

CSGE602055 Operating Systems

CSF2600505 Sistem Operasi

Week 08: Scheduling

Rahmat M. Samik-Ibrahim

University of Indonesia

<http://rms46.vlsm.org/2/207.html>

Always check for the latest revision!

REV115 05-FEB-2018

Operating Systems 2018-1 (Room 3114 Tue/Thu)

Class: A (10:00-12:00) | B (13:00-15:00) | C (16:00-18:00)

| Week | Schedule | Topic | OSC9 |
|----------|----------------------|--|----------------|
| Week 00 | 06 Feb - 12 Feb 2018 | Intro & Review1 | Ch. 1, 16 |
| Week 01 | 13 Feb - 19 Feb 2018 | Review2 & Scripting | Ch. 1, 2 |
| Week 02 | 20 Feb - 26 Feb 2018 | Protection, Security, Privacy, & C-language | Ch. 14, 15 |
| Week 03 | 27 Feb - 05 Mar 2018 | I/O, BIOS, Loader, & Systemd | Ch. 13 |
| Week 04 | 06 Mar - 12 Mar 2018 | Addressing, Shared Lib, & Pointer | Ch. 8 |
| Week 05 | 13 Mar - 19 Mar 2018 | Virtual Memory | Ch. 9 |
| Reserved | 20 Mar - 24 Mar 2018 | | |
| Mid-Term | 26 Mar - 03 Apr 2018 | (UTS) | |
| Week 06 | 05 Apr - 11 Apr 2018 | Concurrency: Processes & Threads | Ch. 3, 4 |
| Week 07 | 12 Apr - 18 Apr 2018 | Synchronization | Ch. 5, 7 |
| Week 08 | 19 Apr - 25 Apr 2018 | Scheduling | Ch. 6 |
| Week 09 | 26 Apr - 05 May 2018 | File System & Persistent Storage | Ch. 10, 11, 12 |
| Week 10 | 07 May - 16 May 2018 | I/O Programming & Network Sockets Programming | |
| Reserved | 17 May - 22 May 2018 | | |
| Final | 23 May - 26 May 2018 | (UAS) | |
| Deadline | 07 Jun 2018 16:00 | Extra assignment deadline | |

Agenda

- 1 Start
- 2 Agenda
- 3 Scheduling
- 4 Threads
- 5 Scheduling Model
- 6 Sockets
- 7 00-server
- 8 01-client
- 9 OUTPUT: 00-server – 01-client
- 10 02-clisvr
- 11 OUTPUT: 02-clisvr
- 12 The End

Week 08: Scheduling

- Reference: (OSC9-ch06 demo-w08)
- Scheduling
 - Basic Concepts
 - **WARNING:** It's just a BURST
 - IO Burst
 - CPU Burst
 - CPU Burst vs. Freq (OLD)
 - Utilization, throughput, {turnaround, waiting, response} time.
 - (Burst) Algorithm
 - FCFS, SJF, RR, Priority, Multilevel Queue.
 - Preemptive / Non-preemptive Scheduling
 - I/O Bound / CPU Bound Processes
- Standard Linux Scheduling
 - Completely Fair Scheduler (CFS).
 - Real Time Scheduling.

Thread Scheduling

- Thread Scheduling
 - User-level thread scheduling
 - Kernel-level thread scheduling
- Multi-threading Models:
 - Many to One Model
 - One to One Model
 - Many to Many Model
- Pthread Contention Scope
 - Process-Contention Scope (PCS): many to many (eg. Linux).
 - System-Contention Scope (SCS): one to one.
- MultiCore/ MultiProcessor/ MultiThread
 - affinity
 - load balancing
- Soft / Hard Real Time
- Big O Notation
 - $O(1)$
 - $O(\log N)$
 - $O(N)$

Scheduling Model

- Two State Model: CPU State – I/O State – CPU State – ...
 - n : processes in memory.
 - p : I/O time fraction.
 - p^n : probability n processes waiting for I/O.
 - $1 - p^n$: CPU utilization of n processes.
 - $\left[\frac{(1-p^n)}{n} \right]$: CPU utilization of ONE processes.
- Example: $p = 60\% \Rightarrow$ **CPU Utilization Per Process:** $\left[\frac{1-(60\%)^n}{n} \right]$

| CPU Utilization | Multiprogramming (%) | | | | |
|-----------------|----------------------|----|----|----|----|
| N | 1 | 2 | 3 | 4 | 5 |
| Per Process | 40 | 32 | 26 | 21 | 18 |

- For 5 concurrent processes:
If total time is 100 seconds, each CPU time will be 18 seconds.

- Sockets

- `atoi()`
- `accept()`
- `bind()`
- `connect()`
- `exit()`
- `fprintf()`
- `getenv()`
- `gethostbyname()`
- `htons()`
- `listen()`
- `memcpy()`
- `memset()`

- Sockets

- perror()
- sizeof()
- socket()
- snprintf()
- strchr()
- strcmp()
- strncpy()
- strlen()
- read()
- write()


```
/*
 * (c) 2007-2016 Rahmat M. Samik-Ibrahim -- This is free software
 * This program was copased from the net and hacked until it works.
 * Feel free to copy and/or modify and/or distribute it,
 * provided this notice, and the copyright notice, are preserved.
 * REV00 Tue Nov 8 11:45:35 WIB 2016
 * START Xxx Xxx XX XX:XX:XX UTC 2007
 */

char pesan[]="[FROM SERVER] ACK MESSAGE...\n";
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <unistd.h>
#include <netdb.h>
#include <sys/socket.h>
#include <arpa/inet.h>
typedef struct sockaddr      sockad;
typedef struct sockaddr_in   sockadin;
typedef struct hostent       shostent;

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

00-server (2)

```
int main(int argc, char *argv[]) {
    char    buffer[256];
    int      clilen, newsockfd, nn, portno, sockfd;
    sockadin serv_addr, cli_addr;
    if (argc < 2) {
        fprintf(stderr, "ERROR, no port provided\n");
        exit(1);
    }
    sockfd = socket(AF_INET, SOCK_STREAM, 0);
    if (sockfd < 0)
        error("ERROR opening socket");
    memset(&serv_addr, 0, 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, (sockad*)&serv_addr, sizeof(serv_addr)) < 0)
        error("ERROR on binding");
    listen(sockfd, 5);
    clilen = sizeof(cli_addr);
    newsockfd=accept(sockfd, (sockad*)&cli_addr, (socklen_t*)&clilen);
    if (newsockfd < 0)
        error("ERROR on accept");
    memset(buffer, 0, 256);
    nn = read(newsockfd,buffer,255);
    if (nn < 0)
        error("ERROR reading from socket");
    printf("[FROM CLIENT]:\n %s\n",buffer);
    nn = write(newsockfd, pesan, sizeof(pesan));
    if (nn < 0)
        error("ERROR writing to socket");
    return 0;
}
```

01-client

```
/*
 * (c) 2007-2016 Rahmat M. Samik-Ibrahim -- This is free software
 * This program was copased from the net and hacked until it works.
 * Feel free to copy and/or modify and/or distribute it,
 * provided this notice, and the copyright notice, are preserved.
 * REV00 Tue Nov  8 11:45:52 WIB 2016
 * START Xxx Xxx XX XX:XX:XX UTC 2007
 */
```

```
char pesan[]="[FROM SERVER] ACK MESSAGE...\n";
```

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <unistd.h>
#include <netdb.h>
#include <sys/socket.h>
#include <arpa/inet.h>
typedef struct sockaddr      sockad;
typedef struct sockaddr_in   sockadin;
typedef struct hostent       shostent;
```

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

```
int main(int argc, char *argv[]) {
    char      buffer[256];
    int       nn, portno, sockfd;
    sockadin  serv_addr;
    shostent* server;
```

01-client (2)

```
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);
}
memset(&serv_addr, 0, sizeof(serv_addr));
serv_addr.sin_family = AF_INET;
memmove(&serv_addr.sin_addr.s_addr, server->h_addr, server->h_length);
serv_addr.sin_port = htons(portno);
if (connect(sockfd, (const struct sockaddr*) &serv_addr, sizeof(serv_addr)) < 0)
    error("ERROR connecting");
printf("Enter the message: ");
memset(buffer, 0, 256);
fgets(buffer, 255, stdin);
nn = write(sockfd, buffer, strlen(buffer));
if (nn < 0)
    error("ERROR writing to socket");
memset(buffer, 0, 256);
nn = read(sockfd, buffer, 255);
if (nn < 0)
    error("ERROR reading from socket");
printf("%s\n", buffer);
return 0;
}
```

OUTPUT: 00-server – 01-client

```
>>>>> $ PS1="SERVER >> "  
SERVER >> 00-server 4444  
[FROM CLIENT]:  
  This is from client via port 4444.
```

```
SERVER >>
```

```
>>>>> $ PS1="CLIENT >> "  
CLIENT >> 01-client localhost 4444  
Enter the message: This is from client via port 4444.  
[FROM SERVER] ACK MESSAGE...
```

```
CLIENT >>
```

```
/*
* (c) 2007 Tadeus Prastowo and Rahmat M. Samik-Ibrahim.
* (c) 2017 Rahmat M. Samik-Ibrahim.
* This is free software. It was copased from the net and hacked until
* it works. Feel free to copy and/or modify and/or distribute it,
* provided this notice, and the copyright notice, are preserved.
* REV01 Wed Nov 8 20:00:02 WIB 2017
* START 2007
*
* This program serves as both a client and a server. Three modes of
* operation are available:
* - initiating mode
* - bridging mode
* - terminating mode
*
* The following are how to run thisprogram for each mode:
* - Initiating mode: client_server null ANOTHER_HOST ANOTHER_PORT
* - Bridging mode: client_server CURRENT_PORT ANOTHER_HOST ANOTHER_PORT
* - Terminating mode: client_server CURRENT_PORT null null
*
* The program having the initiating mode _MUST_ run last after all other
* instances of this program with other operational modes has been started.
*
* In initiating mode, this program just simply sends a hello message to
* another instance of this program that operates either as a bridge or
* as a terminator that this program points to as specified in
* ANOTHER_HOST and ANOTHER_PORT. After that this program will quit
* without printing out any message.
*/
```

02-clisvr (2)

```
/*
 * In bridging mode, this program just simply waits for an incoming hello
 * message in CURRENT_PORT. Once it receives a hello message, it prints
 * out the message in a certain format. Next, this program forwards the
 * modified message to another instance of this program that acts either as
 * a bridge or as a terminator that this program points to as specified
 * in ANOTHER_HOST and ANOTHER_PORT. After that this program will quit.
 *
 * In terminating mode, this program just simply waits for an incoming hello
 * message in CURRENT_PORT. Once it receives a hello message, it prints out
 * the message in a certain format, and then quits.
 *
 * The following illustrates the idea above:
 * 192.168.10.18 (alvin)
 * $ ./client_server 8888 localhost 7777
 * 192.168.10.18 (user)$
 * $ ./client_server 7777 null null
 * 192.168.12.17 (eus)$
 * $ ./client_server null 192.168.10.18 8888
 * The print out will be:
 * 192.168.10.18 (alvin):
 *   From eus to alvin: Hello
 * 192.168.10.18 (user):
 *   From eus to alvin to user: Hello
 */
```

02-clisvr (3)

```
char pesan[]="[FROM SERVER] ACK MESSAGE...\n";
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <unistd.h>
#include <netdb.h>
#include <sys/time.h>
#include <sys/socket.h>
#include <arpa/inet.h>

typedef struct sockaddr      sockad;
typedef struct sockaddr_in   sockadin;
typedef struct hostent       shostent;

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


02-clisvr (4)

```
#define BUFFER_SIZE 4096

int main (int argc, char *argv []) {
    int sockfd, newsockfd, portno, clilen, count, nn, sysup;
    char buffer [BUFFER_SIZE], temp_buffer [BUFFER_SIZE], *colon_pos;
    struct sockaddr_in serv_addr, cli_addr;
    struct hostent *server;
    struct timeval tval;

    if (argc < 4) {
        fprintf (stderr,
            "\nUsage: %s this_port next_sever next_server_port\n\n"
            "Start the chain with 'this_port' = 'null'\n\n"
            "Terminte the chain with 'next_server' = 'next_server_port'"
            " = 'null'\n\n", argv [0]);
        exit (1);
    }
```

02-clisvr (5)

```
if (strcmp (argv [1], "null") == 0) {
    portno = atoi    (argv [3]);
    sockfd = socket (AF_INET, SOCK_STREAM, 0);
    if (sockfd < 0) {
        error ("ERROR opening socket");
    }
    server = gethostbyname(argv[2]);
    if (server == NULL) {
        fprintf (stderr, "ERROR, no such host\n");
        exit (1);
    }
    memset (&serv_addr, 0, sizeof (serv_addr));
    serv_addr.sin_family = AF_INET;
    memcpy(&serv_addr.sin_addr.s_addr, server->h_addr, server->h_length);
    serv_addr.sin_port = htons(portno);
    if (connect(sockfd,(struct sockaddr *)&serv_addr,sizeof(serv_addr))< 0){
        error ("ERROR connecting");
    }
    /* Begin: action */
    memset (buffer, 0, BUFFER_SIZE);
    gettimeofday(&tval,NULL);
    sysup = 0x0000FFFF & (int) (tval.tv_sec * 1000 + tval.tv_usec / 1000);
    snprintf (buffer, BUFFER_SIZE, "From %s[%d]: Hello", getenv ("USER"), sysup);
    nn = write (sockfd, buffer, strlen (buffer));

    if (nn < 0) {
        error ("ERROR writing to socket");
    }
    /* End: action */
    exit (0);
}
```

02-clisvr (6)

```
sockfd = socket(AF_INET,SOCK_STREAM,0);
if (sockfd < 0) {
    error ("ERROR opening socket");
}
memset(&serv_addr,0,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,
    (socklen_t *) &clilen);
if (newsockfd < 0) {
    error ("ERROR on accept");
}
memset (buffer, 0, BUFFER_SIZE);
nn = read(newsockfd,buffer,BUFFER_SIZE-1);
if (nn < 0) {
    error ("ERROR reading from socket");
}
```

02-clisvr (7)

```
/* Modify buffer's message */
colon_pos = strchr (buffer, ':');
nn        = colon_pos - buffer;
memset (temp_buffer, 0, BUFFER_SIZE);
strncpy (temp_buffer, buffer, nn);
memset (buffer, 0, BUFFER_SIZE);
strncpy (buffer, temp_buffer, nn);
for (long ii=0; ii<5000000L; ii++)
    ; // delay
gettimeofday(&tval,NULL);
sysup = 0x0000FFFF &
    (int) (tval.tv_sec * 1000 + tval.tv_usec / 1000);
snprintf (buffer + nn, BUFFER_SIZE-nn,
    " to %s[%d]: Hello", getenv ("USER"), sysup);
/*End of modifying buffer's message*/
```

02-clisvr (8)

```
if (strcmp (argv [2], "null") != 0 && strcmp (argv [3], "null") != 0) {
    portno = atoi (argv [3]);
    sockfd=socket(AF_INET,SOCK_STREAM,0);
    if (sockfd < 0) {
        error ("ERROR opening socket");
    }
    server = gethostbyname (argv [2]);
    if (server == NULL) {
        fprintf (stderr, "ERROR, no such host\n");
        exit (1);
    }
    serv_addr.sin_family = AF_INET;
    memcpy (&serv_addr.sin_addr.s_addr, server->h_addr, server->h_length);
    serv_addr.sin_port = htons (portno);
    if (connect (sockfd,(struct sockaddr *)&serv_addr,sizeof (serv_addr))<0){
        error ("ERROR connecting");
    }
    /* Begin: action */
    printf ("%s\n", buffer);
    nn=write(sockfd,buffer,strlen(buffer));
    if (nn < 0) {
        error ("ERROR writing to socket");
    }
    /* End: action */
} else {
    printf ("%s\n", buffer);
}
return 0;
}
```

OUTPUT: 02-clisvr

```
TERMINAL >> PS1="TERMINAL >> "  
TERMINAL >> 02-clisvr 4000 localhost null  
From demo[23440] to demo[23450] to demo[23461]: Hello  
TERMINAL >>
```

```
MIDDLE >> PS1="MIDDLE >> "  
MIDDLE >> 02-clisvr 4001 localhost 4000  
From demo[23440] to demo[23450]: Hello  
MIDDLE >>
```

```
START >> PS1="START >> "  
START >> 02-clisvr null localhost 4001  
START >>
```

The End

- ☐ This is the end of the presentation.
- ☒ This is the end of the presentation.
 - This is the end of the presentation.