf("%s\n", "Already connected");
        return;
```

```
56      }
57
58      printf("%s\n", "Connected");
59
60      char str[7];
61
62      sprintf(str, "1 %d", getpid()); // puts string into buffer
63
64      write(fd, str, sizeof(str));
65
66      connected = 1;
67
68      return;
69  }
70
71  /*
72  *
73  * PURPOSE : Request the list of the clients connected to the server
74  *
75  * RETURN : void
76  *
77  */
78  void getClientsID(){
79      char str[7];
80      char *s_pid;
81
82      sprintf(s_pid, "%d", getpid());
83      sprintf(str, "2 %s", s_pid); // puts string into buffer
84
85      write(fd, str, sizeof(str));
86
87      return;
88  }
89
90  /*
91  *
92  * PURPOSE : Clear old chars on a stream
93  *
94  * RETURN : void
95  *
96  */
97  void clear_stream(FILE *in){
98      int ch;
99
100     clearerr(in);
101
102     do
103         ch = getc(in);
104     while (ch != '\n' && ch != EOF);
105
106     clearerr(in);
107 }
108
109 /*
110 *
111 * PURPOSE : Get the lenght of an int
112 *
113 * PARAMS : int -> int to measure
114 * RETURN : int -> lenght of the int passed
115 *
116 */
117 int get_int_len(int value){
118   int l=1;
119   while(value>9){ l++; value/=10; }
120   return l;
121 }
122
123 /*
124 *
125 * PURPOSE : Send message to client(s) menu
126 *
127 * RETURN : void
128 *
```

```
129 */
130 void sendMessage(){
131     char msg[MAX_MSG_LEN];
132     int confirm;
133     int i = 1;
134 
135     //read the string message from STDIN
136     clear_stream(stdin);
137     printf("\nEnter the message: ");
138     scanf("%[^\n]s", msg);
139 
140     //output the message to the STDOUT
141     printf("Message entered : %s\n", msg);
142 
143     //message confirm
144     printf("\nPress 1 to confirm, others to delete the message.. ");
145     if(scanf("%d", &confirm)==1 && confirm==1){
146         //confirmed
147         if(DEBUG)
148             printf("%s\n", "Start sending..");
149 
150         int k = 1;
151         int pid;
152 
153         while (1) {
154             printf("\nEnter the %dth pid destination (letters to return to Menu): ", k);
155 
156             if(scanf("%d", &pid)==1){
157                 if(DEBUG)
158                     printf("[DEBUG] pid entered: %d\n", pid);
159 
160                 //send to pid
161                 int size = 5 + get_int_len(getpid()) + get_int_len(pid) + strlen(msg);
162                 char str[size];
163 
164                 if(DEBUG)
165                     printf("[DEBUG] str size: %d\n", size);
166 
167                 sprintf(str, "3 %d %d %s", getpid(), pid, msg); // puts string into
    buffer
168 
169                 if(DEBUG)
170                     printf("[DEBUG] string to send: '%s'\n", str);
171 
172                 write(fd, str, sizeof(str));
173 
174 
175                 k = k + 1;
176             }else{
177                 clear_stream(stdin);
178                 break;
179             }
180         }
181 
182         if(DEBUG)
183             printf("%s\n", "[DEBUG] End sending");
184 
185     }else{
186         clear_stream(stdin);
187         printf("%s\n", "Message aborted");
188     }
189 
190 
191     return;
192 }
193 
194 /*
195 *
196 * PURPOSE : Disconnect from the server
197 *
198 * RETURN : void
199 *
200 */
```

```
201 void disconnect(){
202     if(connected == 0){
203         printf("%s\n", "Already disconnected");
204         return;
205     }
206 
207     printf("%s\n", "Client disconnected");
208 
209     char str[7];
210 
211     sprintf(str, "4 %d", getpid()); // puts string into buffer
212 
213     write(fd, str, sizeof(str));
214 
215     connected = 0;
216 
217     return;
218 }
219 
220 /*
221 *
222 * PURPOSE : Function to exit from client execution
223 *
224 * RETURN : void
225 *
226 */
227 void clientExit(){
228     close(fd);
229     printf("%s\n", "Bye");
230     exit(0);
231 }
232 
233 /*
234 *
235 * PURPOSE : Manage SIGINT signal (CTRL+C)
236 *
237 * PARAMS : int -> signal number
238 * RETURN : void
239 *
240 */
241 void sigHandler_1(int signumber) {
242     if(signumber == SIGINT){
243         printf("\n{SIGNAL}\n");
244 
245         if(DEBUG)
246             printf("    [DEBUG] SIGINT catched\n");
247 
248         printf("{/SIGNAL}\n");
249         disconnect();
250         clientExit();
251     }
252     return;
253 }
254 
255 /*
256 *
257 * PURPOSE : Manage SIGUSR1 signal. When a SIGUSR1 is catched the client read from its
      named pipe
258 *
259 * PARAMS : int -> signal number
260 * RETURN : void
261 *
262 */
263 void sigHandler_2(int signumber){
264 
265     if(signumber == SIGUSR1) {
266         printf("\n{SIGNAL}\n");
267         if(DEBUG)
268             printf("    [DEBUG] SIGUSR1 catched\n");
269 
270         //READ RESPONSE FROM PROCESS PIPE
271         char s_pid[10];
272         int fd_client;
```

```
273         char pipeName[20];
274         char response[100];
275         char *p_pipeName;
276 
277         sprintf(s_pid, "%d", getpid());
278 
279 
280         p_pipeName = concat(PIPES_PATH, s_pid);
281 
282         // sprintf(p_pipeName,"%s %s",PIPES_PATH, s_pid);
283 
284         strcpy(pipeName, p_pipeName); /* BANG!!! */
285         fd_client = open(pipeName, O_RDWR); /* Open it for writing */
286 
287         if(DEBUG)
288             printf("    [DEBUG] Reading from: %s ...\n", pipeName);
289 
290         readLine(fd_client, response);
291         printf("    Received: %s\n", response);
292 
293         close(fd_client);
294 
295         char c[50];
296         sprintf(c, "rm -f  %s",pipeName);
297         FILE *fp = popen(c, "r");
298 
299         // closing files
300         pclose(fp);
301         printf("{/SIGNAL}\n");
302 
303     }
304 }
305 
306 /*
307 *
308 * PURPOSE : Manage SIGUSR2 signal. When a SIGUSR2 is catched the client had tried to send
      a message to a non existing client
309 *
310 * PARAMS : int -> signal number
311 * RETURN : void
312 *
313 */
314 void sigHandler_3(int signumber){
315 
316     if(signumber == SIGUSR2) {
317         printf("\n{SIGNAL}\n");
318 
319         if(DEBUG)
320             printf("    [DEBUG] SIGUSR2 catched.\n");
321 
322         printf("    Pid not found.\n");
323 
324         printf("{/SIGNAL}\n");
325     }
326 }
```

Listing 7: functions.client.h

```
1  /*
2  *
3  * PURPOSE : Create the data folder to store named pipes
4  *
5  * RETURN : void
6  *
7  */
8  int initDataFolder() {
9    FILE *fp;
10 
11   fp = popen("mkdir -p data/", "r");
12   if (fp == NULL) {
13     printf("[Error] - Error initialing process folder\n");
14     exit(1);
15   }
```

```
16
17      pclose(fp);
18
19    return 0;
20  }
21
22  /*
23  *
24  * PURPOSE : Manage SIGINT signal (CTRL+C)
25  *
26  * PARAMS : int -> signal number
27  * RETURN : void
28  *
29  */
30  void sigHandler_1(int signumber) {
31      if(signumber == SIGINT){
32          printf("\n{SIGNAL}\n");
33          if(DEBUG)
34              printf("  [DEBUG] SIGINT catched\n");
35
36          int killed;
37          remove(CMD_PIPE_NAME);
38          // here we have to insert a while to send SIGINT to all clients to disconnect to
        this server
39        killed = clients_killer(n);
40        if(DEBUG)
41          printf("  [DEBUG] killed %d clients\n", killed);
42          printf("{/SIGNAL}\n");
43        exit(0);
44      }
45      return;
46  }
47
48  /*
49  *
50  * PURPOSE : Send text to a pid client. Create a named pipe with the destination pid value
        , write the text and send.
51  *
52  * PARAMS : char* -> destination pid
53  * PARAMS : char* -> string to send
54  * RETURN : void
55  *
56  */
57  void sendTextToClient(char* pid, char* p_textToSend){
58    char pipeName[20];
59    char* p_pipeName;
60    int fd_client;
61    char c_textToSend[strlen(p_textToSend)+1];
62
63    strcpy( c_textToSend, p_textToSend );
64
65    p_pipeName = (char*)malloc(strlen(PIPES_PATH)+strlen(pid)+1);
66    p_pipeName = concat(PIPES_PATH, pid);
67    strcpy(pipeName, p_pipeName); /* BANG!!! */
68    mknod(pipeName, S_IFIFO|0666, 0); /* Create named pipe */
69    if(DEBUG)
70      printf("[DEBUG] Writing '%s' (size: %lu) to '%s'\n", c_textToSend, sizeof(
        c_textToSend), pipeName);
71    fd_client = open(pipeName, O_RDWR); /* Open it for writing */
72
73    int res = write(fd_client, c_textToSend, sizeof(c_textToSend));
74    if(DEBUG)
75      printf("[DEBUG] Written %d elements\n", res);
76    // close(fd_client); /* Close pipe */
77
78  }
```

Listing 8: functions.server.h

```
1  //struct
2  struct node{
3      char data[10];
4      struct node *next;
```

```
}*head;


/*
*
* PURPOSE : Get the number of clients connected
*
* RETURN :  int -> number of clients in the list
*
*/
int clients_count(){
    struct node *n;
    int c=0;
    n=head;
    while(n!=NULL){
        n=n->next;
        c++;
    }
    return c;
}

/*
*
* PURPOSE : Append a node to the end of the concat list
*
* PARAMS : char *pid -> pid to add in the list
* RETURN : void
*
*/
void clients_append(char* pid){
    struct node *temp,*right;
    temp= (struct node *)malloc(sizeof(struct node));
    strcpy(temp->data, pid);

    right=(struct node *)head;
    while(right->next != NULL)
        right=right->next;

    right->next =temp;
    right=temp;
    right->next=NULL;
}

/*
*
* PURPOSE : Add the first node in the concat list
*
* PARAMS : char *pid -> pid to add in the list
* RETURN : void
*
*/
void clients_add( char* num ){
    struct node *temp;
    temp=(struct node *)malloc(sizeof(struct node));
    strcpy(temp->data, num);
    // temp->data=num;
    if (head== NULL){
      head=temp;
      head->next=NULL;
    }
    else{
      temp->next=head;
      head=temp;
    }
}

/*
*
* PURPOSE : Add the (i+1)-node in the concat list
*
* PARAMS : char *pid -> pid to add in the list
* RETURN : void
*
```

```
78 */
79 void clients_addafter(char* num, int loc){
80     int i;
81     struct node *temp,*left,*right;
82     right=head;
83     for(i=1;i<loc;i++){
84         left=right;
85         right=right->next;
86     }
87     temp=(struct node *)malloc(sizeof(struct node));
88     // temp->data=num;
89     strcpy(temp->data, num);
90 
91     left->next=temp;
92     left=temp;
93     left->next=right;
94 }
95 
96 /*
97 *
98 * PURPOSE : Insert a pid in the concat list
99 *
100 * PARAMS : char *pid -> pid to add in the list
101 * RETURN : void
102 *
103 */
104 void clients_insert(char* pid){
105     int c=0;
106     struct node *temp;
107     temp=head;
108     if(temp==NULL){
109     // printf("%s\n", "ok");
110       clients_add(pid);
111     }
112     else{
113       while(temp!=NULL){
114           if(temp->data<pid)
115           c++;
116           temp=temp->next;
117       }
118       if(c==0)
119           clients_add(pid);
120       else if(c<clients_count())
121           clients_addafter(pid,++c);
122       else
123           clients_append(pid);
124     }
125 }
126 
127 /*
128 *
129 * PURPOSE : Search a client in the concat list
130 *
131 * PARAMS : char *pid -> pid to add in the list
132 * RETURN : void
133 *
134 */
135 int clients_search(char* pid){
136     struct node *temp, *prev;
137     temp=head;
138     while(temp!=NULL){
139         if(strcmp(temp->data,pid)==0)
140             return 1;
141 
142         prev=temp;
143         temp= temp->next;
144     }
145 
146     return 0;
147 }
148 
149 /*
150 *
```

```
151 * PURPOSE : Remove a client in the concat list
152 *
153 * PARAMS : char *pid -> pid to remove
154 * RETURN : int -> 1 if removed, 0 otherwise
155 *
156 */
157 int clients_delete(char* num){
158     struct node *temp, *prev;
159     temp=head;
160     while(temp!=NULL){
161         if(strcmp(temp->data,num)==0){
162             if(temp==head){
163                 head=temp->next;
164                 free(temp);
165                 return 1;
166             }
167             else{
168                 prev->next=temp->next;
169                 free(temp);
170                 return 1;
171             }
172         }
173         else{
174             prev=temp;
175             temp= temp->next;
176         }
177     }
178     return 0;
179 }
180
181 /*
182 *
183 * PURPOSE : Get the pid list of the clients connnected
184 *
185 * PARAMS : struct node *r
186 * RETURN : char* -> string of clients connected
187 *
188 */
189 char*  clients_display(struct node *r){
190     char* clients = NULL;
191     char*  toAdd;
192
193     clients = malloc(0);
194
195     r=head;
196     if(r==NULL)
197         return "No Clients Connected";
198
199     while(r!=NULL){
200         toAdd = &(r->data)[0];
201         sprintf(clients, "%s %s", clients, toAdd);
202         r=r->next;
203     }
204
205     return clients;
206 }
207
208 /*
209 *
210 * PURPOSE : Kill all clients connected to the server sending them a SIGINT signal
211 *
212 * PARAMS : struct node *r
213 * RETURN : int -> number of clients killed
214 *
215 */
216 int  clients_killer(struct node *r){
217     int pid;
218     int clientsKilled=0;
219
220     r=head;
221     if(r==NULL)
222       return 0;
223
```

```
224     while(r!=NULL){
225         pid = atoi(r->data);
226         if(DEBUG)
227             printf("[DEBUG] pid to kill: %d\n",pid);
228 
229         kill(pid,SIGINT);
230         clientsKilled += 1;
231         r=r->next;
232     }
233 
234     return clientsKilled;
235 }
```

Listing 9: listmanage.h

```
1  /*
2  *
3  * PURPOSE : Concat two strings
4  *
5  * PARAMS : char* s1 -> first string
6  * PARAMS : char* s2 -> second string
7  * RETURN : char* -> string concatenated
8  *
9  */
10 char* concat(const char *s1, const char *s2){
11     int i_s1 = 0;
12     int i_s2 = 0;
13 
14     if(&(s1)[0] != NULL)
15         i_s1 = strlen(s1);
16 
17     if(&(s2)[0] != NULL)
18         i_s2 = strlen(s2);
19 
20     char *result = malloc(i_s1+i_s2+1);//+1 for the zero-terminator
21 
22     //in real code you would check for errors in malloc here
23     if(&(s1)[0] != NULL)
24         strcpy(result, s1);
25 
26     if(&(s2)[0] != NULL)
27         strcat(result, s2);
28 
29     return result;
30 }
31 
32 /*
33 *
34 * PURPOSE : read a line from a file and write it in str
35 *
36 * PARAMS : int fd -> file descriptor
37 * PARAMS : char* str -> where the line read will go
38 * RETURN : int -> 1 if ok, 0 end-of-input
39 *
40 */
41 int readLine(int fd, char *str) {
42     /* Read a single '\0'-terminated line into str from fd */
43     /* Return 0 when the end-of-input is reached and 1 otherwise */
44     int n;
45     do { /* Read characters until '\0' or end-of-input */
46         n = read (fd, str, 1); /* Read one character */
47     } while (n > 0 && *str++ != '\0');
48     return (n > 0); /* Return false if end-of-input */
49 }
```

Listing 10: functions.inc.h

```
1 #include <stdio.h>
2 #include <stdlib.h>
3 #include <fcntl.h>
4 #include <sys/stat.h>
5 #include <sys/types.h>
6 #include <unistd.h>
```

```c
#include <string.h>
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <math.h>
#include "config.h"

int connected = 0;
char * myfifo = CMD_PIPE_NAME;
int fd;

void menu();
void connect();
void getClientsID();
void sendMessage();
void disconnect();
void clientExit();
void ex_program(int);
void sigHandler_1(int);
void sigHandler_2(int);
void sigHandler_3(int);

#include "functions.inc.h"
#include "functions.client.h"

int main(){
    if(DEBUG)
        printf("[DEBUG] pid: %d\n", getpid());

    signal(SIGINT, sigHandler_1);
    signal(SIGUSR1 ,sigHandler_2);
    signal(SIGUSR2 ,sigHandler_3);

    fd = open(myfifo, O_WRONLY);

    if(fd==-1){
        printf("%s\n", "[ERR]: server is not running");
        return 0;
    }

    printf("Hello. Welcome to the client.\n");
    printf("Press RETURN key to continue...\n");
    getchar();
    menu();

    return 0;
}
```

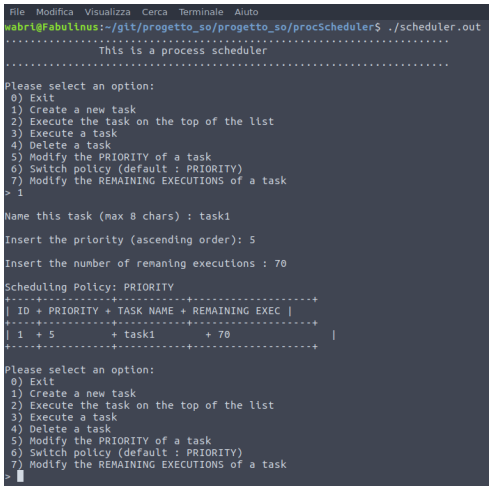
Listing 11: client.c

```c
#include <stdio.h>
#include <stdlib.h>
#include <fcntl.h>
#include <sys/stat.h>
#include <sys/types.h>
#include <unistd.h>
#include <string.h>
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include "config.h"

struct node *n;

int initDataFolder(void);
void sigHandler_1(int);
void sendTextToClient(char*,char*);

#include "functions.inc.h"
#include "listmanage.h"
#include "functions.server.h"

int main(){
```

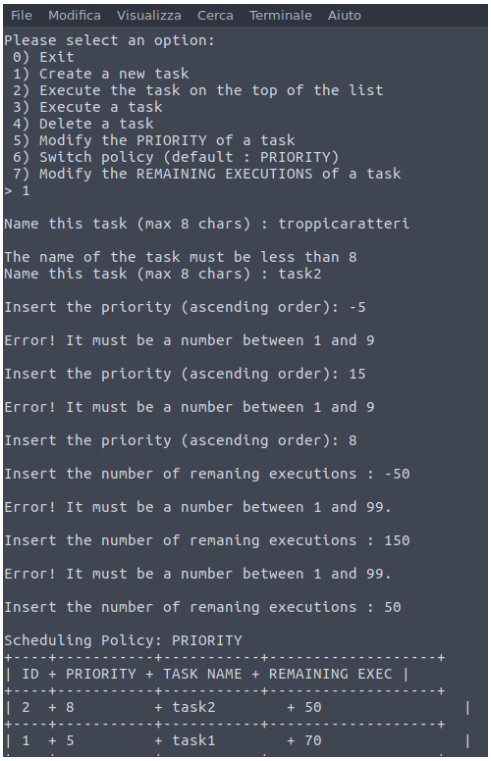
```
24    initDataFolder();
25
26    signal(SIGINT, sigHandler_1);
27
28    int i_fd;
29    int i_pid_m;
30    int i_pid_d;
31
32    char cmd[100];
33    char pid[10];
34
35    char* p_pid_m;
36    char* p_pid_d;
37    char* p_msg;
38    char* p_clientsList;
39    char* p_token;
40
41    //init clients list
42      head=NULL;
43
44    int res = mknod(CMD_PIPE_NAME, S_IFIFO|0666, 0); /* Create named pipe */
45    if(res!=0){
46      printf("%s\n", "[ERR] Problem creating pipe");
47      return 1;
48    }
49
50    i_fd = open(CMD_PIPE_NAME, O_RDONLY); /* Open it for reading */
51    if(i_fd==-1){
52      printf("%s\n", "[ERR] Problem reading pipe");
53      return 1;
54    }
55
56    if(DEBUG)
57      printf("[DEBUG] Reading from pipe %s ..\n\n", CMD_PIPE_NAME);
58
59    while (readLine(i_fd, cmd)){
60      /* Receiving messages */
61          if(DEBUG)
62        printf("[DEBUG] Received: %s\n", cmd);
63
64      char* cmd_detected = strtok(cmd, " ");
65      // printf("%s\n", cmd_detected);
66      char* p_pid_m = strtok(NULL, " ");
67      // printf("%s\n", p_pid_m);
68
69
70      strcpy(pid, p_pid_m); /* BANG!!! */
71      i_pid_m = atoi(pid);
72
73      if(DEBUG)
74        printf("[DEBUG] cmd->%s | pid_m->%s\n", cmd_detected, p_pid_m);
75
76      switch (cmd_detected[0]){
77        case '1':
78          clients_insert(pid);
79          break;
80        case '2':
81          p_clientsList = clients_display(n);
82
83          sendTextToClient(pid, p_clientsList);
84
85          if(DEBUG)
86            printf("[DEBUG] SIGUSR1 TO PID %d\n", i_pid_m);
87
88          //notify client through SIGNAL SIGUSR1
89          kill(i_pid_m, SIGUSR1);
90          break;
91        case '3':
92
93          p_pid_d = strtok(NULL, " ");
94          p_msg = strtok(NULL, " ");
95
96          while(p_token = strtok(NULL, " "))
```

```
97              sprintf(p_msg, "%s %s", p_msg, p_token);
98
99
100           if(DEBUG){
101             printf("[DEBUG] pid_d->%s\n", p_pid_d);
102             printf("[DEBUG] msg received: %s\n", p_msg);
103           }
104
105
106           if(clients_search(p_pid_d)==1){
107             //if the client is connected, send the message
108             i_pid_d = atoi(p_pid_d);
109
110             sendTextToClient(p_pid_d, p_msg);
111             //notify client through SIGNAL SIGUSR1
112             kill(i_pid_d, SIGUSR1);
113           }else{
114             //otherwise notify the client who request to send this message
115             if(DEBUG)
116               printf("[DEBUG] Client %s is not connected\n", p_pid_d);
117
118             //send SIGUSR2 to client
119             kill(i_pid_m, SIGUSR2);
120
121           }
122
123           break;
124         case '4':
125         case '5':
126           clients_delete(pid);
127           break;
128       }
129
130       printf("\n\r");
131     }
132
133     if(DEBUG)
134       printf("%s\n", "End..");
135
136     close (i_fd); /* Close pipe */
137       remove(CMD_PIPE_NAME);
138   }
```

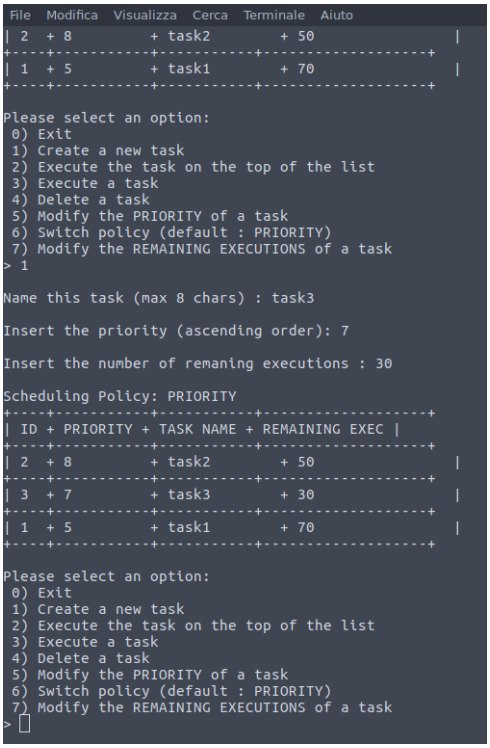
Listing 12: server.c



(a) inserimento

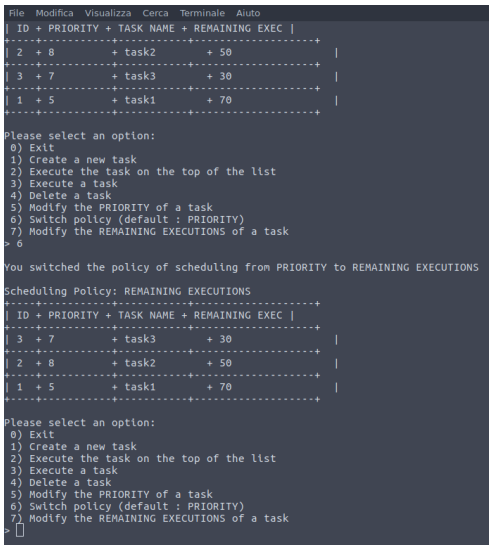


(b) inseriemento con errore

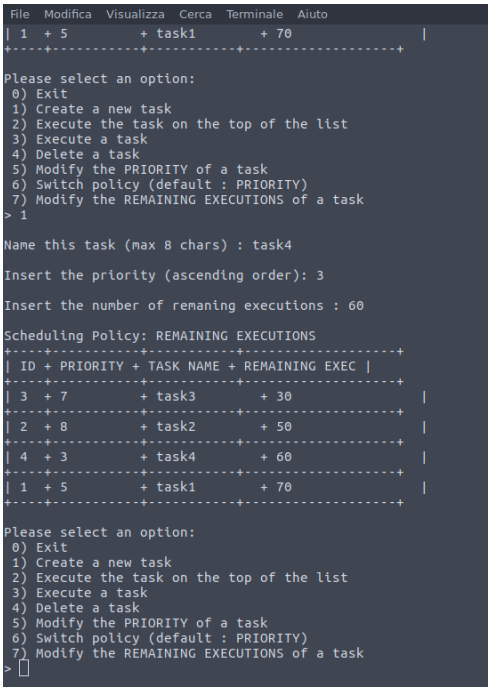


(c) inserimento e ordinamento

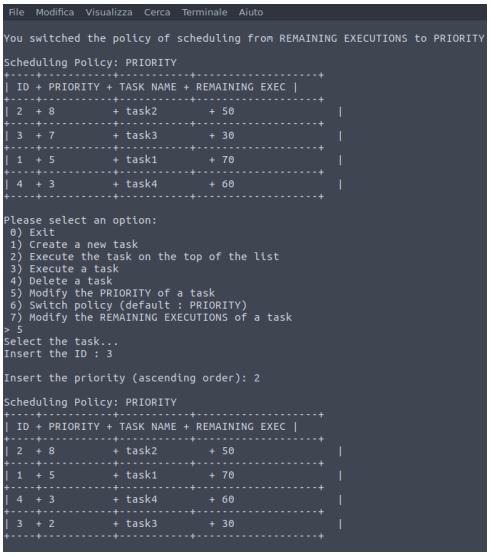
Figure 1: Creazione di un nuovo task



(a) switch della politica di scheduling

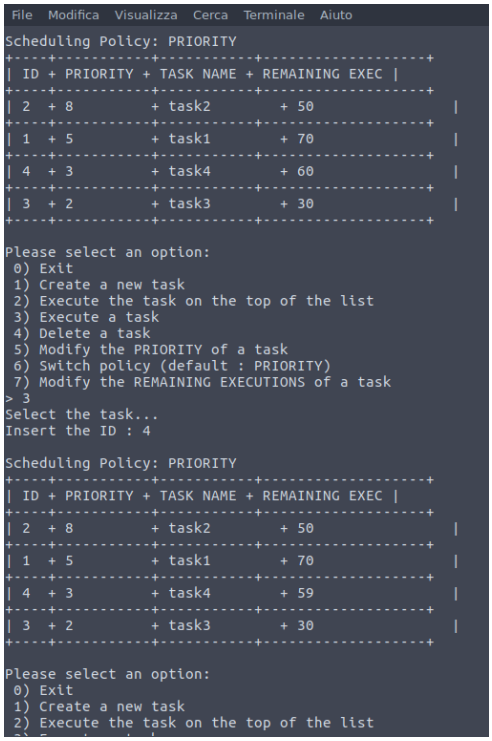


(b) inserimento e ordinamento

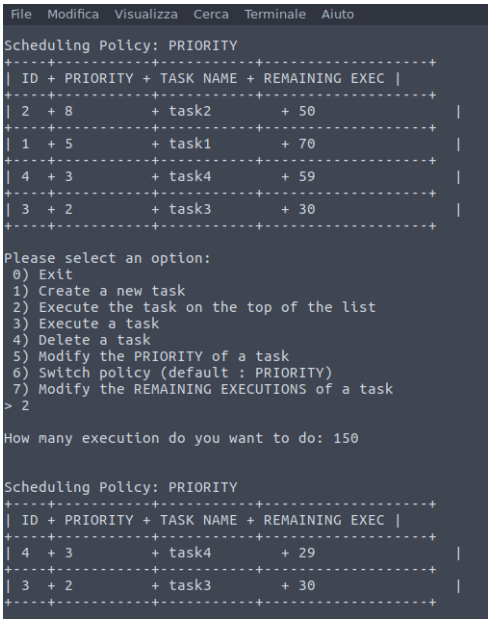


(c) switch della policy e modifica della prioriá

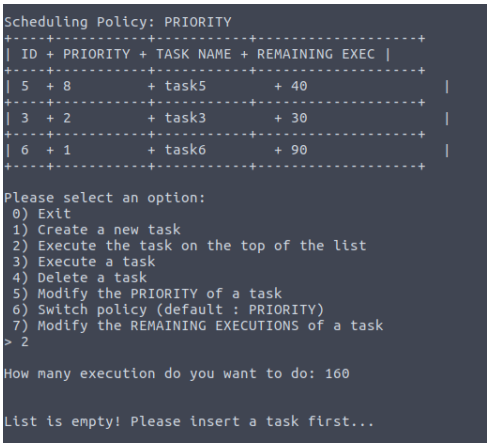
Figure 2: Mantenimento dell'ordinamento della lista dei task e modifica ai parametri



(a) singola esecuzione di un task

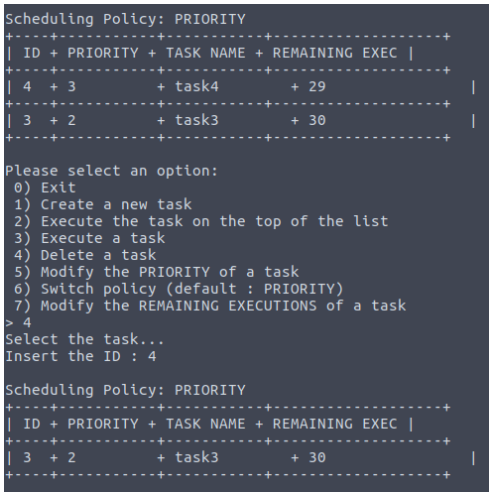


(b) 150 esecuzioni dei task in testa

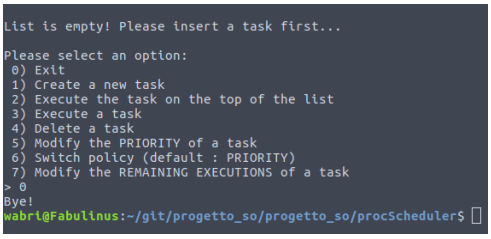


(c) esecuzione di tutti i task

Figure 3: Esecuzioni varie dei task

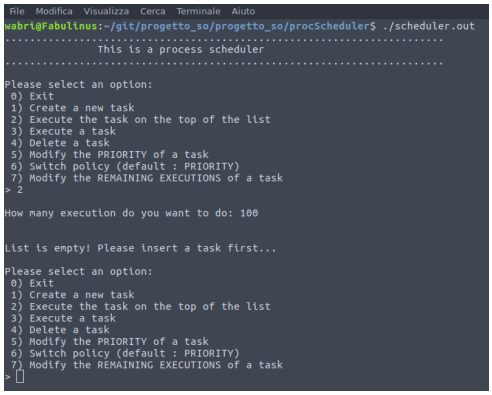


(a) eliminazione di tutti i task

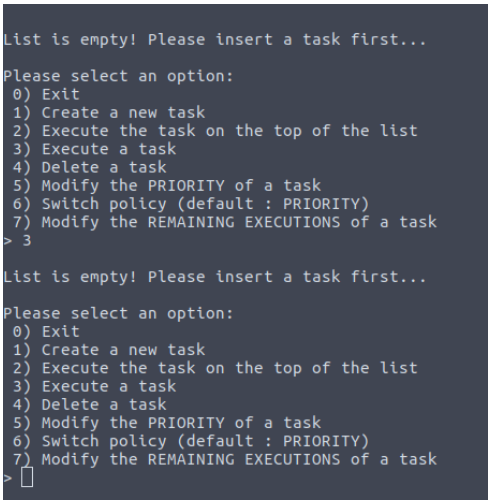


(b) uscita dal programma

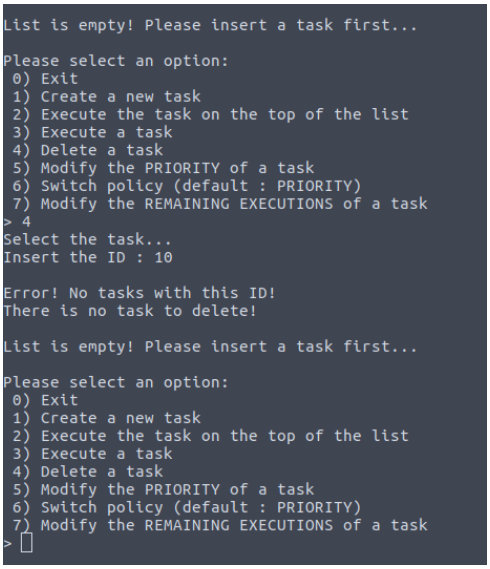
Figure 4: Eliminazione dei task ed uscita dal programma



(a) esecuzione a lista vuota



(b) esecuzione per ID a lista vuota



(c) eliminazione per ID a lista vuota

Figure 5: Esecuzioni a lista vuota

```
List is empty! Please insert a task first...

Please select an option:
 0) Exit
 1) Create a new task
 2) Execute the task on the top of the list
 3) Execute a task
 4) Delete a task
 5) Modify the PRIORITY of a task
 6) Switch policy (default : PRIORITY)
 7) Modify the REMAINING EXECUTIONS of a task
> 5
Select the task...
Insert the ID : 1

Error! No tasks with this ID!

List is empty! Please insert a task first...

Please select an option:
 0) Exit
 1) Create a new task
 2) Execute the task on the top of the list
 3) Execute a task
 4) Delete a task
 5) Modify the PRIORITY of a task
 6) Switch policy (default : PRIORITY)
 7) Modify the REMAINING EXECUTIONS of a task
>
```

(a) modifica della prioritá a lista vuota

```
List is empty! Please insert a task first...

Please select an option:
 0) Exit
 1) Create a new task
 2) Execute the task on the top of the list
 3) Execute a task
 4) Delete a task
 5) Modify the PRIORITY of a task
 6) Switch policy (default : PRIORITY)
 7) Modify the REMAINING EXECUTIONS of a task
> 7
Select the task...
Insert the ID : 4

Error! No tasks with this ID!

List is empty! Please insert a task first...

Please select an option:
 0) Exit
 1) Create a new task
 2) Execute the task on the top of the list
 3) Execute a task
 4) Delete a task
 5) Modify the PRIORITY of a task
 6) Switch policy (default : PRIORITY)
 7) Modify the REMAINING EXECUTIONS of a task
>
```

(b) modifica del n.esec. a lista vuota

Figure 6: Modifiche a lista vuota

4 Evidenza del corretto funzionamento

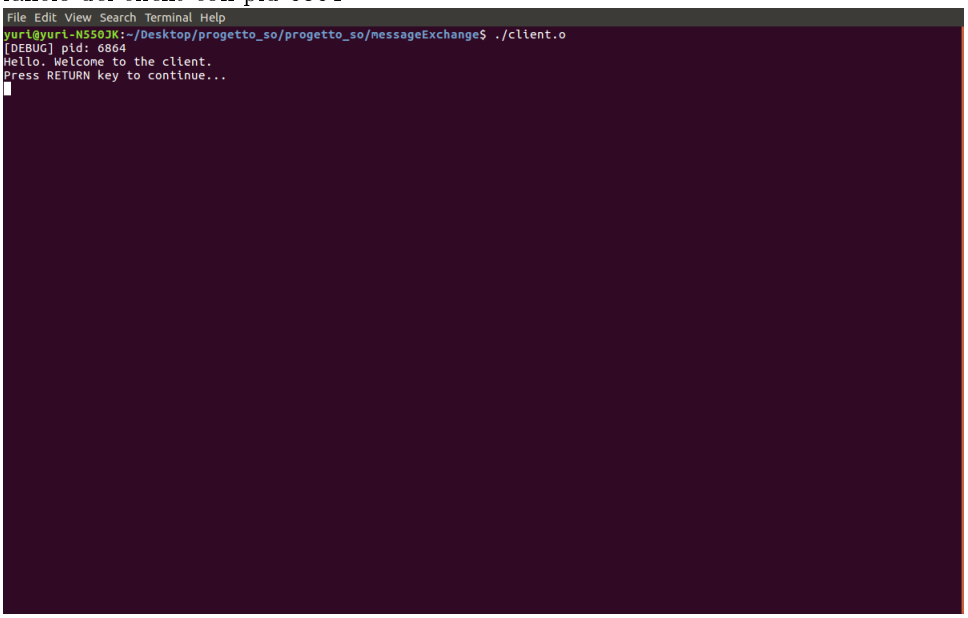
4.1 Esercizio 1

4.1.1 Stress Test

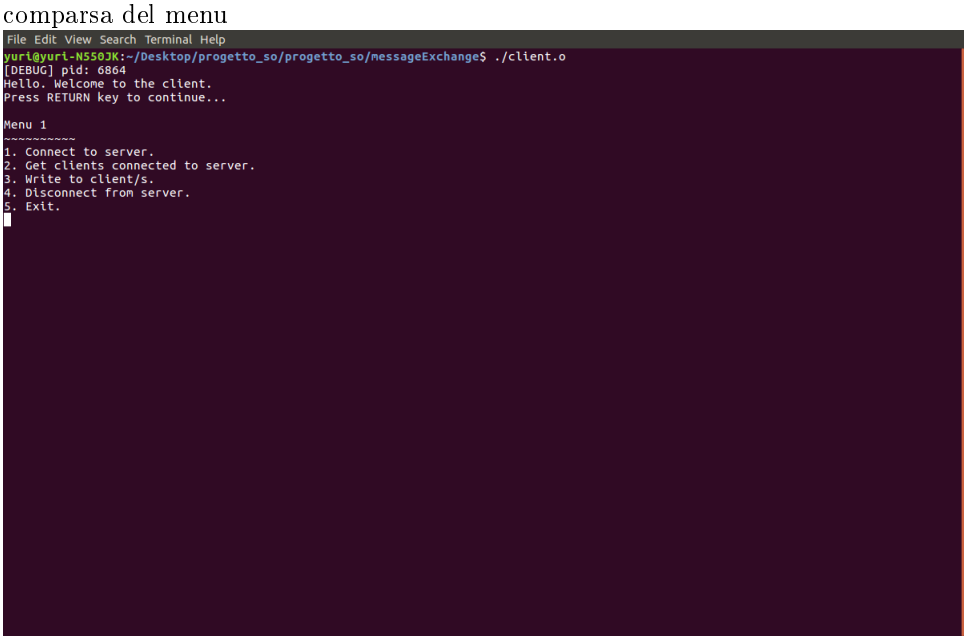
4.2 Esercizio 2

4.3 Esercizio 3

- lancio del client con pid 6864



- comparsa del menu

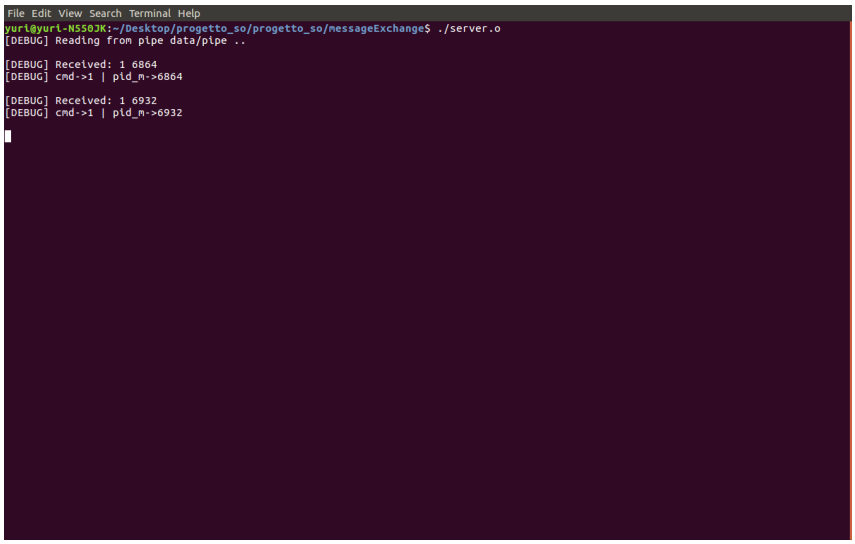


- connessione del client 6864 al server

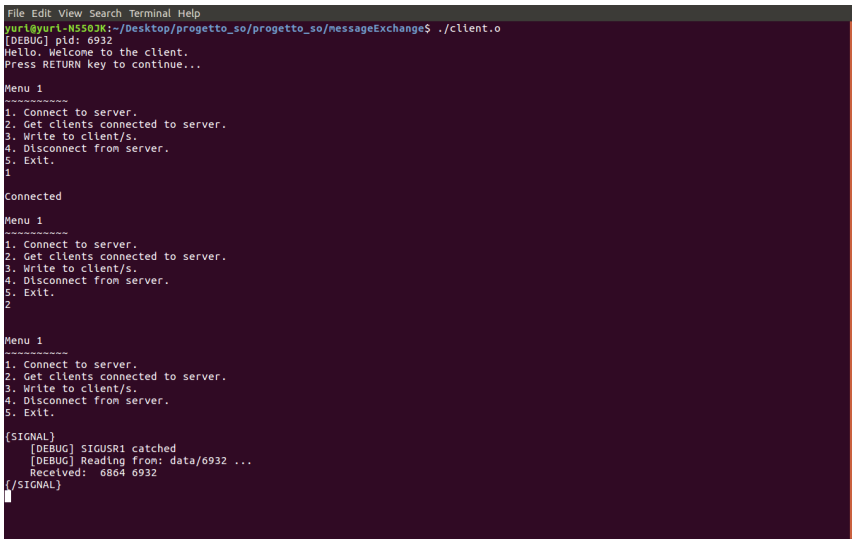
```
File  Edit  View  Search  Terminal  Help
yuri@yuri-N550JK:~/Desktop/progetto_so/progetto_so/messageExchange$ ./client.o
[DEBUG] pid: 6864
Hello. Welcome to the client.
Press RETURN key to continue...

Menu 1
~~~~~~~~~~
1. Connect to server.
2. Get clients connected to server.
3. Write to client/s.
4. Disconnect from server.
5. Exit.
1

Connected

Menu 1
~~~~~~~~~~
1. Connect to server.
2. Get clients connected to server.
3. Write to client/s.
4. Disconnect from server.
5. Exit.
```

- connessione del client 6932 al server

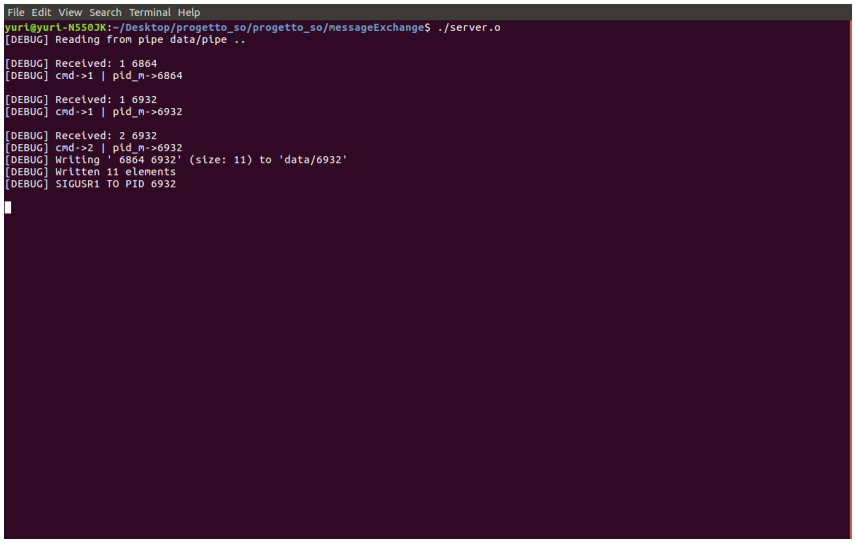
```
File  Edit  View  Search  Terminal  Help
yuri@yuri-N550JK:~/Desktop/progetto_so/progetto_so/messageExchange$ ./client.o
[DEBUG] pid: 6932
Hello. Welcome to the client.
Press RETURN key to continue...

Menu 1
~~~~~~~~~~
1. Connect to server.
2. Get clients connected to server.
3. Write to client/s.
4. Disconnect from server.
5. Exit.
1

Connected

Menu 1
~~~~~~~~~~
1. Connect to server.
2. Get clients connected to server.
3. Write to client/s.
4. Disconnect from server.
5. Exit.
```



(a) Connessioni dei client 6864 e 6932 lato server

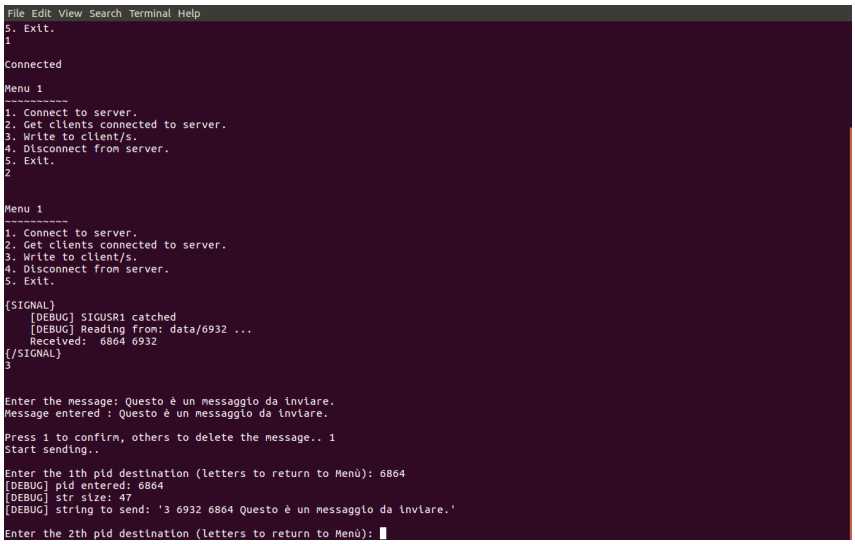


(b) Richiesta da parte di 6932 dei client connessi

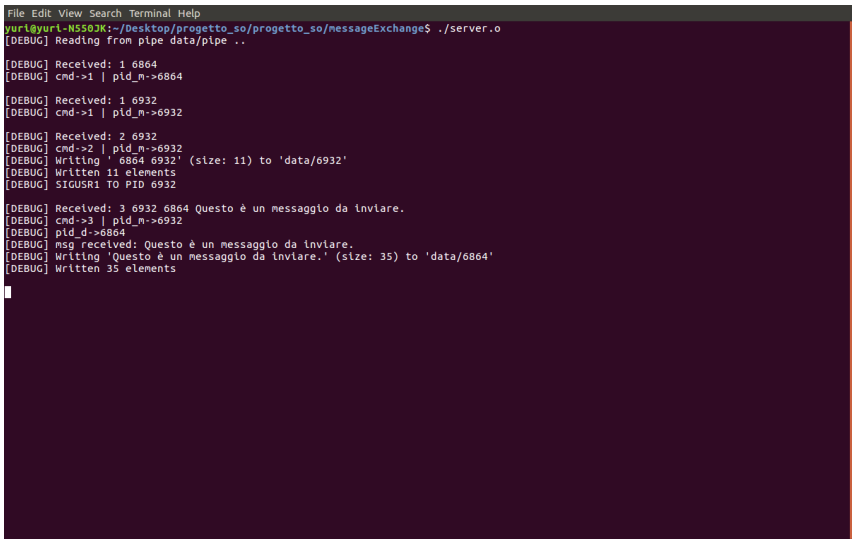


(c) Risposta del server a 6932

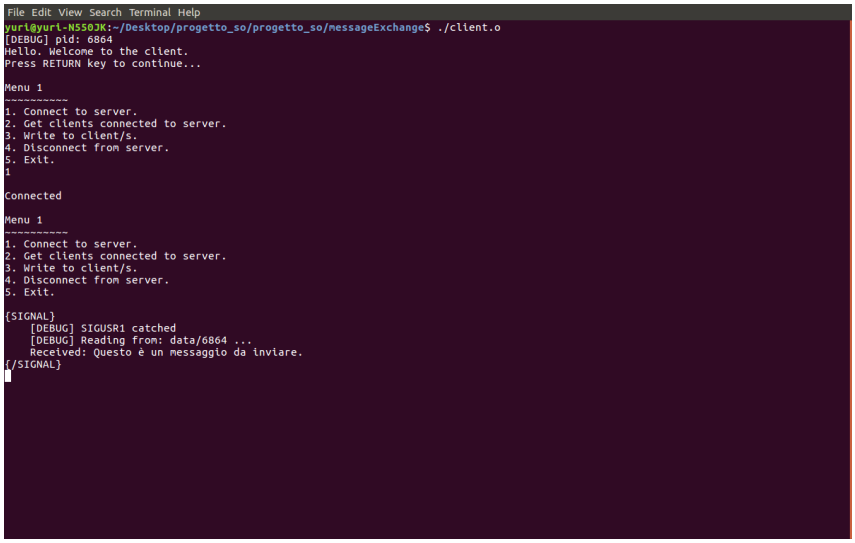
Figure 7: Connessioni e richiesta dei client connessi



(a) 6932 invia un messaggio a 6864

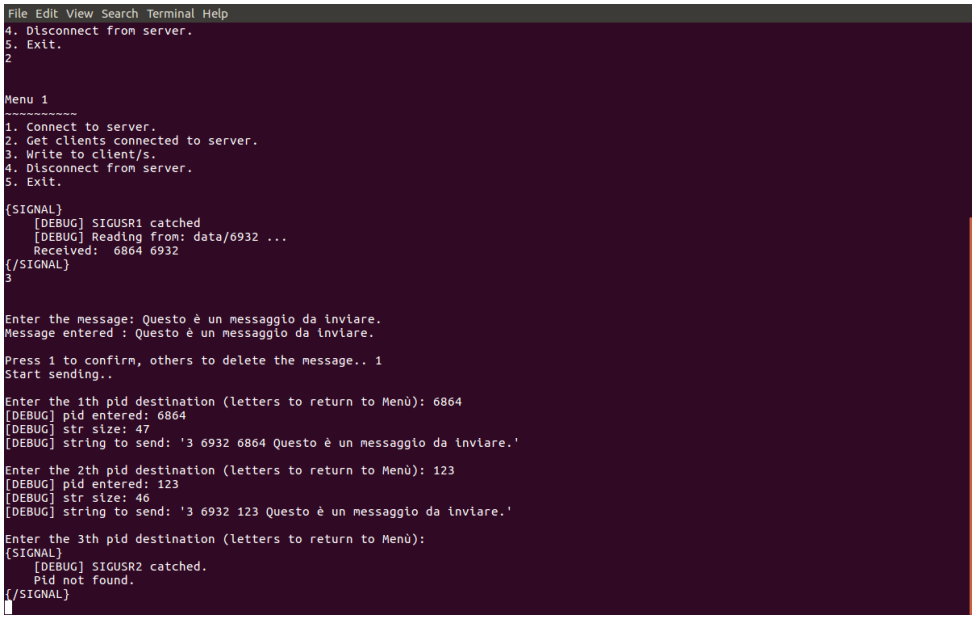


(b) Risposta del server alla richiesta di 6932

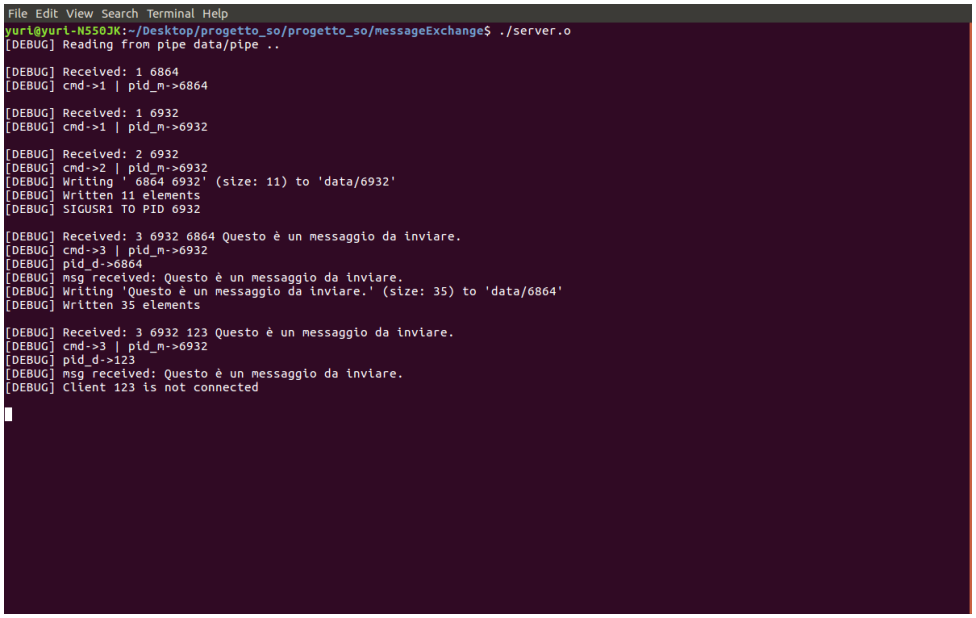


(c) Ricezione del messaggio da parte di 6864

Figure 8: Message passing

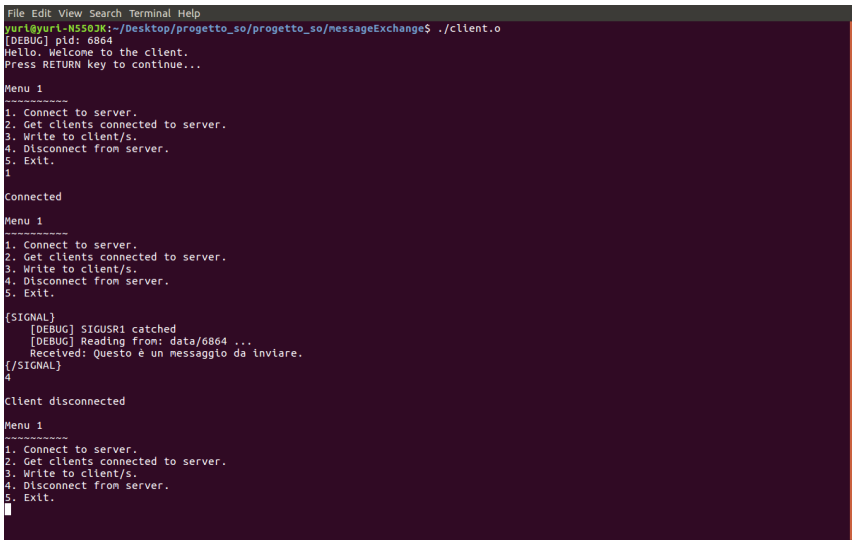


(a) Gestione dell'errore nell'invio di un messaggio ad un client inesistente

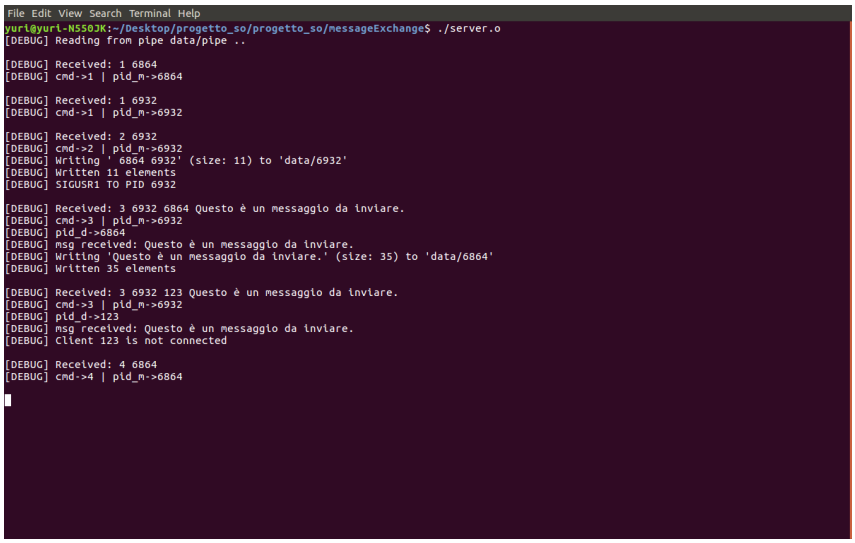


(b) Gestione dell'errore nell'invio di un messaggio ad un client inesistente lato server

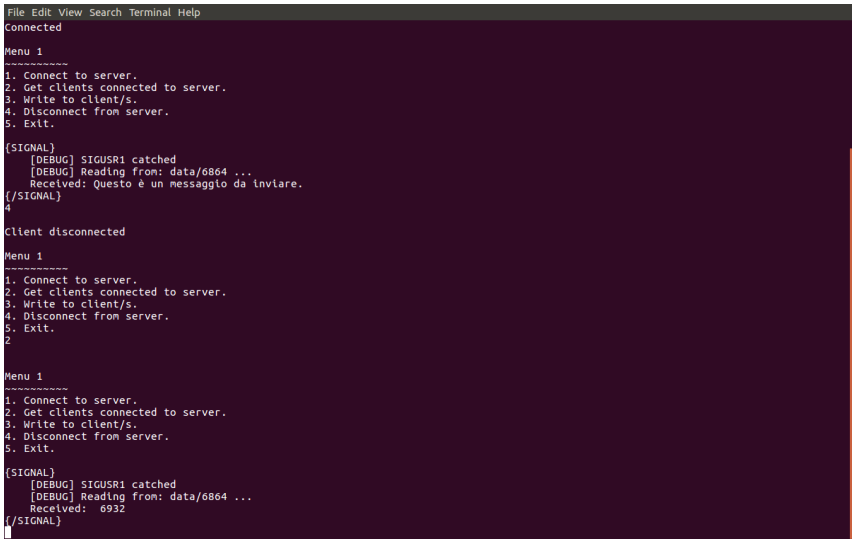
Figure 9: Errori



(a) Disconnessione di 6864 dal server

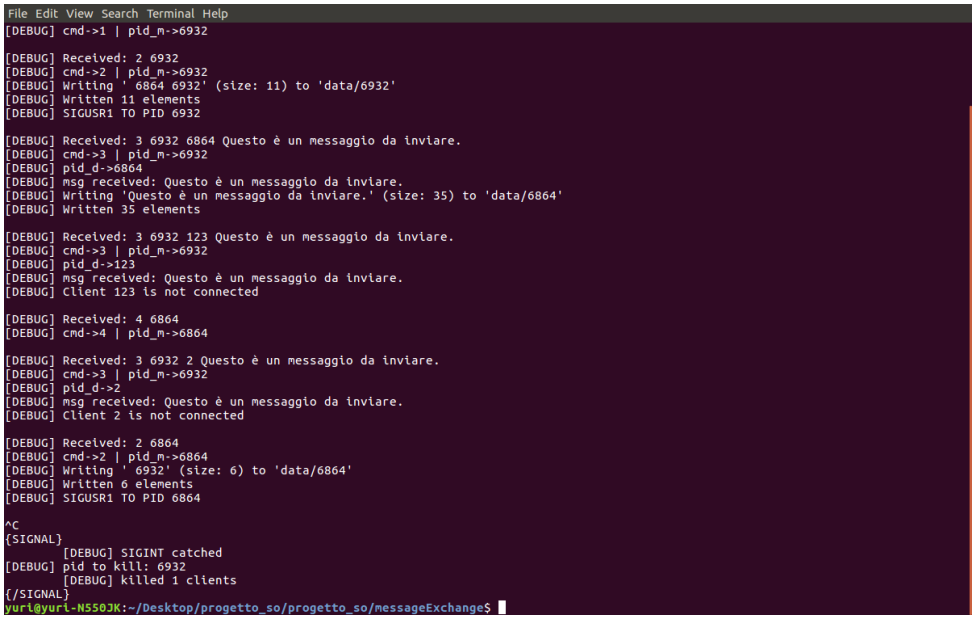


(b) Risposta del server

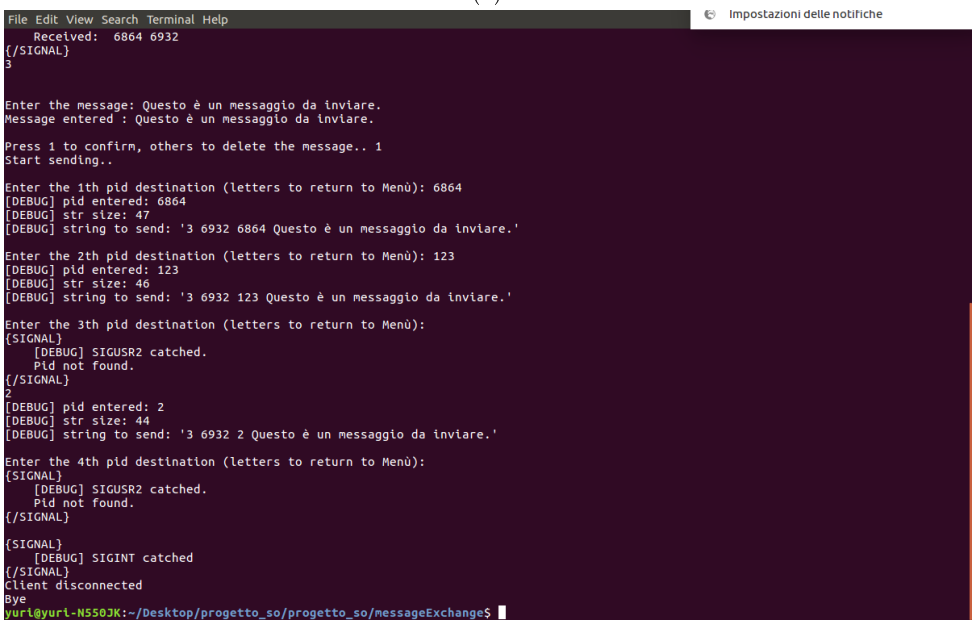


(c) Richiesta dei client connessi al server

Figure 10: Disconnessione



(a)



(b)

Figure 11: Errori