PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE

ACADEMIC YEAR: 2023-24

DEPARTMENT of COMPUTER ENGINEERING DEPARTMENT

CLASS: T.E. **SEMESTER: I**

SUBJECT: LP-1 (SP&OS)

ASSINGMENT NO.	A1 (Part 1)
TITLE	Implement pass-I of two-pass assembler.
PROBLEM STATEMENT/ DEFINITION	Design suitable data structures and implement pass-I of a two-pass assembler for pseudo-machine in Java. Implementation should consist of a few instructions from each category and few assembler directives.
OBJECTIVE	1. To learn systems programming tools 2. Implement language translator (i.e., assembler: a language translator for low level language like assembly language)
OUTCOME	After implementing this assignment, learners will be able to 1. Generate intermediate data structures like IC, SYMTAB, LITTAB, POOLTAB 2. Understand the relevance of the intermediate data structures with respect to Pass-II of assembler
S/W PACKAGES AND HARDWARE/ APPARATUS USED	**Operating System recommended:** 64-bit Open-source Linux or its derivative **Programming tools recommended:** Eclipse IDE **Programming language:** JAVA **Hardware requirements:** I3 and I5 machines
REFERENCES	Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4. Find eBook in the following link: https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing
STEPS	**Step1. Input for Pass-I of assembler:** 1. Assembly language program in hypothetical language as per the Author Dhamdhere, in a file. 2. OPTAB 3. Condition code table 4. Register table **Step2. Open the input file and apply the Pass1 of assembler algorithm, process the input file line by line and inside a line token by token** Please refer algorithm of Pass I of assembler from the following textbook: Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4. Please refer the following link for e-Book and solved test cases

	https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing **Step3. Output of Pass-I of assembler:** 1. IC 2. SYMTAB 3. LITTAB 4. POOLTAB
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/Analysis

Prerequisites:

Microprocessor, Data structures and Algorithm, Programming and problem solving

Concepts related Theory:

1. Assembler is a low-level translator who translates source code to machine code.
2. It works in two phases: analysis phase and synthesis phase.
3. In analysis phase, source assembly code is analyzed to generate some intermediate data structures.
4. In synthesis phase, machine code is generated.
5. There are well defined system level standard algorithms to design the assembler as a two-pass assembly, namely Pass-I and Pass-II algorithms of assembler.
6. Pass-I takes the source code in assembly language as input and generates intermediate data structures.

Algorithm:

Please refer algorithms of Pass-I of assembler from the following textbook: Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4.

Please refer the following link for algorithm in e-Book:

https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing

Conclusion:

Input assembly language program is processed by applying Pass-I algorithm of assembler and intermediate data structures, SYMTAB, LITTAB, POOLTAB, IC, are generated.

Review Questions:

1. What is two pass assembler?
2. What is the significance of symbol table?
3. Explain the assembler directives EQU, ORIGIN.
4. Explain the assembler directives START, END, LTORG.
5. What is the use of POOLTAB and LITTAB?
6. How are literals handled in Pass-I?
7. What are the tasks done in Pass-I?
8. How is error handling done in Pass-I?
9. Which variant is used in implementation? Why?
10. Which intermediate data structures are designed and implemented in Pass-I?

ASSINGMENT NO.	A1 (Part 2)
TITLE	Implement pass-II of two-pass assembler.
PROBLEM STATEMENT/ DEFINITION	Design suitable data structures and implement pass-II of a two-pass assembler for pseudo-machine in Java. Implementation should consist of a few instructions from each category and few assembler directives. The output of Pass-I (intermediate code file and symbol table) should be input for pass-II.
OBJECTIVE	1. To learn systems programming tools 2. Implement language translator (i.e., assembler: a language translator for low level language like assembly language)
OUTCOME	After implementing this assignment, learners will be able to 1. generate the machine code from intermediate data structures like IC, SYMTAB, LITTAB, POOLTAB understand the complete process of translator i.e translating a source program into the target program w.r.t low level translator i.e., assembler.
S/W PACKAGES AND HARDWARE/ APPARATUS USED	**Operating System recommended:** 64-bit Open-source Linux or its derivative **Programming tools recommended:** Eclipse IDE **Programming language:** JAVA **Hardware requirements:** I3 and I5 machines
REFERENCES	Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4. Find eBook in the following link: https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing
STEPS	**Step1. Input for Pass-II of assembler:** 1. IC (in a file) 2. SYMTAB 3. LITTAB 4. POOLTAB **Step2. Open the input IC file and apply the Pass2 of assembler algorithm, process the input file line by line and inside a line token by token** Please refer algorithms of Pass-II of assembler from the following textbook: Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4. Please refer the following link for e-Book and solved test cases **https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing** **Step3. Output of Pass-II of assembler:**

	Machine code
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/Analysis

Prerequisites:

Microprocessor, Data structures and Algorithm, Programming and problem solving

Concepts related Theory:

1. Assembler is a low-level translator who translates source code to machine code.
2. It works in two phases: analysis phase and synthesis phase.
3. In analysis phase, source assembly code is analyzed to generate some intermediate data structures.
4. In synthesis phase, machine code is generated.
5. There are well defined system level standard algorithms to design the assembler as a two-pass assembly, namely Pass-I and Pass-II algorithms of assembler.
6. Pass-II takes the intermediate data structures generated by the Pass-I as input and generates machine code.

Algorithm:

Please refer algorithms of Pass-II of assembler from the following textbook: Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4.

Please refer the following link for algorithm in e-Book:

https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing

Conclusion:

Generated machine code from intermediate data structures like IC, SYMTAB, LITTAB, POOLTAB.

Review Questions:

1. What is the format of a machine code generated in Pass-II?
2. What is forward reference? How is it resolved by assembler?
3. How is error handling done in pass II?

4. What is the difference between IS, DL and AD?
5. What are the tasks done in Pass II?

ASSIGNMENT NO.	A2 (Part 1)
TITLE	Implement pass-I of two-pass macro processor.
PROBLEM STATEMENT/ DEFINITION	Design suitable data structures and implement Pass-I and Pass-II of a two-pass macro- processor. The output of Pass-I (MNT, MDT and intermediate code file without any macro definitions) should be input for Pass-II.
OBJECTIVE	1. Understand the internals of system software viz. i.e., macro processor. 2. Identify and create data structures required in the design of macro processor. 3. Learn parameter processing in macro processor.
OUTCOME	After implementing this assignment, learners will be able to 1. Identify macro definitions and create the intermediate data structures like MNT, MDT, PNTAB, KPDTAB. 2. Understand the relevance of the intermediate data structures with respect to Pass-II of macro processor. 3. Separate macro definitions from the source code.
S/W PACKAGES AND HARDWARE/ APPARATUS USED	**Operating System recommended:** 64-bit Open-source Linux or its derivative **Programming tools recommended:** Eclipse IDE **Programming language:** JAVA **Hardware requirements:** i3/ i5 machines
REFERENCES	Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4. Find eBook in the following link: https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing
STEPS	**Step1. Input for Pass-I of macro processor:** 1. Assembly language program in hypothetical language containing macro definitions and macro calls. **Step2. Open the input file and apply the Pass-1 of macro processor algorithm, process the input file line by line and inside a line token by token** Please refer algorithm of Pass-I of macro processor from the following textbook: Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4. Please refer the following link for e-Book and solved test cases **https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing** **Step3. Output of Pass-I of macro processor:** 1. MNT 2. MDT 3. PNTAB 4. KPDTAB

INSTRUCTIONS FOR WRITING JOURNAL	1. Assignment no. 2. Title 3. Date of completion 4. Problem definition 5. Learning objectives 6. Learning outcomes 7. Concepts related theory 8. Algorithm 9. Test cases 10. Conclusion/ Analysis 11. Implementation output screenshot

Prerequisites:

Microprocessor, Data structures and Algorithm, Programming and problem solving

Concepts related Theory:

Macro processing feature allows the programmer to write shorthand version of a program (modular programming). The macro processor replaces each macro invocation with the corresponding sequence of statements i.e., macro expansion.

Tasks done by the macro processor

- Recognize macro definitions
- Save the macro definition, recognize macro calls
- Expand macro calls

Tasks in pass-I of a two pass macro processor

- Recognize macro definitions
- Save the macro definition (Create MDT, MNT, PNTAB, KPDTAB).
- Remove macro definitions from the source program.

Algorithm:

```
1. SSNTAB_ptr:=1; PNTAB_ptr:=1;
2. Process the macro prototype statement and form the MNT entry.
    a) Name:=macro name;
    b) For each positional parameter
        i.   Enter parameter name in PNTAB[PNTAB_ptr].
        ii.  PNTAB_ptr:=PNTAB_ptr + 1;
        iii. #PP:=#PP+1;
    c) KPDTP:=KPDTAB_ptr;
    d) For each keyword parameter
        i.   Enter parameter name and default value (if any) in KPDTAB[KPDTAB_ptr].
        ii.  Enter parameter name in PNTAB[PNTAB_ptr].
        iii. KPDTAB_ptr:=KPDTAB_ptr+1;
        iv.  PNTAB_ptr:=PNTAB_ptr+1;
        v.   #KP:=#KP+1;
    e) MDTP:=MDT_ptr;
    f) #EV:=0;
    g) SSTP:=SSTAB_ptr;


3. While not a MEND statement
    a) If an LCL statement then
        i.   Enter expansion time variable name in EVNTAB.
        ii.  #EV:=#EV + 1;
    b) If a model statement then
        i.   If label field contains a sequencing symbol then
                 If symbol is present in SSNTAB then
                         q:=entry number in SSNTAB;
             else
                 Enter symbol in SSNTAB[SSNTAB_ptr].
                 q:=SSNTAB_ptr;
                 SSNTAB_ptr:=SSNTAB_ptr + 1;
                 SSTAB[SSTP + q -1] := MDT_ptr;
        ii.  For a parameter, generate the specification (P,#n)
        iii. For an expansion variable, generate the specification (E,#m).
        iv.  Record the IC in MDT[MDT_ptr];
        v.   MDT_ptr:=MDT_ptr + 1;
```

```
c) If a preprocessor statement then
     i.   If a SET statement
          Search each expansion time variable name used in the statement in EVNTAB
          and
          generate the spec (E,#m).
     ii.  If an AIF or AGO statement then
                If sequencing symbol used in the statement is present in SSNTAB Then
                          q:=entry number in SSNTAB;
                else
                          Enter symbol in SSNTAB[SSNTAB_ptr].
                          q:=SSNTAB_ptr;
                          SSNTAB_ptr:=SSNTAB_ptr+1;
                Replace the symbol by (S,SSTP + q -1).
     iii. Record the IC in MDT[MDT_ptr]
     iv.  MDT_ptr:=MDT_ptr+1;

4.  (MEND statement)
    If SSNTAB_ptr=1 (i.e. SSNTAB is empty) then
              SSTP:=0;
    Else
              SSTAB_ptr:=SSTAB_ptr+SSNTAB_ptr-1;
    If #KP=0 then KPDTP=0;
```

Conclusion:

Input assembly language program containing macros is processed by applying Pass-I algorithm of macro processor and intermediate data structures, MNT, PNTAB, KPDTAB, MDT, are generated.

Review Questions:

1. What is macro and macro processor?
2. What is MDT, MNT?
3. What is nested macro?
4. What are the tasks done in pass I of macro processor?
5. How macro call definitions are handled in pass I?
6. How formal and actual parameters are linked?
7. What are the steps to implement pass I of macro processor?

ASSIGNMENT NO.	A2 (Part 2)
TITLE	Implement pass-II of two-pass macro processor.
PROBLEM STATEMENT/ DEFINITION	Design suitable data structures and implement Pass-I and Pass-II of a two-pass macro- processor. The output of Pass-I (MNT, MDT and intermediate code file without any macro definitions) should be input for Pass-II.
OBJECTIVE	1. Understand the internals of system software viz. i.e., macro processor. 2. Understand the macro expansion in Pass-II. 3. Replace the formal parameters with actual parameters. 4. Understand the use of data structures developed in Pass-I.
OUTCOME	After implementing this assignment, learners will be able to 1. Separate the macro definitions from the source code. 2. Generate intermediate data structures like MNT, MDT, PNTAB, KPDTAB. 3. Understand the relevance of the intermediate data structures with respect to Pass-II of macro processor.
S/W PACKAGES AND HARDWARE/ APPARATUS USED	**Operating System recommended:** 64-bit Open-source Linux or its derivative **Programming tools recommended:** Eclipse IDE **Programming language:** JAVA **Hardware requirements:** i3/ i5 machines
REFERENCES	Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4. Find eBook in the following link: https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing
STEPS	**Step1. Input for Pass-I of macro processor:** 1. Assembly language program in hypothetical language containing macro definitions and macro calls. **Step2. Open the input file and apply the Pass-1 of macro processor algorithm, process the input file line by line and inside a line token by token** Please refer algorithm of Pass-I of macro processor from the following textbook: Dhamdhere D., "Systems Programming and Operating Systems", McGraw Hill, ISBN 0 - 07 - 463579 – 4. Please refer the following link for e-Book and solved test cases **https://drive.google.com/drive/folders/1vbu_x7DPHPaIKAbIngKquh5zgYtOgpTe?usp=sharing** **Step3. Output of Pass-I of macro processor:** 1. MNT 2. MDT 3. PNTAB 4. KPDTAB

INSTRUCTIONS FOR WRITING JOURNAL	1. Assignment no. 2. Title 3. Date of completion 4. Problem definition 5. Learning objectives 6. Learning outcomes 7. Concepts related theory 8. Algorithm 9. Test cases 10. Conclusion/ Analysis 11. Implementation output screenshot

Prerequisites:

Microprocessor, Data structures and Algorithm, Programming and problem solving

Concepts related Theory:

Macro processing feature allows the programmer to write shorthand version of a program (modular programming). The macro processor replaces each macro invocation with the corresponding sequence of statements i.e., macro expansion.

Tasks done by the macro processor

- Recognize macro definitions
- Save the macro definition, recognize macro calls
- Expand macro calls

Tasks in pass-I of a two pass macro processor

- Recognize macro definitions
- Save the macro definition (Create MDT, MNT, PNTAB, KPDTAB).
- Remove macro definitions from the source program.

Algorithm:

```
1. SSNTAB_ptr:=1; PNTAB_ptr:=1;
2. Process the macro prototype statement and form the MNT entry.
   a) Name:=macro name;
   b) For each positional parameter
      i.   Enter parameter name in PNTAB[PNTAB_ptr].
      ii.  PNTAB_ptr:=PNTAB_ptr + 1;
      iii. #PP:=#PP+1;
   c) KPDTP:=KPDTAB_ptr;
   d) For each keyword parameter
      i.   Enter parameter name and default value (if any) in KPDTAB[KPDTAB_ptr].
      ii.  Enter parameter name in PNTAB[PNTAB_ptr].
      iii. KPDTAB_ptr:=KPDTAB_ptr+1;
      iv.  PNTAB_ptr:=PNTAB_ptr+1;
      v.   #KP:=#KP+1;
   e) MDTP:=MDT_ptr;
   f) #EV:=0;
   g) SSTP:=SSTAB_ptr;


3. While not a MEND statement
   a) If an LCL statement then
      i.   Enter expansion time variable name in EVNTAB.
      ii.  #EV:=#EV + 1;
   b) If a model statement then
      i.   If label field contains a sequencing symbol then
                If symbol is present in SSNTAB then
                        q:=entry number in SSNTAB;
           else
                Enter symbol in SSNTAB[SSNTAB_ptr].
                q:=SSNTAB_ptr;
                SSNTAB_ptr:=SSNTAB_ptr + 1;
                SSTAB[SSTP + q -1] := MDT_ptr;
      ii.  For a parameter, generate the specification (P,#n)
      iii. For an expansion variable, generate the specification (E,#m).
      iv.  Record the IC in MDT[MDT_ptr];
      v.   MDT_ptr:=MDT_ptr + 1;
```

```
c) If a preprocessor statement then
      i.   If a SET statement
           Search each expansion time variable name used in the statement in EVNTAB
           and
           generate the spec (E,#m).
      ii.  If an AIF or AGO statement then
                If sequencing symbol used in the statement is present in SSNTAB Then
                          q:=entry number in SSNTAB;
                else
                          Enter symbol in SSNTAB[SSNTAB_ptr].
                          q:=SSNTAB_ptr;
                          SSNTAB_ptr:=SSNTAB_ptr+1;
                Replace the symbol by (S,SSTP + q -1).
      iii. Record the IC in MDT[MDT_ptr]
      iv.  MDT_ptr:=MDT_ptr+1;

4.  (MEND statement)
    If SSNTAB_ptr=1 (i.e. SSNTAB is empty) then
              SSTP:=0;
    Else
              SSTAB_ptr:=SSTAB_ptr+SSNTAB_ptr-1;
    If #KP=0 then KPDTP=0;
```

Conclusion:

All the macro calls in the assembly program are processed using the output of Pass-I algorithm of macro processor and intermediate data structures, MNT, PNTAB, KPDTAB, MDT. APTAB generated in the Pass-II of macro processor.

Review Questions:

1. What is macro and macro processor?
2. What is MDT, MNT?
3. What is nested macro?
4. What are the tasks done in pass I of macro processor?
5. How macro call definitions are handled in pass I?
6. How formal and actual parameters are linked?
7. What are the steps to implement pass I of macro processor?

ASSINGMENT NO.	B1
TITLE	Synchronization Using Mutex and Semaphore
PROBLEM STATEMENT /DEFINITION	Write a program to solve Classical Problems of Synchronization using Mutex and Semaphore
OBJECTIVE	To learn and understand 1. To Implement Process Synchronization using Mutex & Semaphore 2. To Solve Classical Synchronization problems using Mutex & Semaphore
OUTCOME	Refer to details
S/W PACKAGES AND HARDWARE Requirement	C/C++ editors and compilers for Linux OS Linux OS/Fedora/Ubuntu PC i3/i5/i7 2.4 GHz. 4/8 GB RAM, 500/1TB G.B HDD,Mouse and Keyboard
REFERENCES	**1.** Stallings W., “Operating Systems”, 4th Edition, Prentice Hall, 81 – 7808 – 503 – 8. **2.** Silberschatz, Galvin, Gagne, "Operating System Principles", 9th Edition, Wiley, ISBN 978-1-118-06333-0.
STEPS	Refers To Details
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/Analysis

Prerequisites: Semaphore concepts, Producer consumer problem, Reader Writer problem

Concepts related Theory:

A process can stop at a specified place until it has received a specific signal. For signaling, special variables called Semaphores are used. The wait() operation decrements the semaphore value. If the value becomes negative, then the process executing the wait() is blocked. The signal() operation increments the semaphore value. If the value is not positive, then a process is unblocked.

```
struct semaphore {
int count;
queuetype queue;
}
void wait (semaphore s) {
s.count --; //decrement
if (s.count < 0) {
place this process in s.queue;
block this process;
}
}

void signal (semaphore s) {
s.count ++; //increment
if (s.count < = 0) {
remove a process P from s.queue;
place P on ready queue;
}
}
```

Mutex is an abbreviation for "mutual exclusion". Mutex variables are one of the primary means of implementing thread synchronization and for protecting shared data when multiple writes occur. A mutex variable acts like a "lock" protecting access to a shared data resource. The basic concept of a mutex as used in Pthreads is that only one thread can lock (or own) a mutex variable at any given time. Thus, even if several threads try to lock a mutex only one thread will be successful. No other thread can own that mutex until the owning thread unlocks that mutex.

wait (mutex); *//locks*

…..

Critical Section

…..

signal (mutex); *//unlocks*

The producer-consumer problem (Also called the bounded-buffer problem.) illustrates the need for synchronization in systems where many processes share a resource. In the problem, two processes share a fixed-size buffer. One process(producer) produces information and puts it in the buffer, while the other process (consumer) consumes information from the buffer. These processes do not take turns accessing the buffer, they both work concurrently. Herein lies the problem. What happens if the producer tries to put an item into a full buffer? What happens if the consumer tries to take an item from an empty buffer?

In order to synchronize these processes, we will block the producer when the buffer is full, and we will block the consumer when the buffer is empty. So, the two processes, Producer and Consumer, should work as follows:

Algorithm:

Assuming there are total N number of slots.

```
Initialization: semaphores: mutex = 1; Full = 0 , empty
      = N;integers : in = 0; out = 0;
producer:
        Repeat    forever
        produce   (item);
        wait(empty);
        wait(mutex);
        enter_item(item)
        ;  signal(mutex);
        signal(full);

Consumer:
         Repeat forever
         wait(full);
         wait(mutex);
         remove_item(item);
         signal( mutex );
         signal(empty);
```

POSIX: POSIX stands for Portable Operating System Interface

sem_init()
Initializes a semaphore
#include
<semaphore.h>
int sem_init(sem_t *sem, int pshared, unsigned int value);

- First argument is the pointer to semaphore, that you want to initialize. sem_init initializes the semaphore object pointed to by sem.
- The pshared argument indicates whether the semaphore is local to the current process (pshared is zero) or is to be shared between several processes (pshared is not zero). LinuxThreads currently does not support process-shared semaphores, thus sem_init alwaysreturns with error ENOSYS if pshared is not zero.
- Third argument is the value of the semaphore. The count associated with the semaphore is set initially to value.

pthread_create()

```
#include <pthread.h>
int pthread_create(pthread_t * thread, pthread_attr_t * attr, void *(*start_routine)(void *), void
* arg);
```

pthread_create creates a new thread of control that executes concurrently with the calling thread.

The new thread applies the function start_routine passing it arg as first argument.

The new thread terminates either explicitly, by calling pthread_exit(3), or implicitly, by returning from the start_routine function. The latter case is equivalent to calling pthread_exit(3) with the result returned by start_routine as exit code.

The attr argument specifies thread attributes to be applied to the new thread.

pthread_join()

```
#include <pthread.h>
int pthread_join(pthread_t th, void **thread_return);
```

pthread_join suspends the execution of the calling thread until the thread identified by **th** terminates, either by calling pthread_exit(3) or by being cancelled. If thread_return is not NULL, the return value of th is stored in the location pointed to by thread_return. The return value of **th** is either the argument it gave to pthread_exit(3), or PTHREAD_CANCELED if th was cancelled.

The joined thread th must be in the joinable state.

Conclusion: Producer consumer problem is solved successfully using POSIX threads and semaphore.

Review Questions:

1. What is race condition?
2. What is multi-threading? write advantages of multi-threading
3. What is Critical Section?
4. What is process Synchronization?
5. Define Mutex And Semaphore.
6. Solve Reader writer problem using Mutex and Semaphore

ASSINGMENT NO.	B2
TITLE	Implement CPU Scheduling Algorithms.
PROBLEM STATEMENT/ DEFINITION	Write a program to simulate CPU Scheduling Algorithms: FCFS, SJF (Preemptive), Priority (Non-Preemptive) and Round Robin (Preemptive).
OBJECTIVE	To learn and understand 1. Process Scheduling in Multitasking and multiusers OS. 2. Implementation of Scheduling Algorithms.
OUTCOME	After implementing this assignment, learners will be able to 1. Implement FCFS, SJF, RR, Priority Scheduling Algorithms 2. Analyze and compare performance of scheduling algorithms.
S/W PACKAGES AND HARDWARE/ APPARATUS USED	**Operating System recommended:** 64-bit Open-source Linux or its derivative **Programming tools recommended:** Eclipse IDE **Programming language:** C/ C++/ JAVA/ Python **Hardware requirements:** i3/ i5 machines
REFERENCES	Stallings W., “Operating Systems”, 4th Edition, Prentice Hall, 81 – 7808 – 503 – 8.
STEPS	Refer to details.
INSTRUCTIONS FOR WRITING JOURNAL	1. Assignment no. 2. Title 3. Date of completion 4. Problem definition 5. Learning objectives 6. Learning outcomes 7. Concepts related theory 8. Algorithm 9. Test cases 10. Conclusion/ Analysis 11. Implementation output screenshot

Prerequisites:

Basic Operating System Functionalities.

Concept of Multitasking and Multiuser OS.

THEORY:

Process scheduling: It is an activity process manager that handles the task of scanning process from

CPU and running of another process on basis of some strategy. Such OS allows more than one to be loaded in executable memory.

Scheduler:

They are special system software that handle process scheduling in various ways:
Its main task is to select jobs to be submitted into system and to be divided and decide which process to run.

Types of Schedulers:

1. Long-term scheduler
2. Short-term scheduler
3. Medium term scheduler

Arrival Time: The request arrives in the system when user submits it to OS. When request arrives, the time is called arrival time.
Scheduling: The pending request is scheduled for service when scheduler selects it for servicing.
Pre-emption: The process is pre-empted when CPU switches to another process before completing it and this process is added to pending request.
Non pre-emption: The scheduled process is always completed before next scheduling of the process.
Completion: The process is completed, and next process is selected for processing by CPU.
The CPU scheduling takes the information about arrival time, size of request in CPU seconds, CPU time already consumed by the request, deadline of the process for scheduling policy.
CPU scheduling deals with the problem of deciding which of the processes in the ready queue is to be allowed to utilize the CPU. The criteria for selection of an algorithm are

- Least turnaround time.
- Minimum waiting time.
- Maximum CPU utilization.
- The maximum throughput

Some definitions in scheduling are:
Arrival time is when the process arrives in the system. (Ai)
Process time is the execution time required for the process (Xi)
Completion time is time at which the process is completed. (Ci)
Deadline is the time by which the process output is required (Di)
Turnaround time is the time to complete the process after arrival (Ci-Ai)
Average or Mean turnaround time is the average of turnaround time of all processes.
Weighted time around time is the turnaround time of a process to its execution time. (Ci-Ai)/Xi
Throughput is the measure of performance and no of processes completed per unit time. (n/(max (Ci)-min(Ai))

Scheduling Policies:

FCFS Scheduling:

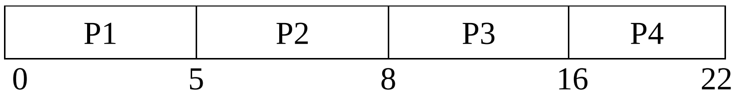
The process requests are scheduled in the order of their arrival time. The pending requests are in a queue. The first request in the queue is scheduled first. The request that comes is added to the end of the queue.

Performance of FCFS scheduling: (Time in sec)

Process No	**Arrival time**	**Burst Time**	**Turnaround time**	**Waiting time**
1	0	5	0	0
2	1	3	5	4
3	2	8	8	6
4	3	6	16	13

Average waiting time= (0+4+6+13)/4= 5.75

Gantt Chart:



Algorithm:

1. Input the processes along with burst times.
2. Input arrival time for all processes
3. Sort according to their arrival time along with indices.
4. Perform processes in sorted order
5. Stop.

Shortest job first (SJF) scheduling:

Best approach to minimize waiting time. It is easy to implement in batch systems where required CPU time is known in advance.

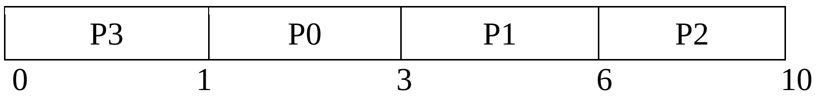
a) **Non pre-emptive:**

Performance of SJF scheduling: (Time in sec)

Process No	**Arrival time**	**Burst time**	**Turnaround time**	**Waiting time**
1	0	2		1
2	0	3		3
3	1	4		5
4	0	1		0

Average waiting time= 2.25

Gantt Chart:



b) **<u>Pre-emptive:</u>**

Process	**Arrival time**	**Burst time**	**Waiting time**
P1	0	300	425
P2	0	125	150
P3	0	400	725
P4	0	150	275
P5	0	100	0
P6	150	50	0

Gantt Chart:

P5	P2	P6	P2	P4	P1	P3

0 100 150 200 275 425 725 1125

Average waiting time= 262.5

<u>Algorithm</u>

1. Calculate burst time
2. Sort all processes in increasing order of burst time
3. Apply FCFS to sorted list
4. Perform all processes
5. Stop

<u>Round Robin scheduling:</u>

Schedules using time slicing. The amount of CPU time a process may use when allocated is limited. The process is pre-empted if the process requires more time or if process requires I/O operation before the time slice. It makes weighted turnaround time approximately equal all time, but throughput may not be well as all processes are treated equally.

Performance of Round Robin scheduling:

Process No	**Arrival time Ai**	**Burst time**	**Waiting time**
1	1	150	250
2	2	100	200
3	3	200	300
4	4	50	150

Time quantum= 50
Average waiting time= 225

Gantt Chart:

P1	P2	P3	P4	P1	P2	P3	P1	P3

0 50 100 150 200 250 300 350 400 550

<u>Algorithm:</u>

1. Get input for processes with arrival time and burst time. Take time quantum.
2. Sort processes according to arrival time.
3. Process till all processes are done.
4. End

<u>Priority based Scheduling:</u>

It is non-preemptive algorithm and one of the common scheduling algorithm in batch system. Each process is assigned a priority and process with highest priority is executed first and so on. Processes with same priority are executed on FCFS basis.

Process	Arrival time	Burst time	Priority	Waiting time
P0	0	5	1	9
P1	1	3	2	5
P2	2	8	1	12
P3	3	6	3	0

Gantt Chart:

P3	P1	P0	P2

0 6 9 14 22

<u>Algorithm:</u>

1. Get input for process including arrival time, burst time and priority.
2. Sort process according to arrival time.
3. If process have same arrival time, sort them by priority.
4. Print process according to index.
5. End

Steps to do /algorithm:

1. Create a menu to select various scheduling algorithms
2. Take number of tasks and CPU time as input.
3. Calculate average waiting time and turnaround time for each scheduling strategy.
4. Perform a comparative assessment of best policy for given set of processes.

FAQs

1. What are the inputs to be taken?

Ans: The inputs for each process with process no, Arrival time, Execution time to be taken.

2. What all parameters to be calculated?

Ans: The turnaround time, Waiting time, Average Turnaround Time, Average Waiting Time.

3. How the output to be shown?

Ans: The output for each algorithm for the same set of inputs to be shown as table and Gant chart to be shown in write-up.

Oral/ Review Questions:

1. Why is job scheduling required in OS?
2. What are basic job scheduling policies used in OS?
3. What is preemptive scheduling?
4. What is the computational complexity of RR, SJF, FCFS?
5. What is Gant chart?

ASSINGMENT NO.	B4
TITLE	Simulate Page replacement algorithm.
PROBLEM STATEMENT/ DEFINITION	Write a program to simulate Page replacement algorithm. 1. FIFO 2. Least Recently Used (LRU) 3. Optimal
OBJECTIVE	1. To understand virtual memory management. 2. To analyze the need of page replacement algorithms. 3. To compare various page replacement algorithms.
OUTCOME	After implementing this assignment, learners will be able to 1. Implement page replacement algorithms viz. FIFO, LRU and Optimal. 2. Compare the performance of page replacement algorithms based on hit ratio.
S/W PACKAGES AND HARDWARE/ APPARATUS USED	**Operating System recommended:** 64-bit Open-source Linux or its derivative **Programming tools recommended:** Eclipse IDE **Programming language:** C/ C++/ JAVA/ Python **Hardware requirements:** i3/ i5 machines
REFERENCES	Stallings W., "Operating Systems", 4th Edition, Prentice Hall, 81 – 7808 – 503 – 8.
STEPS	Refer to details.
INSTRUCTIONS FOR WRITING JOURNAL	1. Assignment no. 2. Title 3. Date of completion 4. Problem definition 5. Learning objectives 6. Learning outcomes 7. Concepts related theory 8. Algorithm 9. Test cases 10. Conclusion/ Analysis 11. Implementation output screenshot

Theory:

What is Page Replacement in Operating Systems?

Page replacement is needed in the operating systems that use virtual memory using Demand Paging. As we know that in Demand paging, only a set of pages of a process is loaded into the memory. This is done so that we can have more processes in the memory at the same time.

When a page that is residing in virtual memory is requested by a process for its execution, the Operating System needs to decide which page will be replaced by this requested page. This process is known as page replacement and is a vital component in virtual memory management.

Why we need page replacement algorithms?

To understand why we need page replacement algorithms, we first need to know about page faults.

Page Fault: A Page Fault occurs when a program running in CPU tries to access a page that is in the address space of that program, but the requested page is currently not loaded into the main physical memory, the RAM of the system.

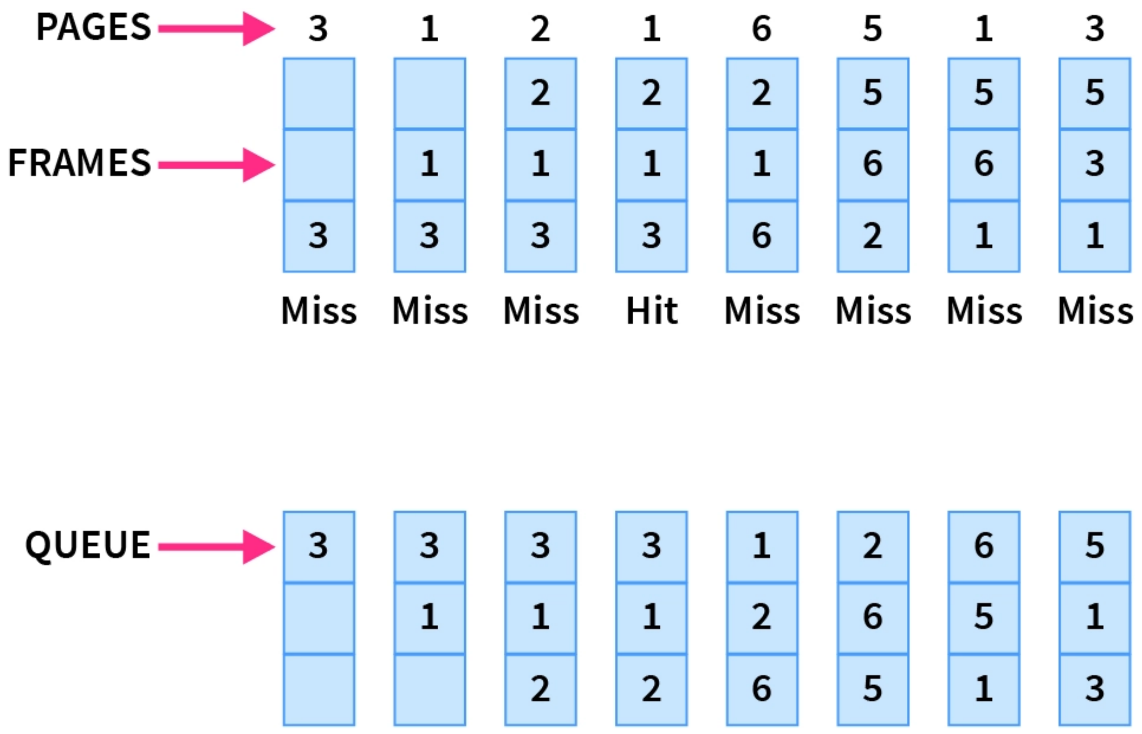
Since the actual RAM is much less than the virtual memory the page faults occur. So, whenever a page fault occurs, the Operating system has to replace an existing page in RAM with the newly requested page. In this scenario, page replacement algorithms help the Operating System in deciding which page to replace. The primary objective of all the page replacement algorithms is to minimize the number of page faults.

First In First Out (FIFO) Page Replacement Algorithm

FIFO algorithm is the simplest of all the page replacement algorithms. In this, we maintain a queue of all the pages that are in the memory currently. The oldest page in the memory is at the front-end of the queue and the most recent page is at the back or rear-end of the queue.

Whenever a page fault occurs, the operating system looks at the front-end of the queue to know the page to be replaced by the newly requested page. It also adds this newly requested page at the rear-end and removes the oldest page from the front-end of the queue.

Example: Consider the page reference string as 3, 1, 2, 1, 6, 5, 1, 3 with 3-page frames. Let's try to find the number of page faults:



Total page faults = 7

Belady's anomaly:

Generally, if we increase the number of frames in the memory, the number of page faults should decrease due to obvious reasons. Belady's anomaly refers to the phenomena where increasing the number of frames in memory, increases the page faults as well.

Advantages of FIFO policy:
Simple to understand and implement
Does not cause more overhead

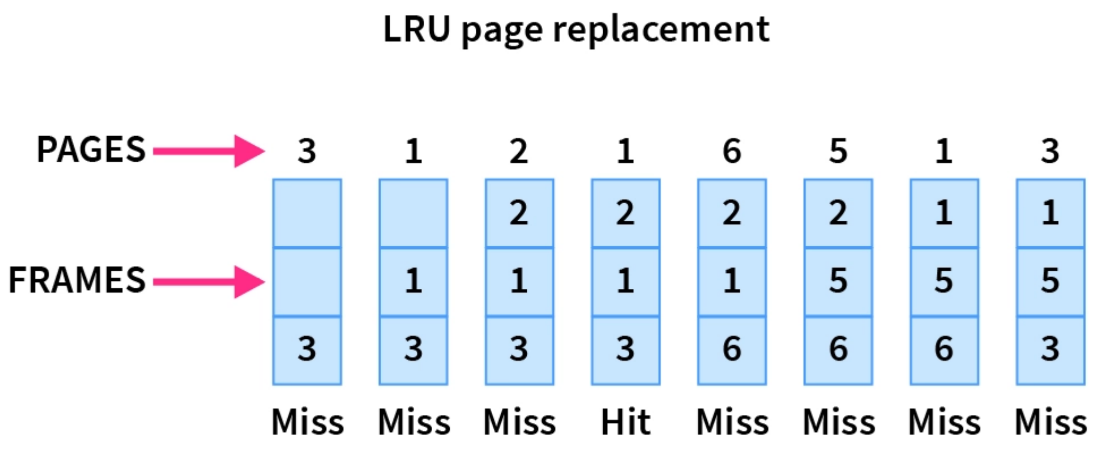
Disadvantages of FIFO policy:
Poor performance
Doesn't use the frequency of the last used time and just simply replaces the oldest page.
Suffers from Belady's anomaly.

Least Recently Used (LRU) Page Replacement Algorithm

The least recently used page replacement algorithm keeps the track of usage of pages over a period of time. This algorithm works on the basis of the principle of locality of a reference which states that a program has a tendency to access the same set of memory locations repetitively over a short period of time. So, pages that have been used heavily in the past are most likely to be used heavily in the future also.

In this algorithm, when a page fault occurs, then the page that has not been used for the longest duration of time is replaced by the newly requested page.

Example:
Let's see the performance of the LRU on the same reference string of 3, 1, 2, 1, 6, 5, 1, 3 with 3-page frames:



Total page faults = 7

Now in the above example, the LRU causes the same page faults as the FIFO, but this may not always be the case as it will depend upon the series, the number of frames available in memory, etc. In fact, on most occasions, LRU is better than FIFO.

Advantages of LRU policy:
It is open for full analysis
Doesn't suffer from Belady's anomaly
Often more efficient than other algorithms

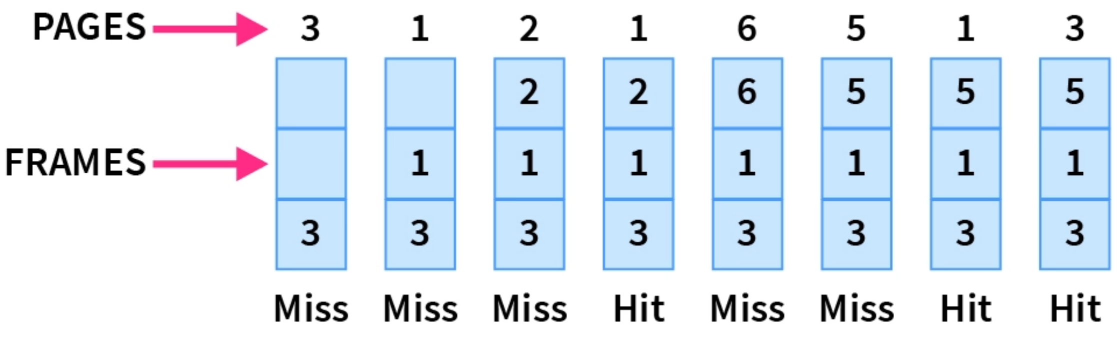
Disadvantages of LRU policy:
It requires additional data structures to be implemented

More complex
High hardware assistance is required

Optimal Page Replacement Algorithm:

Optimal page replacement is the best page replacement algorithm as this algorithm results in the least number of page faults. In this algorithm, the pages are replaced with the ones that will not be used for the longest duration of time in the future. In simple terms, the pages that will be referred farthest in the future are replaced in this algorithm.

Example:
Let’s take the same page reference string 3, 1, 2, 1, 6, 5, 1, 3 with 3-page frames as we saw in FIFO. This also helps you understand how Optimal Page replacement works the best.



Total page faults = 5

Optimal page replacement algorithm is difficult to implement, because it requires future knowledge of the reference string. As a result, the optimal algorithm is used mainly for comparison studies. For instance, it may be useful to know that, although a new algorithm is not optimal, it is within 12.3 percent of optimal at worst, and within 4.7 percent on average.

Advantages of Optimal policy:
Excellent efficiency
Less complexity
Easy to use and understand
Simple data structures can be used to implement
Used as the benchmark for other algorithms

Disadvantages of optimal policy:
More time consuming
Difficult for error handling
Need future awareness of the programs, which is not possible every time

Conclusion:
The objective of page replacement algorithms is to minimize the page faults.
FIFO page replacement algorithm replaces the oldest page in the memory.
Optimal page replacement algorithm replaces the page which will be referred farthest in the future.
LRU page replacement algorithm replaces the page that has not been used for the longest duration of time.

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE

ACADEMIC YEAR: 2023-24

DEPARTMENT of COMPUTER ENGINEERING DEPARTMENT

CLASS: T.E. **SEMESTER: I**

SUBJECT: LP-1 (IoT & ES)

ASSIGNMENT NUMBER: 1

Revised On: 18-07-2022

TITLE	Connectivity of Raspberry Pi/Arduino with InfraRed (IR)sensor.
PROBLEM STATEMENT /DEFINITION	Understanding the connectivity of Raspberry-Pi/Arduino with IR sensor. Write an application to detect obstacle and notify user using LEDs.
OBJECTIVE	Understanding the connectivity of Raspberry Pi/ Arduino circuit withIR sensor.
S/W PACKAGES AND HARDWARE APPARATUS USED	Raspberry pi board/Arduino, IR sensor, LED Raspbian (OS),
REFERENCES	1. https://www.raspberrypi.org/
STEPS	Refer to details
INSTRUCTIONS FOR WRITING JOURNAL	• Title • Problem Definition • Objectives • Theory • Interfacing Diagram • Algorithm • Test cases • Program Listing (soft copy) • Output • Conclusion

Aim: Connectivity of Raspberry Pi / Arduino circuit with IR sensor to detect obstacleand notify user using LEDs.

Pre-requisite:

Basic knowledge of GPIO of Raspberry pi/ Arduino.
Basic knowledge of Python programming.
Working and connections of sensors.

Learning Objectives:

- Understanding the connectivity of Raspberry Pi /Arduino with IR sensor.

Learning Outcomes:

The students will be able to

- To interface IR sensor to Raspberry pi.
- Detect the obstacle with IR sensor.
- Can perform actuation.

H/W AND S/W Requirements:

Raspberry Pi/ Arduino Boards

PC / Monitor/Keyboard

IR (Infrared) Sensor, 1 LED, 1 Resistor (330 Ω)

Few jumper cables,1 Breadboard
Raspbian (OS), Debian LINUX and Python

Theory:

Introduction:

The Raspberry Pi is a series of credit card-sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries. It is a capable little computer which can be used in electronics projects, and for many of the things that your desktop PC does, like spreadsheets, word processing, browsing the internet, and playing games. It also plays high-definition video.

The Raspberry Pi is open hardware, with the exception of the primary chip on the Raspberry Pi, the Broadcom SoC (System on a Chip), which runs many of the main components of the board–CPU, graphics, memory, the USB controller, etc. Many of the projects made with a

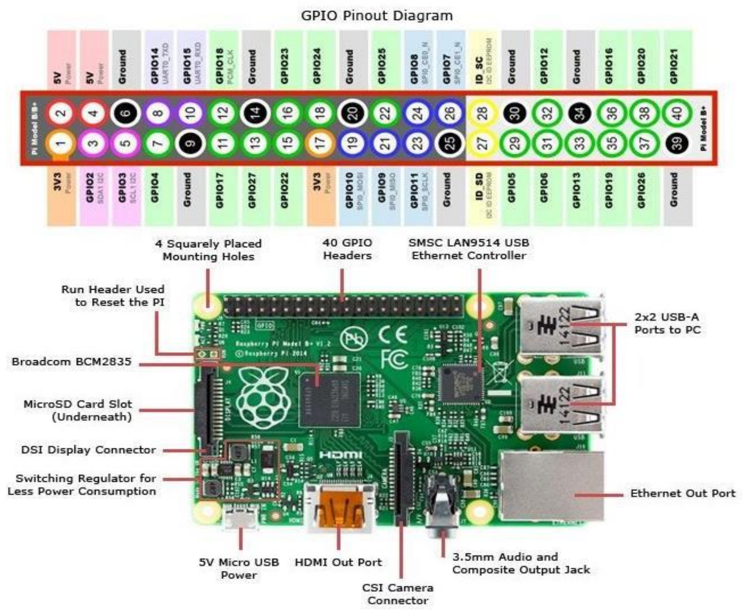
Raspberry Pi are open and well-documented as well and are things you can build and modify yourself.

The Raspberry Pi was designed for the Linux operating system, and many Linuxdistributions now have a version optimized for the Raspberry Pi.

One powerful feature of the Raspberry Pi is the row of GPIO (general purpose input/output) pins along the top edge of the board. These pins are a physical interface between the Pi and the outside world. At the simplest level, you can think of them as switches that you can turn on or off (input) or that the Pi can turn on or off (output). Of the 40 pins, 26 are GPIO pinsand the others are power or ground pins (plus two ID EEPROM pins which you should not play with unless you know your stuff!)

You can program the pins to interact in amazing ways with the real world. Inputs don't have to come from a physical switch; it could be input from a sensor or a signal from another computer or device, for example. The output can also do anything, from turning on an LED to sending a signal or data to another device. If the Raspberry Pi is on a network, you can control devices that are attached to it from anywhere and those devices can send data back. Connectivity and control of physical devices over the internet is a powerful and exciting thing, and the Raspberry Pi is ideal for this.

Raspberry Pi Board with GPIO:

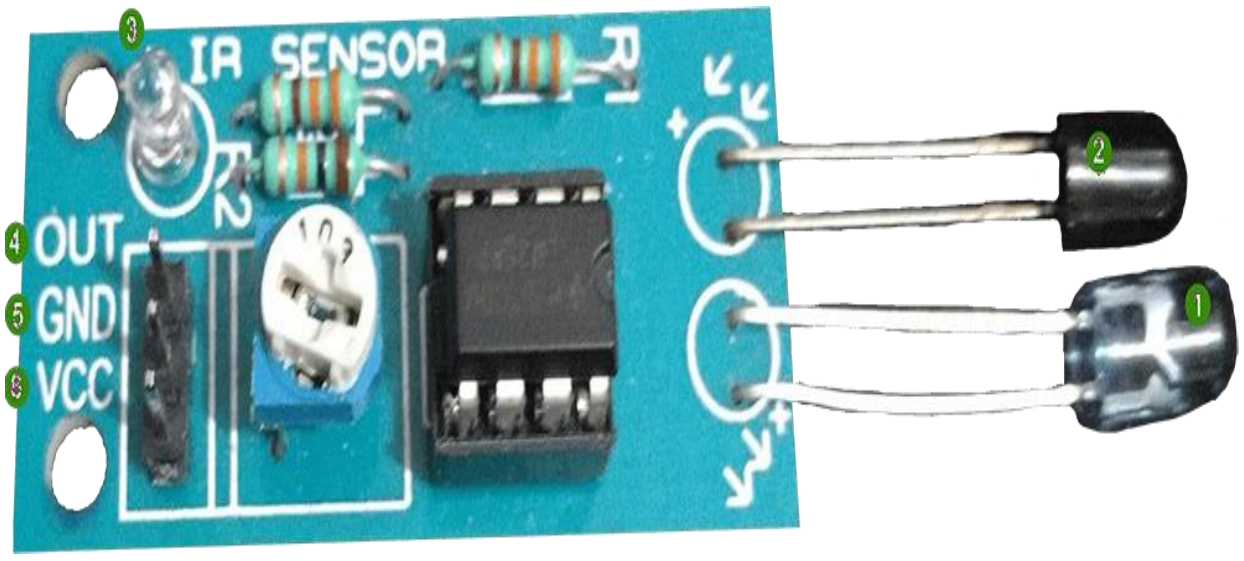


Technical Specification:

- Broadcom BCM2837 64bit ARMv7 Quad Core Processor powered Single Board
- Computer running at 1.2GHz
- 1GB RAM
- BCM43143 WiFi on board
- Bluetooth Low Energy (BLE) on board
- 40pin extended GPIO
- 4 x USB 2 ports
- 4 pole Stereo output and Composite video port
- Full size HDMI
- CSI camera port for connecting the Raspberry Pi camera
- DSI display port for connecting the Raspberry Pi touch screen display
- Micro SD port for loading your operating system and storing data
- Upgraded switched Micro USB power source (now supports up to 2.4 Amps)
- Expected to have the same form factor has the Pi 2 Model B, however the LEDs willChange position

InfraRed (IR) Sensor:

IR (Infrared) Sensor works by emitting infrared signal/radiation and receiving of the signal when the signal bounces back from any obstacle. In other words, the IR Sensor works by continuously sending signal (in a direction) and continuously receive signal, if comes back by bouncing on any obstacle in the way.



Components: IR Sensor

1. **Emitter**: This component continuously emits the infrared signal
2. **Receiver**: It waits for the signal which is bounced back by obstacle
3. **Indicator**: On board LED to signal if obstacle is deducted by the sensor
4. **Output**: Could be used as Input for further processing of the signal
5. **Ground**: Ground/Negative point of the circuit
6. **Voltage**: Input 3.3V

IR Sensor has 3 pins, viz VCC, GND and OUT. We will use GPIO 17 (do not get confused with pin number 17) for receiving input from the sensor.

Connecting IR Sensor

1. Connect GPIO 17 from the Raspberry Pi to Breadboard
2. Connect OUT pin of the sensor with the Breadboard
   This will send input received from sensor to GPIO 17, which will be processed further.
3. Connect GND (any pin from board will work) with negative line on left side of the breadboard
4. Connect GND of the IR Sensor to Breadboard
5. Connect GND from Step 3 to Breadboard
6. Connect VCC of the IR Sensor to Breadboard
7. Connect 3v3 (Pin #1) to positive line on left side of the breadboard
8. Connect 3v3 (connected in Step 7) to the Breadboard

Connecting LED

Objective is to turn on the LED when obstacle is detected.

1. Connect GPIO 4 from the board to the Breadboard
2. Connect positive point of the LED (longer pin of the LED) to the Breadboard
3. Connect negative point of the LED (smaller pin of the LED) to the Breadboard
4. Use resistor (330 Ω) to connect negative to the negative point of the LED

Python code to detect obstacle

```
from gpiozero import LED
from signal import pause

import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)

LED_PIN = 27
IR_PIN = 17
indicator = LED(LED_PIN)
GPIO.setup(IR_PIN, GPIO.IN)
```

```
count = 1

while True:
  got_something = GPIO.input(IR_PIN)
  if got_something:
    indicator.on()
    print("{:>3} Got something".format(count))
  else:
    indicator.off()
    print("{:>3} Nothing detected".format(count))
  count += 1
  time.sleep(0.2)
```

Conclusion:

Students will be able to interface IR sensor with Raspberry Pi and detect an obstacle with it.

FAQs:

1. What is IR sensor?
2. How is it interfaced with Raspberry pi/Arduino?

ASSIGNMENT NUMBER: 2

Revised On: 18-07-2022

TITLE	Connectivity of Raspberry Pi /Beagle board circuit with temperaturesensor.
PROBLEM STATEMENT /DEFINITION	Write an application to read the environment temperature. If temperature crosses a threshold value, the application indicated user using LEDSs
OBJECTIVE	Understanding the connectivity of Raspberry Pi /Beagle board circuitwith temperature sensor.
S/W PACKAGES AND HARDWARE APPARATUS USED	Raspberry pi board/ BBB , DTH-11 temperature sensor,LED Raspbian (OS), Adafruit_DTH Library
REFERENCES	https://www.raspberrypi.org/ https://www.bbb.org/ https://www.adafruit.com/
STEPS	Refer to details
INSTRUCTIONSFOR WRITINGJOURNAL	Title Problem Definition Objectives Theory Interfacing Diagram Algorithm Test cases Program Listing (soft copy) Output Conclusion

Aim:

Connectivity of Raspberry Pi /Beagle board circuit with temperature sensor to readthe environment temperature. If temperature crosses a threshold value, the application indicated user using LEDs.

Pre-requisite:

- Basic knowledge of GPIO of Raspberry pi/BBBBasic knowledge of Python programming.
- Working and connections of sensors.

Learning Objectives:

- Understanding the connectivity of Raspberry Pi /Beagle board circuit with temperature sensor.

Learning Outcomes:

The students will be able to

- To interface temperature sensor to Raspberry pi.
- Read and analyze temperature values.
- Can perform actuation.

Theory:

Introduction:

The Raspberry Pi is a series of credit card-sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries. It is a capable little computer which can be used in electronics projects, and for many of the things that your desktop PC does, like spreadsheets, word processing, browsing the internet, and playing games. It also plays high- definition video.

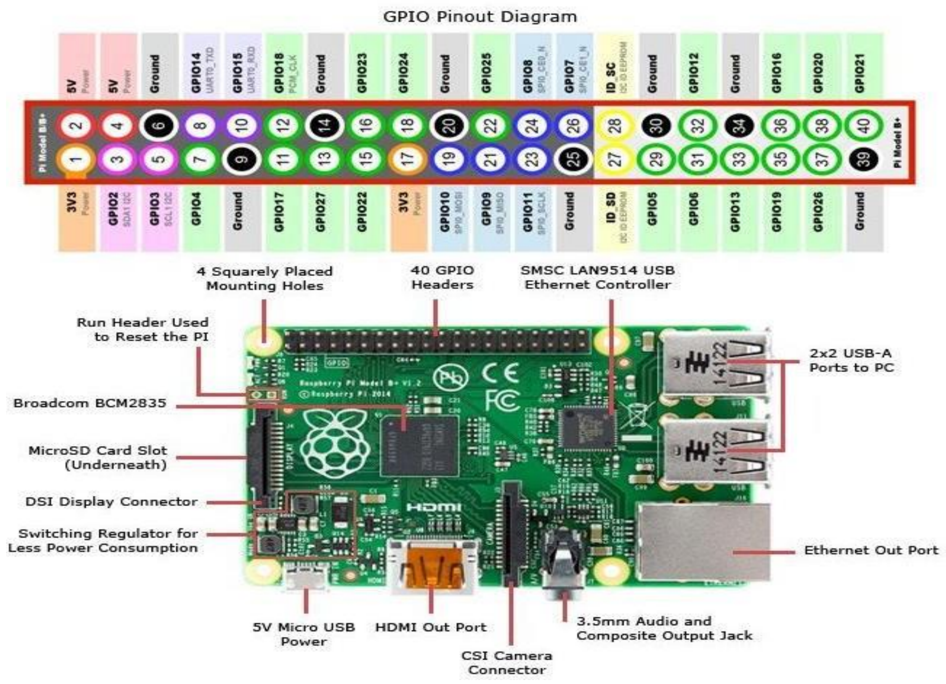
The Raspberry Pi is open hardware, with the exception of the primary chip on the Raspberry Pi, the Broadcom SoC (System on a Chip), which runs many of the main components of the board–CPU, graphics, memory, the USB controller, etc. Many of the projects made with a Raspberry Pi are open and well-documented as well and are things you can build and modify yourself.

The Raspberry Pi was designed for the Linux operating system, and many Linux distributions now have a version optimized for the Raspberry Pi.

One powerful feature of the Raspberry Pi is the row of GPIO (general purpose input/output) pins along the top edge of the board. These pins are a physical interface between the Pi and the outside world. At the simplest level, you can think of them as switches that you can turn on or off (input) or that the Pi can turn on or off (output). Of the 40 pins, 26 are GPIO pinsand the others are power or ground pins (plus two ID EEPROM pins which you should not play with unless you know your stuff!)

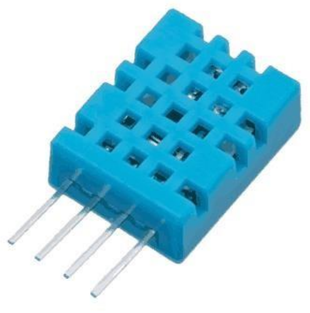
You can program the pins to interact in amazing ways with the real world. Inputs don't haveto come from a physical switch; it could be input from a sensor or a signal from another computer or device, for example. The output can also do anything, from turning on an LEDto sending a signal or data to another device. If the Raspberry Pi is on a network, you can control devices that are attached to it from anywhere and those devices can send data back. Connectivity and control of physical devices over the internet is a powerful and exciting thing, and the Raspberry Pi is ideal for this.

Raspberry Pi Board with GPIO:


GPIO Pinout Diagram
4 Squarely Placed Mounting Holes
40 GPIO Headers
SMSC LAN9514 USB Ethernet Controller
Run Header Used to Reset the PI
2x2 USB-A Ports to PC
Broadcom BCM2835
MicroSD Card Slot (Underneath)
DSI Display Connector
Switching Regulator for Less Power Consumption
Ethernet Out Port
5V Micro USB Power
HDMI Out Port
CSI Camera Connector
3.5mm Audio and Composite Output Jack

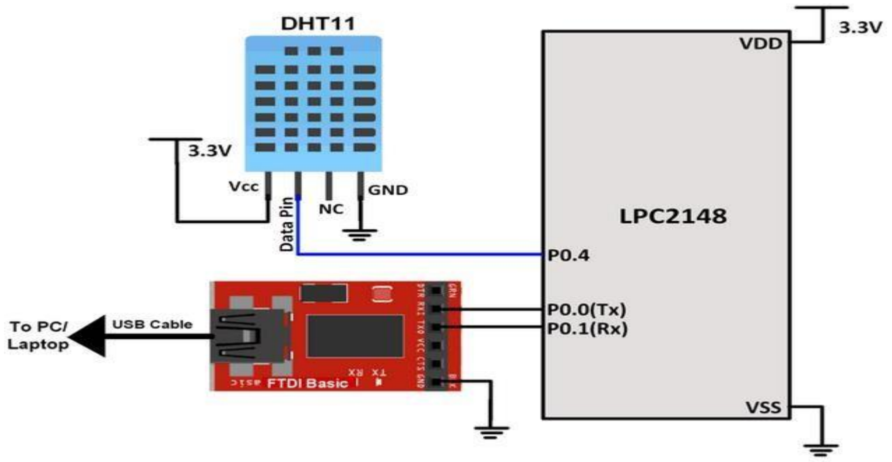
Technical Specification:
Broad com BC M28 37 64bit AR Mv7 Quad Core Processor powered Single Board Computer running at 1.2GHz
1GB RAM
BCM43143 WiFi on board
Bluetooth Low Energy (BLE) on board
40pin extended GPIO
4 x USB 2 ports
4 pole Stereo output and Composite video port
Full size HDMI
CSI camera port for connecting the Raspberry Pi camera
DSI display port for connecting the Raspberry Pi touch screen display
Micro SD port for loading your operating system and storing data
Upgraded switched Micro USB power source (now supports up to 2.4 Amps)
Expected to have the same form factor has the Pi 2 Model B, however the LEDs willChange position

DHT11 Sensor
Introduction


DHT11 Sensor

DHT11 is a single wire digital humidity and temperature sensor, which provides humidity and temperature values serially.
It can measure relative humidity in percentage (20 to 90% RH) and temperature in degreeCelsius in the range of 0 to 50°C.
It has 4 pins of which 2 pins are used for supply, 1 is not used and the last one is used fordata.
The data pin is the only pin used for communication. Pulses of different TON and TOFF aredecoded as logic 1 or logic 0 or start pulse or end of the frame.
For more information about DHT11 sensor and how to use it, refer the topic DHT11 sensor inthe sensors and modules topic.

Interfacing Diagram:



Interfacing DHT11 Sensor with LPC2148

Conclusion:
Students will be able to interface DHT sensor with Raspberry Pi and detect temperature and humidity with it.

FAQs:

- What is DHT sensor? How does it work?
- How is it interfaced with Raspberry pi/Arduino?

ASSIGNMENT NUMBER: 3

Revised On: 18-07-2022

TITLE	Write an application to capture and store the image.
PROBLEM STATEMENT /DEFINITION	Understanding and connectivity of Raspberry-Pi /Beagle board with camera. Write an application to capture and store the image.
OBJECTIVE	To capture and store image using Raspberry-pi.
S/W PACKAGESAND HARDWARE APPARATUS USED	Picamera packageRaspberry pi Camera module
REFERENCES	http://www.electronicwings.com/raspberry-pi/pi-camera-module-interface-with-raspberry-pi-using-python
STEPS	Refer to details
INSTRUCTIONSFOR WRITINGJOURNAL	Title Problem Definition Objectives Theory Class Diagram/ER diagram Test cases Program Listing Output Conclusion

Aim:

Study of Connectivity and configuration of Raspberry-Pi /Beagle board circuit with basic peripherals, LEDS. Understanding GPIO and its use in program.

Pre-requisite:

Basic knowledge of configuration.

Learning Objectives:

To understand configuration of Raspberry-pi/Beagle board circuit with basicperipherals and its use in the program.

Learning Outcomes:

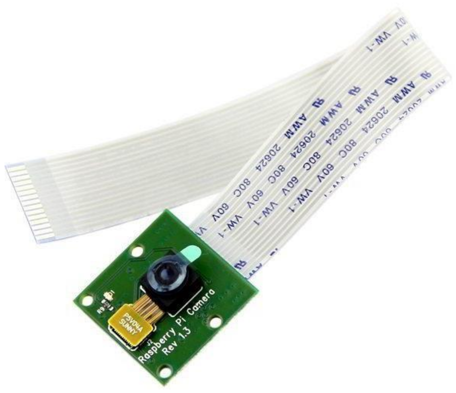
The students will be able to
Connectivity of Raspberry-pi and Implement the program

Theory:

Pi Camera Module Interface with Raspberry Pi using Python

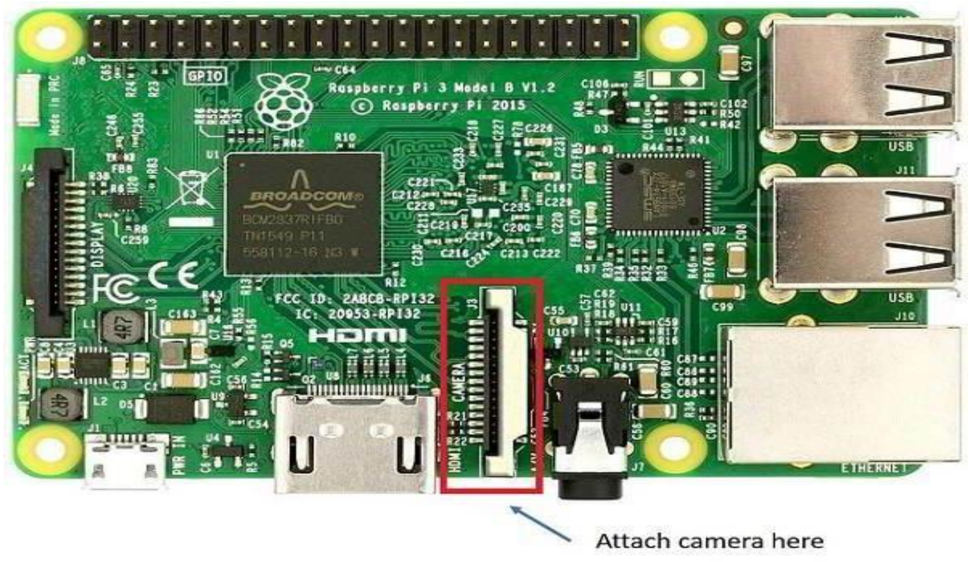
Introduction

Pi Camera module is a camera which can be used to take pictures and high definition video.Raspberry Pi Board has CSI (Camera Serial Interface) interface to which we can attach PiCamera module directly.This Pi Camera module can attach to the Raspberry Pi‟s CSI port using 15-pin ribbon cable.



How to attach Pi Camera to Raspberry Pi?

Connect Pi Camera to CSI interface of Raspberry Pi board as shown below,



Now, we can use Pi Camera for capturing images and videos using Raspberry Pi.
Python Program for Image Capture & Storeimport picamera from time import sleep

#create object for PiCamera classcamera = picamera.PiCamera() #set resolution
camera.resolution = (1024, 768)
camera.brightness = 60

```
camera.start_preview()#add text on image
camera.annotate_text = 'Hi Pi User'sleep(5)
#store image camera.capture('image1.jpeg')camera.stop_preview()
```

Conclusion:
Students will be able to interface pi camera module with Raspberry Pi and capture image and record video using pi-camera.

FAQs:

- How do you interface camera module with Raspberry pi/Arduino?
- Which commands are used to capture image and record video?

ASSIGNMENT NUMBER: 4

Revised On: 18-07-2022

TITLE	Create a small dashboard application to be deployed on cloud.
PROBLEM STATEMENT /DEFINITION	Create a small dashboard application to be deployed on cloud. Different publisher devices can publish their information and interested application can subscribe.
OBJECTIVE	To develop comprehensive approach towards building small lowcost embedded IoT system. To understand different sensory inputs.
S/W PACKAGESAND HARDWARE APPARATUS USED	Cloud (ThingSpeak), client server model, controller/processor, Python, PC with the configuration as Latest Version of 64 bit Operating Systems, Open Source Fedora-GHz. 8 G.B. RAM, 500 G.B. HDD, 15"Color Monitor, Keyboard, Mouse
REFERENCES	Olivier Hersent, David Boswarthick, Omar Elloumi , “The Internet of Things – Key applications and Protocols”, Wiley, 2012, ISBN:978-1-119-99435-0 Barrie Sosinsky, “Cloud Computing Bible”, Wiley-India, 2010.ISBN : 978-0-470-90356-8 Adrian McEwen, Hakim Cassimally, “Designing the Internet of Things”, Wiley, 2014, ISBN: 978-1-118-43063-7
STEPS	Refer to details
INSTRUCTIONSFOR WRITINGJOURNAL	Title Problem Definition Objectives Theory Class Diagram/ER diagram Test cases Program Listing Output Conclusion

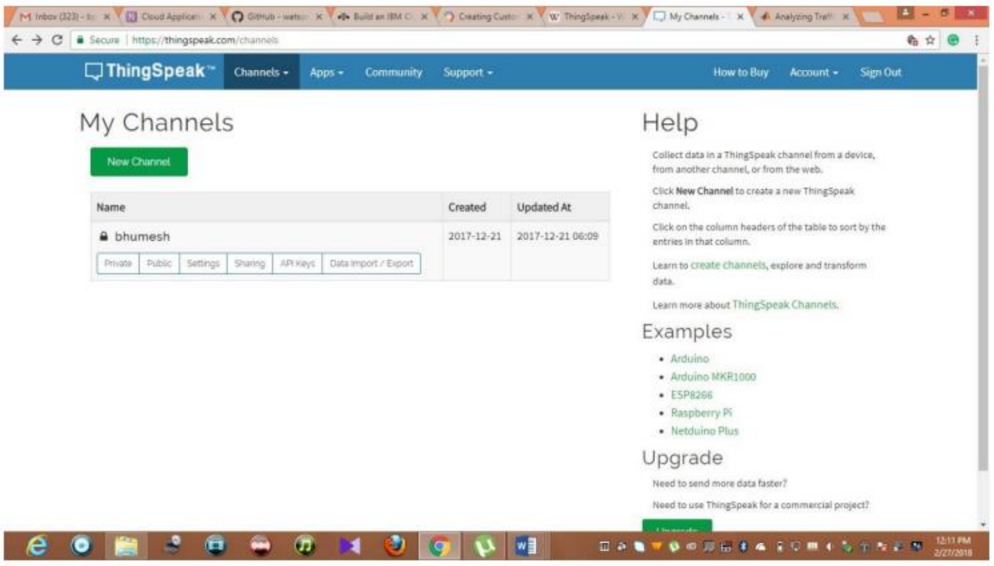
Aim: Create a small dashboard application to be deployed on cloud. Different publisher devicescan publish their information and interested application can subscribe.

Pre-requisite:
Basic knowledge of Embedded system and IOT

Learning Objectives:
To Develop application based on cloud.
To understand different sensory inputs
Understand client server model programming.

Learning Outcomes:
The students will be able to
Perform the connectivity with Raspberry-Pi, Beagle board, Arduino and other microcontroller.
Implement cloud application with the help of client server programming by using python.

Theory:
Thingspeak is an open-source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates. ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications. For accessing Thingspeak Need to create account on https://thingspeak.com/login



https://thingspeak.com/channels

My Channels

Name	Created	Updated At
bhumesh	2017-12-21	2017-12-21 06:09

Help

Collect data in a ThingSpeak channel from a device, from another channel, or from the web.

Click **New Channel** to create a new ThingSpeak channel.

Click on the column headers of the table to sort by the entries in that column.

Learn to create channels, explore and transform data.

Learn more about ThingSpeak Channels.

Examples

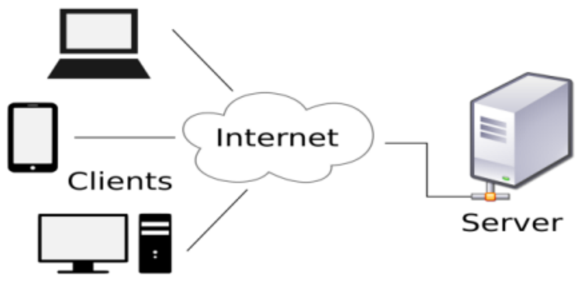
- Arduino
- Arduino MKR1000
- ESP8266
- Raspberry Pi
- Netduino Plus

Upgrade

Need to send more data faster?

Need to use ThingSpeak for a commercial project?

Client-Server model: The client–server model is a distributed application structure that partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters, called clients. Often clients and servers communicate over a computer network on separate hardware, but both client and server may reside in the same system.
A server host runs one or more server programs which share their resources with clients. A client does not share any of its resources but requests a server's content or service function. Clients therefore initiate communication sessions with servers which await incoming requests. Examples of computer applications that use the client–server model are Email, network printing, and the World Wide Web.



SETTING UP AN APACHE WEB SERVER ON A RASPBERRY PI:
Apache is a popular web server application you can install on the Raspberry Pi to allow it to serve web pages
On its own, Apache can serve HTML files over HTTP, and with additional modules can serve dynamic web pages using scripting languages such as PHP.
INSTALL APACHE
First install the apache2 package by typing the following command in to the Terminal:
sudo apt-get install apache2 -y
TEST THE WEB SERVER
By default, Apache puts a test HTML file in the web folder. This default web page is served when you browse to http://localhost/ on the Pi itself, or http://192.168.1.10 (whatever the Pi's IP address is) from another computer on the network.
Navigate to this directory in the Terminal and have a look at what's inside:
cd /var/www/html ls -al

For Developing your own application install language as preferred.
For Installing php in your server
Type the following command to install these:
sudo apt-get install php5 libapache2-mod-php5 -y
On Apache server when localhost is called by default index page get displayed. Check for version of php installed in your server with help of terminal.
Algorithm:
Install Apache server to your system(windows/linux).
Test for localhost whether page is opening as per requirement or not. (e.g., http://localhost/)
Install latest version of php in server.
Test the version and check for index.php file for proper execution.
Write a program for creating your own dashboard.
Make use of essential library functions for sending email or receiving email notifications.
Deploy the application on cloud server and check for the functionality.
WHAT THE COLUMNS MEAN
The permissions of the file or directory
The number of files in the directory (or 1 if it's a file).
The user which owns the file or directory
The group which owns the file or directory
The file size
The last modification date & time

As you can see, by default the html directory and index.html file are both owned by the root user.
In order to edit the file, you must gain rootpermissions. Change the owner to your own userwith sudo chown pi: index.html before editing.

Try editing this file and refreshing the browser to see the web page change.

YOUR OWN WEBSITE

If you know HTML you can put your own HTML files and other assets in this directory andserve them as a website on your local network.

ADDITIONAL - INSTALL PHP

To allow your Apache server to process PHP files, you'll need to install PHP5 and the PHP5module for Apache. Type the following command to install these:

```
sudo apt-get install php5 libapache2-mod-php5 -y
```

Now remove the index.html file:sudo rm index.html
and create the file index.php:sudo leafpad index.php
Note: Leafpad is a graphical editor. Alternatively, use nano *if you're restricted to the commandline*

Put some PHP content in it:

```
<?php echo "hello world"; ?>
```
Now save and refresh your browser. You should see "hello world". This is not dynamic but stillserved by PHP. Try something dynamic:

```
<?php echo date('Y-m-d H:i:s'); ?>or show your PHP info:
<?php phpinfo(); ?>
```

```
sudo apt-get install apache2 –y
sudo apt-get install php5 libapache2-mod-php5 -ysudo apt-get install git-core

git clone git://git.drogon.net/wiringPicd wiringPi
./build
```

now open terminal and enter this:

```
$cd /var/www
$sudo nano rahul.php
```

------------------------this will open a empty black screen window where we have to write theseinstructions------------
****

```
<html>
<head>
<meta name="viewport" content="width=device-width" />
<title>LED Control</title>
</head>
<body>
WEB PAGE ON PHP BASED GPIO Control:
<form method="get" action="gpio.php">
<input type="submit" value="ON" name="on">
<input type="submit" value="OFF" name="off">
</form>
```

```
<?php
$setmode17 = shell_exec("/usr/local/bin/gpio -g mode 17 out");if(isset($_GET['on'])){
$gpio_on = shell_exec("/usr/local/bin/gpio -g write 17 1");echo "LED is on";
}
else if(isset($_GET['off'])){
$gpio_off = shell_exec("/usr/local/bin/gpio -g write 17 0");echo "LED is off";
}
?>
</body>
</html>
-*-*-*-*-*-*-*-**-*-*-**-*---*-*-*-*-*-*-*-*-*

--------or can try this also------------
<?php
$myfile = fopen("/home/pi/log.txt", "r") or die("Unable to open file!");echo
fread($myfile,filesize("/home/pi/log.txt"));
fclose($myfile);
?>

*****************************************************************************
    -----------------------------------------------------------------------------

-------now press "cnt+O" to save and then "cnt+X" to exit
--------once go to /var/www library there we can find rahul.php open it and cross check it---------
--------now check ip address of our pi by giving ifconfig in terminal window------------

--------enter that ip in your mobile brouser as 192.168.2.26/rahul.php------
-------------bingo here it is---
```

Mail code: -

```
import RPi.GPIO as GPIO from subprocess import callimport time
import os import glob import smtplibimport base64
from email.mime.image import MIMEImage
from email.mime.multipart import MIMEMultipartimport subprocess
gmail_user = "checking999mail@gmail.com"gmail_pwd = "mail999checking"
FROM = 'checking999mail@gmail.com'
TO = ['hyd.embedded@pantechmail.com'] #must be a list


i=1


while (i):
i=i-1
subprocess.Popen( "fswebcam -r 1280x720 /home/pi/Downloads/pan.jpg", shell=True )
time.sleep(1)
msg = MIMEMultipart()time.sleep(1)
msg['Subject'] ="testing msg send from python"time.sleep(1)
fp = open("/home/pi/Downloads/pan.jpg", 'rb')time.sleep(1)
img = MIMEImage(fp.read())time.sleep(1)
```

```
fp.close() time.sleep(1)
msg.attach(img) time.sleep(1)
try:
server = smtplib.SMTP("smtp.gmail.com", 587) #or port 465 doesn't seem to work!print "smtp.gmail"
server.ehlo()
print "ehlo"server.starttls()
print "starttls" server.login(gmail_user, gmail_pwd)
print "reading mail & password" server.sendmail(FROM, TO, msg.as_string())
print "from"server.close()
print 'successfully sent the mail'
except:
print "failed to send mail"sudo apt-get install apache2
sudo apt-get install php5 libapache2-mod-php5sudo apt-get install git-core
git clone git://git.drogon.net/wiringPicd wiringPi
./build
```

............now open terminal and enter this:...........

```
$cd /var/www/html
$sudo leafpad gpio.php
```

------------------------this will open a empty black screen window where we have to write theseinstructions------------

****
****

```
<html>
<head>
<meta name="viewport" content="width=device-width" />
<title>LED Control</title>
</head>
<body>
WEB PAGE ON PHP BASED GPIO Control:
<form method="get" action="gpio2.php">
<input type="submit" value="ON" name="on">
<input type="submit" value="OFF" name="off">
</form>
<?php
$setmode17 = shell_exec("/usr/local/bin/gpio -g mode 17 out");if(isset($_GET['on'])){
$gpio_on = shell_exec("/usr/local/bin/gpio -g write 17 1");echo "LED is on";
}
else if(isset($_GET['off'])){
$gpio_off = shell_exec("/usr/local/bin/gpio -g write 17 0");echo "LED is off";
}


?>
</body>
</html>
```

-*-*-*-*-*-*-*-**-*-*-**-*---*-*-*-*-*-*-*-*-*-*

--------or can try this also------------

```
<?php
$myfile = fopen("/home/pi/log.txt", "r") or die("Unable to open file!");echo
```

```
fread($myfile,filesize("/home/pi/log.txt"));
fclose($myfile);
?>
***************************************************************************
```

-------now press "cnt+s" to save and then to exit
--------once go to /var/www/html library there we can find gpio.php open it and cross check it----
--------now check ip address of our pi by giving ifconfig in terminal window------------
--------enter that ip in your mobile browser as 192.168.2.26/gpio.php------
............bingo here it is...

```
import subprocess
from subprocess import callimport RPi.GPIO as GPIO import time
GPIO.setmode(GPIO.BCM)
GPIO.setup(6, GPIO.IN, pull_up_down = GPIO.PUD_UP) GPIO.setup(13, GPIO.IN ,pull_up_down =
GPIO.PUD_UP)GPIO.setup(19, GPIO.IN, pull_up_down = GPIO.PUD_UP)GPIO.setup(26, GPIO.IN,
pull_up_down = GPIO.PUD_UP)
while True:

if(GPIO.input(26) == 0): pageToOpen="en.wikipedia.org/wiki/A" subprocess.Popen(["midori","-a",
pageToOpen]) call(["espeak","Object found is an apple"],shell=True)time.sleep(5)
else:
print('a')
time.sleep(0.5)
#GPIO.cleanup()
```

Conclusion:
Thus, students will be able to install and configure the server and the programming language. Also, students will be able to host their application with subscription and subscription option.

Review Questions:
1.Explain concept pf server in detail.
2.Explain significance of client server architecture with its use.
3.What are the php tags used for sending emails? Explain them with proper example.
4.What is cloud? How to store data on cloud?
5.What is an embedded system? How is it used on cloud?

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE

ACADEMIC YEAR: 2023-24

DEPARTMENT of COMPUTER ENGINEERING DEPARTMENT

CLASS: T.E. **SEMESTER: I**

SUBJECT: LP-1 (HCI)

ASSINGMENT NO.	1
TITLE	Design a paper prototype for selected Graphical User Interface.
PROBLEM STATEMENT /DEFINITION	Develop ideas and designing user flows using hand-sketched screens that represent a digital product for any application.
OBJECTIVE	To process where design teams create paper representations of digital products to help them realize concepts and test designs
OUTCOME	To intend for a definite purpose, to assign in thought or intention**.**
S/W PACKAGES AND HARDWARE/ APPARATUS USED	Apparatus: Paper and pen
REFERENCES	https://www.uxpin.com/studio/blog/paper-prototyping-the-practical-beginners-guide/
STEPS	1. Use printer paper and cheap pencils/pens. Ruled or line pads often stifle creativity as designers get side-tracked drawing between the lines rather than developing lots of ideas. 2. Start with a warm-up! Sometimes it takes a few sketches to loosen up and get into the flow. Crazy eights is a fantastic paper prototyping method to design many versions of the same screen fast. After a couple of crazy eight rounds, you'll have many ideas to expand on. 3. Prototype mobile-first or progressive enhancement starts with the smallest screen and adjusts the layout as you scale the viewport (this applies to mobile and web design. Scaling up is much easier than scaling down because you prioritize content and avoid elaborate desktop layouts that don't translate to mobile. 4. Stick to one sketch per screen (a piece of paper). Paper prototyping requires you to create user flows by placing pieces of paper in sequences. You'll also switch these around or add new screens. If you have more than one screen on a piece of paper, you lose this speed and flexibility. 5. Iterate as the ideas come to mind. The goal is quantity, not quality. When you create lots of paper prototype ideas, you often end up taking bits from each to get the final result—like a Lego set, but with paper.
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no.

	3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/Analysis

Prerequisites: UI design and Software design

Concepts related Theory:

With tools like reMarkable and Apple Pencil, teams can collaborate remotely while enjoying the speed and versatility of the physical paper experience. Using digital sketch tools can accelerate the paper prototyping process. Designers can make changes faster (without needing to redraw a screen), attach detailed notes, and upload finished prototypes instantly to design tools like UXPin to build high-fidelity prototypes or go with wireframing. Paper prototyping digitally also reduces paper and plastic waste, which is better for the environment.

Paper prototyping is the fun part of product design. It's an opportunity for team members to brainstorm and sketch ideas. Don't worry about how beautiful your sketches look. Even the best UX designers aren't brilliant sketch artists! The goal is to visualize your ideas and get the creative juices flowing.

Algorithm: (Testing)

Testing paper prototypes:

- Designate one person other than the presenter as play the "human computer" or product simulator – The person playing the human-computer will simulate scrolling, swiping, navigating to different screens, and other functionality.
- Rehearse – Rehearsing is essential so that the presenter and simulator are in sync. The presenter can work out a good cadence for the simulator to keep up with the presentation.
- Follow standard usability test best practices – Standards like using a minimum of 5 users and recording the tests still apply. You can download our free Guide to Usability Testing for more understanding of usability standards and practices.
- If you're giving users a paper prototype to inspect, ensure you provide guidance and annotations, so they know where to focus and what they're supposed to test.

Conclusion:

Paper prototyping can be extremely helpful during the early-stage conceptualizing — when a team needs to explore a variety of different concepts and choose the one that will be used. The paper prototype allows quickly visualize and test various ideas.

Review Questions:

1) How do you make a paper prototype?
2) What is a prototype in user interface design?
3) What are the features of paper prototype?
4) How prototype is useful in GUI?
5) How do you create a prototype in design thinking?

ASSINGMENT NO.	2

TITLE	Implement GOMS (Goals, Operators, Methods and Selection rules) modeling technique to model user's behavior in given scenario
PROBLEM STATEMENT /DEFINITION	Implement GOMS (Goals, Operators, Methods and Selection rules) modeling technique to model user's behavior in given scenario
OBJECTIVE	To improve the efficiency of human-machine interaction by identifying and eliminating unnecessary user actions.
OUTCOME	*Goals*, *operators*, *methods*, and *selection rules* is a *method* derived from human-computer interaction (HCI) and constructs a description of human performance.
S/W PACKAGES AND HARDWARE/ APPARATUS USED	Critical-Path Model GOMS (**CPM-GOMS**) Natural GOMS language (**NGOMSL**)
REFERENCES	http://cs4760.csl.mtu.edu/2016/lectures/goals-operators-methods-selection-goms/
STEPS	1) Goals: A goal is something that the user tries to accomplish. The analyst attempts to identify and represent the goals that typical users will have. A set of goals usually will have a hierarchical arrangement in which accomplishing a goal may require first accomplishing one or more subgoals. 2) Operators are actions that the user executes. There is an important difference between goals and operators. Both take an action-object form, such as the goal of revising document and the operator of Keystroke ENTER. But in a GOMS model, a goal is something to be accomplished, while an operator is just executed. This distinction is intuitively based, and is also relative; it depends on the level of analysis chosen by the analyst (John & Kieras, 1996) 3) Methods: A method is a sequence of steps that accomplishes a goal. A step in a method typically consists of an external operator, such as pressing a key, or a set of mental operators involved with setting up and accomplishing a subgoal. Much of the work in analyzing a user interface consists of specifying the actual steps that users carry out in order to accomplish goals, so describing the methods is the focus of the analysis. 4) Steps More than one operator can appear in a step, and at least one step in a method must contain the operator Return_with_goal_accomplished. A step starts with the keyword Step, contains an optional label, followed by a period, and one or more operators separated by semicolons, with a final period:
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/Analysis

Prerequisites: Software Engineering & Design

Concepts related Theory:

Keystroke-level Model GOMS (KLM-GOMS)

Card, Moran, and Newell (The Keystroke-level Model for User Performance with Interactive Systems, Communications of the ACM, 23:396-410, 1980) measured the time for users to perform a series of gestures on the computer. They discovered a fundamental principle:

The total time to perform a sequence of gestures is the sum on the individual gestures.

A lot is implied in this statement. The most important is that there are fundamental gestures. Individual users perform the fundamental gestures in different times; the researchers attempted to determine typical values:

K = 0.2 sec Keying: The time to perform a keystroke, or mouse click

P = 1.1 sec Pointing: The time to position the mouse pointer

H = 0.4 sec Homing: The time for user to move hands from keyboard to mouse

M = 1.35 sec **Mental**: The time for the user to prepare for the next step

R =? **Responding**: The time for the computer to respond to the user inputs.

The variation of the timings across users can be as much as 100%, for example an expert typist can type 200 words per minute = 0.06 sec (Note that the measurement assumes 5 characters/words). So the model cannot accurately predicate the response time of an individual user. Chris Blazek and I have measured these variables for a web user and they are surprisingly accurate. Even without precise gesture times for a specific user, the model can be used to determine times for expert users and compare across interfaces.

We calculate the total response time by listing the individual gesture and summing their individual execution time. The difficult part is determining where a mental preparation, **M**, occurs. The researchers determined heuristics rules for placing mental operations:

Rule 0: Initial insertion of candidate Ms: Insert M before all Ks and Ps

Rule 1: Deletion of anticipated Ms: If P or K is fully anticipated by a preceding P or K then delete the middle M. For example, moving the mouse to tap on the button; PMK => PK

Rule 2: Deletion of Ms in cognitive units: If a series of Ks represent a string, then delete the middle Ks; for example, type ‘1.2’ is a cognitive unit; MKMKMK => MKKK

Rule 3: Deletion of Ms before consecutive terminators: If several delimiters are typed only keep the first M. For example, if ‘))’ is the terminator, use only one M.

Rule 4: Deletion of Ms that are terminators of commands: If the terminator is a frequently used, delete the M before the terminator; for example, a command followed by “return,” so the M before the K representing the “return” is deleted. But if the terminator delimits arguments for a command string that vary then keep the M. This represents checking that the arguments are correct.

Rule 5: Deletion of overlapped Ms: Do not count any portion of an M that overlaps with a command response. (This is the reason that a responsive interface only needs to respond in a second.)

Algorithm:

We want to design an interface to convert centimetres to inches and vice a versa.

This is a simple problem, but we develop 4 designs.

Design 1: Dialog box

Interface consists of two radial buttons to choose between centimetres or inches and two text fields; one text field to type the 4 characters for distance and the other to display the result.

Sequence of Tasks:

1. Move hand to mouse,
2. Move mouse to units' radio button,
3. Click on units,
4. Move hand to keyboard,
5. Type 3 characters,
6. Type enter.

Design 2: A GUI

Sequence of gestures:

1. Move hand to mouse.
2. Move mouse to pointer.
3. Click mouse.
4. Move pointer, dragging the pointer to a new distance.
5. Release pointer

Design 3: Message box request for information

A message box appears asking the user to input the units (cm/inches), the distance (4 digits) followed by return/enter. Then the keystroke sequence is MK KKKK MK = 3.9 sec.

Design 4: Bifurcated output

A box appears with text field for entering 3 digits and automatically there appears two output text fields, one text field conversion in centimetre the other in inches.

The required keystrokes are MKKKK = 2.15 sec. *IDEAL*.

Conclusion:

GOMS is a specialized human information processor model for human-computer interaction observation that describes a user's cognitive structure on four components

Review Questions:

1) What are operators in GOMS model?
2) How do you do GOMS analysis?
3) What is the mental operator in KLM?
4) How GOMS are used in technical documentation?
5) What is KLM and GOMS?

ASSIGNMENT NO.	3
TITLE	Design a User Interface in Python.

PROBLEM STATEMENT /DEFINITION	Design a User Interface in Python.
OBJECTIVE	To improve the efficiency of human-machine interaction by identifying and eliminating unnecessary user actions.
OUTCOME	Build a Python GUI Application With wxPython
S/W PACKAGES AND HARDWARE/ APPARATUS USED	Python and IDLE, python package wxpython
REFERENCES	1. https://realpython.com/python-gui-with-wxpython/#installing-wxpython 2. https://www.uxmatters.com/mt/archives/2009/02/reviewing-user-interfaces.php
STEPS	1) **Installing wxPython** User interfaces have some common components: ● Main window ● Menu ● Toolbar ● Buttons ● Text Entry ● Labels 2) **Creating a Skeleton Application** ● Widgets ● Absolute Positioning ● Sizers (Dynamic Sizing) ● Adding an Event 3) **Creating a Working Application** For example - ● mp3-tagger ● eyeD3 ● mutagen 4) **Creating the User Interface** 5) **Make a Functioning Application** ● Creating an Editing Dialog
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/Analysis

Prerequisites: Software Engineering & Design

Concepts related Theory:

There are many graphical user interface (GUI) toolkits that you can use with the Python programming language. The big three are Tkinter, wxPython, and PyQt. Each of these toolkits will work with Windows, macOS, and

Linux, with PyQt having the additional capability of working on mobile.

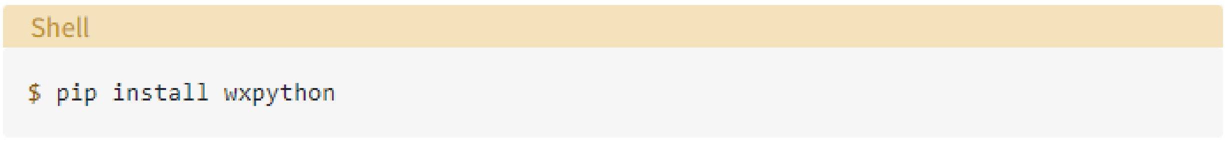
Algorithm:

1. Getting Started with wxPython

   The wxPython GUI toolkit is a Python wrapper around a C++ library called wxWidgets. The wxPython toolkit has many custom widgets included with it, along with dozens upon dozens of core widgets. The wxPython 3 and wxPython 2 versions are built only for Python.

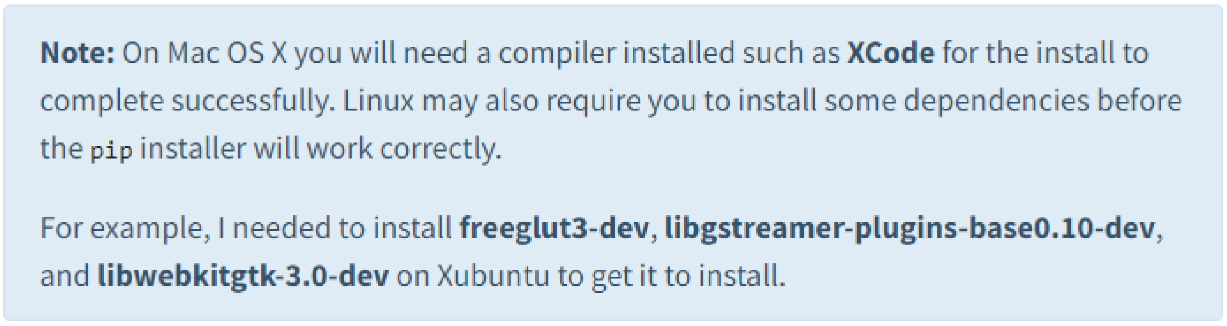
2. The wxPython 4 package is compatible with both Python 2.7 and Python

3. Use pip to install wxPython 4, which was not possible in the legacy versions of wxPython. You can do the following to install it on your machine:



Shell

```
$ pip install wxpython
```



Note: On Mac OS X you will need a compiler installed such as **XCode** for the install to complete successfully. Linux may also require you to install some dependencies before the `pip` installer will work correctly.

For example, I needed to install **freeglut3-dev**, **libgstreamer-plugins-base0.10-dev**, and **libwebkitgtk-3.0-dev** on Xubuntu to get it to install.

- **Definition of a GUI**

  User interfaces have some common components:All of these items are known generically as widgets

  a. Main window
  b. Menu
  c. Toolbar
  d. Buttons
  e. Text Entry
  f. Labels

- **Event Loops-** the GUI toolkit is running an infinite loop that is called an event loop. The event loop just waits for events to occur and then acts on those events according to what the developer has coded the application to do.

When you are programming a graphical user interface, you will want to keep in mind that you will need to hook up each of the widgets to event handlers so that your application will do something.

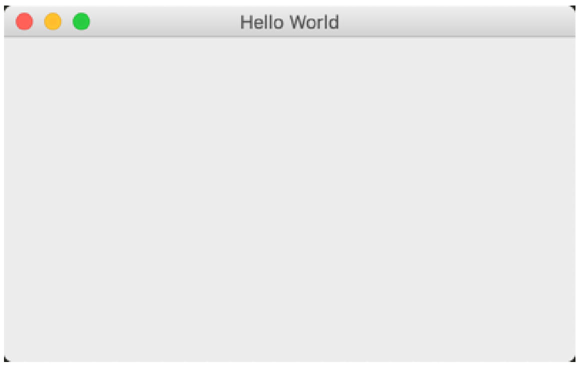
2. Creating a Skeleton Application

An application skeleton in a GUI context is a user interface with widgets that don't have any event handlers. These are useful for prototyping. You basically just create the GUI and present it to your stakeholders for sign-off before spending a lot of time on the backend logic.

Let’s start by creating a Hello World application with wxPython:

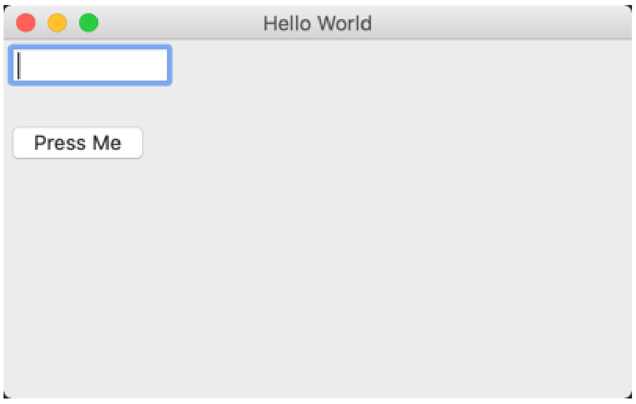
we have two parts: wx.App and the wx.Frame. The wx.App is wxPython’s application object and is required for running your GUI. The wx.App starts something called a .MainLoop(). This is the event loop so we also need wx.Frame, which will create a window for the user to interact with.By default, a wx.Frame will include minimize, maximize, and exit buttons along the top.

With no parent wx.Frame will result like its title is Hello World. Here is what it looks like when you run the code:



a. Widgets- The wxPython toolkit has more than one hundred widgets to choose from. This allows you to create rich applications, but it can also be daunting trying to figure out which widget to use.Most GUI applications allow the user to enter some text and press a button.

   Most GUI applications allow the user to enter some text and press a button. Let’s go ahead and add those widgets: When you run this code, your application should look like this:



- -The first widget you need to add is something called wx.Panel. This widget is not required but recommended.
- -The next step is to add a wx.TextCtrl to the panel. The first argument for almost all widgets is which parent the widget should go onto.
- - In wxPython, the origin location is (0,0) which is the upper left corner of the parent. So for the text control, you tell wxPython that you want to position its top left corner 5 pixels from the left (x) and 5 pixels from the top (y).
- -Then you add your button to the panel and give it a label. To prevent the widgets from overlapping, you need to set the y-coordinate to 55 for the button’s position.

b. Absolute Positioning- When we provide exact coordinates for our widget’s position, the technique that we used is called absolute positioning. Most GUI toolkits provide this capability, but it's not actually recommended.As application becomes more complex, it becomes difficult to keep track of all the widget locations and if you have to move the widgets around. Resetting all those positions becomes very difficult.

Fortunately all modern GUI toolkits provide a solution for this.

c. Sizers (Dynamic Sizing)

Here are the primary types of sizer's that you will see used most often:

- wx.BoxSizer
- wx.GridSizer
- wx.FlexGridSizer

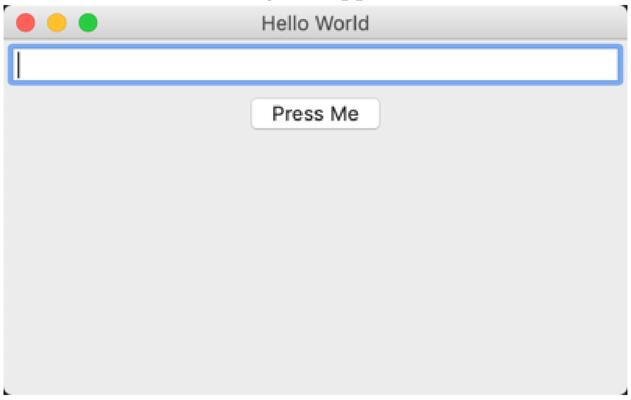
-create an instance of a wx.BoxSizer and pass it wx.VERTICAL, which is the orientation that widgets are added to the sizer.

-You may also set a BoxSizer's orientation to wx.HORIZONTAL. When you do that, the widgets would be added from left to right.

-To add a widget to a sizer, you will use .Add(). It accepts up to five arguments:

- window (the widget)
- proportion
- flag
- border
- userDat

When you run this version of the code, your application should look like the following:



d. Adding an Event- The widgets in wxPython allow you to attach event bindings to them so that they can respond to certain types of events.

we want the button to do something when the user presses it. we can accomplish this by calling the button's .Bind() method. .Bind() takes the event you want to bind to, the handler to call when the event happens, an optional source, and a couple of optional ids.

Bind your button object to the wx.EVT_BUTTON event and tell it to call on_press() when that event gets fired.

3. Creating a Working Application-

If we do a Google search for Python mp3 tagging, we will find you have several options:

- **mp3-tagger**
- **eyeD3**
- **mutagen**

Install eyeD3 using pip, like this:

Shell

```
$ pip install eyed3
```

4. Designing the User Interface

We need to be able to do the following:

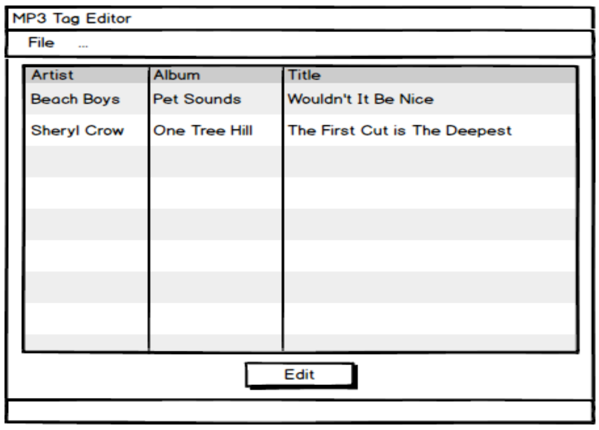
- Open up one or more MP3 files
- Display the current MP3 tags
- Edit an MP3 tag

user interfaces use a menu or a button for opening files or folders. we can go with a *File* menu for this. Since we will probably want to see tags for multiple MP3 files, we will need to find a widget that can do this in a nice manner.

Something that is tabular with columns and rows would be ideal because then we can have labeled columns for the MP3 tags. The wxPython toolkit has a few widgets that would work for this, with the top two being the following:

- wx.grid.Grid
- wx.ListCtrl

for reference see the following image -



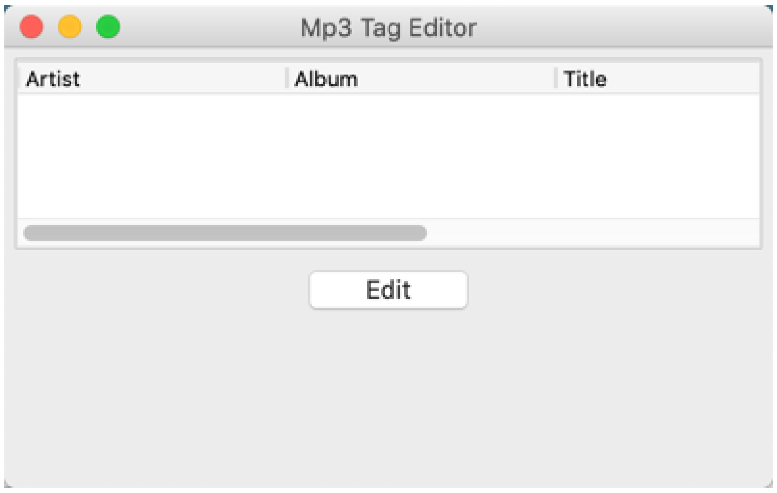
Artist	Album	Title
Beach Boys	Pet Sounds	Wouldn't It Be Nice
Sheryl Crow	One Tree Hill	The First Cut is The Deepest

5. Creating the User Interface

For example, do we need to follow the Model-View-Controller design pattern? How do we split up the classes? One class per file? **need two classes-**

- A wx.Panel class

- A wx.Frame class
- import the eyed3 package, Python's glob package, and the wx package for your user interface. Next, you subclass wx.Panel and create your user interface. You need a dictionary for storing data about your MP3s, which you can name row_obj_dict.
- Then you create a wx.ListCtrl and set it to report mode (wx.LC_REPORT) with a sunken border (wx.BORDER_SUNKEN).
- To make the ListCtrl have the correct headers, you will need to call InsertColumn() for each column header.
- The last step is to add your Edit button, an event handler, and a method. You can create the binding to the event and leave the method that it calls empty for now.
- When you are all done, your user interface should look like this:



6. Make a Functioning Application

- The first step in making our application work is to update the application so that it has a *File* menu because then we can add MP3 files to our creation. Menus are almost always added to the wx.Frame class, so that is the class you need to modify.
- Here, we add a call to .create_menu() within the class's constructor. Then in .create_menu() itself, you will create a wx.MenuBar instance and a wx.Menu instance.
- To add a menu item to a menu, you call the menu instance's .Append() and pass it the following:
- A unique identifier
- The label for the new menu item
- A help string

Next, you need to add the menu to the menu bar, so you will need to call the menu bar .Append(). It takes the menu instance and the label for the menu.

Note: If you would like to add keyboard shortcuts to your application, then you will want to use an instance of wx.AcceleratorTable to create them.

- To create an event binding, you will need to call **self.Bind(),** which binds the frame to **wx.EVT_MENU.**
- Finally, you must call the frame's **.SetMenuBar()** and pass it the menu bar instance for it to be shown to the user.
- Now that you have the menu added to your frame, let's go over the menu item's event handler

- Since you want the user to choose a folder that contains MP3s, you will want to use wxPython's **wx.DirDialog.** The **wx.DirDialog** allows the user to only open directories.
    - **Creating an Editing Dialog**
- The text controls should have the existing tag information pre-populated within them. we can create a label for the text controls by creating instances of **wx.StaticText.**
- start off by subclassing **wx.Dialog** and giving it a custom title based on the title of the MP3 that you are editing.
- Next you can create the sizer you want to use and the widgets. To make things easier, you can create a helper method called **.add_widgets()** for adding the **wx.StaticText** widgets as rows with the text control instances. The only other widget here is the *Save* button.
- **add_widgets()** takes the label's text and the text control instance. It then creates a horizontally oriented **BoxSizer.**
- You can set the dialog's title and various style flags. To show the dialog, you will need to call .ShowModal(). This will cause the dialog to show modally, which means that the user won't be able to interact with your main application while the dialog is shown.
- If the user presses the dialog's *OK* button, you can get the user's path choice via the dialog's .GetPath(). You will want to pass that path to your panel class, which you can do here by calling the panel's .update_mp3_listing().
- Finally you need to close the dialog. To close a dialog, the recommended method is to call its .Destroy().
- Dialogs do have a .Close() method, but that basically just hides the dialog, and it will not destroy itself when you close your application, which can lead to weird issues such as your application now shutting down properly. It's simpler to call .Destroy() on the dialog to prevent this issue.
- Now let's update your Mp3Panel class. You can start by updating .update_mp3_listing():

Conclusion:

we learned how to create a working GUI, application MP3 tag editor **.**

- Here you set the current directory to the specified folder and then you clear the list control. This keeps the list control fresh and only shows the MP3s that you are currently working on. That also means that you need to re-insert all the columns again.
- Next, you'll want to take the folder that was passed in and use Python's glob module to search for MP3 files.
- Then you can loop over the MP3s and turn them into eyed3 objects. You can do this by calling the .load() of eyed3. Assuming that the MP3s have the appropriate tags already, you can then add the artist, album, and title of the MP3 to the list control.T
- The method of adding a new row to a list control object is by calling .InsertItem() for the first column and SetItem() for all the subsequent columns.
- The last step is to save off your MP3 object to your Python dictionary, row_obj_dict.
- Now you need to update the .on_edit() event handler so that you can edit an MP3's tags:

    - **Creating an Editing Dialog**
- The final piece of the puzzle is creating an MP3 tag editing dialog. For brevity, we will skip sketching out this interface as it is a series of rows that contains labels and text controls. The text controls should have the existing tag information pre-populated within them. You can create a label for the text controls by creating instances of **wx.StaticText.**
- When you need to create a custom dialog, the **wx.Dialog** class is your friend. You canHere you want to start off by subclassing **wx.Dialog** and giving it a custom title based on the title of the MP3 that you are editing.

- Next you can create the sizer you want to use and the widgets. To make things easier, you can create a helper method called **.add_widgets()** for adding the **wx.StaticText** widgets as rows with the text control instances. The only other widget here is the *Save* button.

- Let's write the **add_widgets** method next, use that to design the editor:
- **add_widgets()** takes the label's text and the text control instance. It then creates a horizontally oriented **BoxSizer.**
- Next you will create an instance of **wx.StaticText** using the passed-in text for its label parameter. You will also set its size to be **50** pixels wide and the default height is set with a -1. Since you want the label before the text control, you will add the StaticText widget to your BoxSizer first and then add the text control .
- Finally, you want to add the horizontal sizer to the top level vertical sizer. By nesting the sizers in each other, you can design complex applications.

- Now you will need to create the on_save() event handler so that you can save your changes:

Here you set the tags to the contents of the text controls and then call the **eyed3** object's **.save().** Finally, you call the **.Close()** of the dialog. The reason you call **.Close()** here instead of **.Destroy()** is that you already call **.Destroy()** in the **.on_edit()** of your panel subclass.

Now your application is complete!

Review Questions:

1) What is user interface design?
2) What Does a Comprehensive UI Review Involve?
3) What are the guidelines for Design Elements in UI?
4) How to Link Elements in User Interface design?
5) How to add graphics and color in the user interface?
6) how to test configuration matches and design specifications in UI application?

ASSIGNMENT NO.	4
TITLE	To redesign existing Graphical User Interface with screen complexity.

PROBLEM STATEMENT /DEFINITION	To redesign existing Graphical User Interface with screen complexity.
OBJECTIVE	From this experiment, the student will be able to, ● To Point up the importance of a good interface design ● To motivate students to apply HCI in their day – to – day activities.
OUTCOME	The learner will be able, ● To understand and apply principles of a good interface design. ● To analyze the local and global impact of computing on individuals, organizations, and society
S/W PACKAGES AND HARDWARE/ APPARATUS USED	Programming Language (any One)- Java,PHP,DOTNET
REFERENCES	1. Donald A. Norman, "The design of everyday things", Basic books. 2. Alan Dix, J. E. Finlay, G. D. Abowd, R. Beale "Human Computer Interaction", Prentice Hall. 3. Wilbert O. Galitz, "The Essential Guide to User Interface Design", Wiley publication
STEPS	● **Measuring Complexity** ● **Procedure**: **Reducing complexity**
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/Analysis

Theory-

The design goals in creating a user interface are described below.

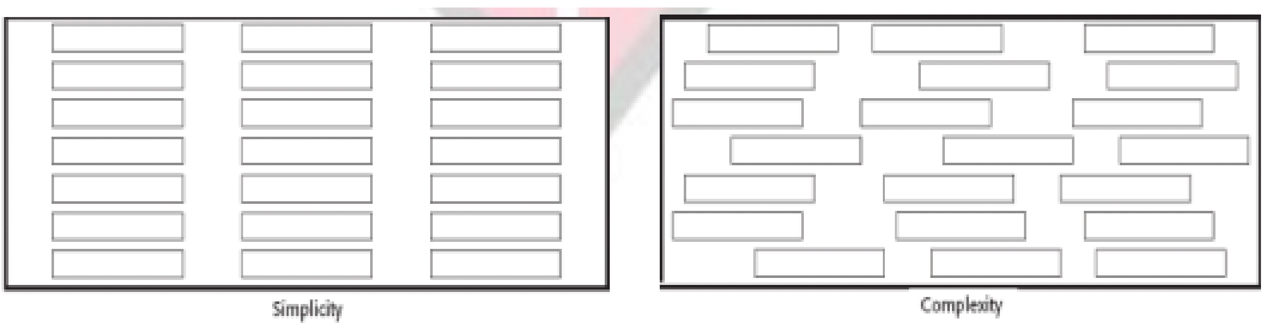
1. Aesthetically Pleasing: Visual appeal is provided by following the presentation and graphic design principles-
    - Provide meaningful contrast between screen elements.
    - Create groupings.
    - Align screen elements and groups.
    - Provide three-dimensional representation.
    - Use color and graphics effectively and simply.
2. Clarity: The interface must be clear in visual appearance, concept, and wording.
    - Visual elements should be understandable, relating to the user's real-world concepts and functions.
    - Metaphors, or analogies, should be realistic and simple.

        - Interface words and text should be simple, unambiguous, and free of computer jargon.
3. Compatibility: Provide compatibility with the following:
    - The User:Design must be appropriate and compatible with the needs of the user or client. “Know the user” is the fundamental principle in interface design.
    - The task and job:The organization of a system should match the tasks a person must do to perform the job. The structure and flow of functions should permit easy transition between tasks. The user must never be forced to navigate between applications or many screens to complete routine daily tasks.
    - The product: Compatibility across products must always be considered in relation to improving interfaces, making new systems compatible with existing systems. As a result, it reduces the necessity for new learning as users are aware of the system.
4. Comprehensibility: A system should be understandable, flowing in a comprehensible and meaningful order.
5. Configurability: Permit easy personalization, configuration, and reconfiguration of settings. Enhances a sense of control.Encourages an active role in understanding.
6. Consistency: A system should look, act, and operate the same throughout.
   Similar components should:
    - Have a similar look.
    - Have similar uses.
    - Operate similarly.

   The same action should always yield the same result.
    - The function of elements should not change.
    - The position of standard elements should not change.

Simplicity, illustrated in Figure, is directness and singleness of form, a combination of elements that results in ease of comprehending the meaning of a pattern. The opposite pole on the continuum is **complexity.**

To achieve simplicity, one needs to optimize the number of elements on a screen, within limits of clarity. And minimize the alignment points, especially horizontal or columnar.



Method for Measuring Complexity:

1. Draw a rectangle around each element on a screen, including captions, controls, headings, data, title, and so on.

2. Count the number of elements and horizontal alignment points (the number of columns in which a field, inscribed by a rectangle, starts).

3. Count the number of elements and vertical alignment points (the number of rows in which an element, inscribed by a rectangle, starts).

4. Calculate number of bits required by horizontal (column) alignment points and number of bits required by vertical (row) alignment points by applying the following formula for calculating the measure of complexity.

$$C = -N \sum_{n=1}^{m} p_n \log_2 p_n$$

- C, complexity of the system in bits N,
- total number of events (widths or heights) m,
- number of event classes (number of unique widths or heights) pn,
- probability of occurrence of the nth event class (based on the frequency of events within that class)

5. Calculate overall complexity by adding the number bits required by horizontal alignment points and vertical alignment points.

Guidelines for reducing complexity:

1. The way to minimize screen complexity is to reduce the number of controls displayed. Fewer controls will yield lower complexity measures.

2. Optimize the number of elements on a screen, within limits of clarity.

3. Alignment: Minimize the alignment points, especially horizontal or columnar. Fewer alignment points will have a strong positive influence on the complexity calculation. When things don't align, a sense of clutter and disorganization often results. In addition to reducing complexity, alignment helps create balance, regularity, sequentiality, and unity.

6. Procedure:

1. Calculate Screen Complexity for existing Graphical User Interface (GUI).

2. Redesign the Screen by applying various guidelines to lower the complexity of selected Graphical User Interface (GUI) to achieve simplicity.

7. Conclusion: Good alignment is related to shorter screen search times and higher viewer preferences for a screen. Misalignments and uneven spacing, no matter how slight, can create bothersome unconscious disruptions to our perceptual systems.

Review Questions:

1. What is needed for alignment and grouping?
2. How alignment helps in reducing the complexity of the screen?

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE

ACADEMIC YEAR: 2023-24

DEPARTMENT of COMPUTER ENGINEERING DEPARTMENT

CLASS: T.E. **SEMESTER: I**

SUBJECT: LP-1 (Distributed Systems)

ASSINGMENT NO.	1
TITLE	Inter-process communication
PROBLEM STATEMENT /DEFINITION	Implementation of Inter-process communication using socket programming: implementing multithreaded echo server.
OBJECTIVE	Understand system calls for client server communication using socket programming.

	Understand thread concept.
OUTCOME	Reliable communication between client and server
S/W PACKAGES AND HARDWARE APPARATUS USED	Ubuntu 10.04, Fedora
REFERENCES	1. Unix Network Programming by W. Richard Stevens. Published by Prentice Hall. 2. Beej's Guide to Network Programming http:/beej.us/guide/bgnet/ 3. Remote procedure call,http://www.linuxjournal.com/article/2204 4. Multithreading," http://www4.comp.polyu.edu.hk/~csajaykr/myhome/teaching/eel358/MT.pdf " 5. How to create thread," http://www.thegeekstuff.com/2012/04/create-threads-in-linux/"
STEPS	Refer to student activity theory.
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/ Analysis

Title: Inter-process communication

Problem Statement: Implementation of Inter-process communication using socket programming: implementing multithreaded echo server.

Objective: To understand system calls for client server communication using socket programming.

Aim: Implementing multithreaded echo server program.

The working of the program can be as below.

- Multiple clients at a time read string from its standard input and write the line to the server.
- The server read a line from its network input and echoes the line back to the clients.
- The clients read the echoed line and print it on its standard output.

Theory:

The standard model for network applications is the client-server model. A server is process that is waiting to be contacted by a client process sot that the server can do something for the client. A typical scenario is as follows:

- The server process is started on some computer system. It initializes itself, and then goes to sleep waiting for a client process to contact it requesting some service.
- A client process is started, either on the same system or on another system that is connected to the server's system with a network. Client processes are often initiated by an interactive user entering a command to a time-sharing system. The client process sends a request across the network to the server requesting service of some form. Some examples of the type of server that a server can provide are-
    1. Return the time of day to the client.
    2. Print a file on printer for the client
    3. Read or write a file on the server's system for the client
    4. Allow the client to login to server's system.
    5. Execute a command for the client on the server's system.
    6. When the server process has finished providing its service to the client, server goes back to sleep, waiting for the next client request to arrive.

Sockets is a method for communication between a client program and a server program in a network, A socket is defined as "the endpoint in a connection." Sockets are created and used with a set of programming requests or "function calls" sometimes called the sockets application-programming interface (API). The most common sockets API is the Berkeley Unix C interface for sockets. Sockets can also be used for communication between processes within the same computer.

System calls allow you to access the network functionality of a Unix. When you call one of these functions, the kernel takes over and does all the work for you automatically.

1. **Socket ()** System call –

```
#include <sys/types.h>

#include <sys/socket.h>

int socket(int family, int type, int protocol);
```

The family is one of

AF_UNIX	Unix internal protocols
AF_INET	Internet protocols
AF_NS	Xerox NS protocols
AF_IMPLINK	IMP link layer

The AF_ prefix stands for "address family".

The socket type is one of the following.

SOCK_STREAM	stream socket
SOCK_DGRAM	datagram socket

The protocol argument to the socket system call is typically set to 0 for most user applications.

2. **bind** System call

bind system call assigns a name to an unnamed socket.

```
#include <sys/types.h>

#include <sys/socket.h>

int bind(int sockfd, struct sockaddr *myaddr,int addrlen);
```

The second argument is a pointer to a protocol-specific address and the third argument is the size of this address structure.

3. **connect** System call

A client process connects a socket descriptor following the socket system call to establish a connection with a server.

```
#include <sys/types.h>

#include <sys/socket.h>

int connect (int sockfd, struct sockaddr *servaddr,int addrlen);
```

The sockfd is a socket descriptor that returned by the socket system call.The second and third arguments are a pointer to a socket address and its size.

4. **listen** System call

This system call is used by a connection-oriented server to indicate that is willing to receive connections.

```
int  listen(int sockfd, int backlog);
```

The backlog argument specifies how many connection requests can be queued by the system while it waits for the server to execute the accept system call. This argument is usually specified as 5, the maximum value currently allowed.

5. **accept** System call

After a connection-oriented server executes the listen system call, an actual connection from some client process is waited for by having the server execute the accept system call.

```
#include <sys/types.h>

 #include <sys/socket.h>

int accept(int sockfd, struct sockaddr *peer,int *addrlen);
```

accept takes the first connection request on the queue and creates another socket with the same properties as sockfd. If there are no connection request pending, this call blocks the caller until on arrives.

The peer and addrlen arguments are used to return the address of the connected peer process (the client).

The system call returns up to three values : an integer return code that is either an error indication or a new socket descriptor, the address of the client process(peer), and the size of this address(addrlen).

6. **read** System call

   Data is read from buffer

   int read(int sockfd,char *buff,unsigned int nbytes);

   If the read is successful , the number of bytes read is returned- this can be less than the nbytes that was requested. If the end of buffer is encountered, zero is returned. If an error is encountered, -1 is returned.

7. **write** System call

   Data is written to buffeR

   int write(int sockfd, char *buff,unsigned int nbytes);

   The actual number of bytes written is returned by the system call. This is usually equal to nbytes argument. If an error occurs , -1 returned.

8. **send, sendto, recv and recvfrom** system calls:

   #include <sys/types.h>

   #include <sys/socket.h>

   int send(int sockfd, char *buff, int nbytes,int flags);

   int sendto(int sockfd, char *buff, int nbytes,int flags,struct sockaddr *to,int addrlen);

   int recv(int sockfd, char *buff, int nbytes,int flags);

   int sendto(int sockfd, char *buff, int nbytes,int flags,struct sockaddr *from,int addrlen);

   The first three argument,sockfd,buff, and nbytes , to the four system call are similar to the first three arguments for read and write.

   The flags argument is zero.

   The to argument for sendto specifies the protocol-sepcific address of where the data is to be sent. Since this address is protocol specific, its length must be specified by addrlen.

   The recvfrom system call fills in the protocol-specific address of who sent the data into from.The length of this address is also returned to the caller in addrlen.

   Final argument to sendto is an integer value, while the final argument to recvfrom is a pointer to an integer value.

All four system calls return the length of the data that was written or read as the value of the function.

9. **close** system call

The normal Unix close system call is also used to close a socket.
int close(int fd);

Multithreaded servers - A multithreaded server is any server that has more than one thread. Each thread can handle the request of the client. start the server with one thread and create a new thread for new requests each time the server receives a request to process. This way, the server always has one thread available for a new request. You delete each thread as the request completes processing, always retaining a minimum of one thread.

Multithreading is a specialized form of multitasking, and a multitasking is the feature that allows your computer to run two or more programs concurrently. In general, there are two types of multitasking: process-based and thread-based.

Process-based multitasking handles the concurrent execution of programs. Thread-based multitasking deals with the concurrent execution of pieces of the same program.

A multithreaded program contains two or more parts that can run concurrently. Each part of such a program is called a thread, and each thread defines a separate path of execution.

C does not contain any built-in support for multithreaded applications. Instead, it relies entirely upon the operating system to provide this feature.

This tutorial assumes that you are working on Linux OS and we are going to write multi-threaded C program using POSIX. POSIX Threads, or Pthreads provides API which are available on many Unix-like POSIX systems such as FreeBSD, NetBSD, GNU/Linux, Mac OS X and Solaris.

The following routine is used to create a POSIX thread −

```
#include <pthread.h>
pthread_create (thread, attr, start_routine, arg)
```

Here, **pthread_create** creates a new thread and makes it executable. This routine can be called any number of times from anywhere within your code. Here is the description of the parameters.

Parameter	**Description**
Thread	An opaque, unique identifier for the new thread returned by the subroutine.
Attr	An opaque attribute object that may be used to set thread attributes. You can specify a thread attributes object, or NULL for the default values.
start_routine	The C routine that the thread will execute once it is created.
Arg	A single argument that may be passed to start_routine. It must be passed by reference as a pointer cast of type void. NULL may be used if no argument is

Parameter	Description
	to be passed.

The maximum number of threads that may be created by a process is implementation dependent. Once created, threads are peers, and may create other threads. There is no implied hierarchy or dependency between threads.

Terminating Threads

There is following routine which we use to terminate a POSIX thread –

```
#include <pthread.h>
pthread_exit (status)
```

Here **pthread_exit** is used to explicitly exit a thread. Typically, the pthread_exit() routine is called after a thread has completed its work and is no longer required to exist.

If main() finishes before the threads it has created, and exits with pthread_exit(), the other threads will continue to execute. Otherwise, they will be automatically terminated when main() finishes.

Example Code

```
#include <iostream>
#include <cstdlib>
#include <pthread.h>
using namespace std;
#define NUM_THREADS 5
void *PrintHello(void *threadid) {
  long tid;
  tid = (long)threadid;
  printf("Hello World! Thread ID, %d\n", tid);
  pthread_exit(NULL);
}
int main () {
  pthread_t threads[NUM_THREADS];
  int rc;
  int i;
  for( i = 0; i < NUM_THREADS; i++ ) {
    cout << "main() : creating thread, " << i << endl;
    rc = pthread_create(&threads[i], NULL, PrintHello, (void *)i);
    if (rc) {
      printf("Error:unable to create thread, %d\n", rc);
      exit(-1);
    }
  }
  pthread_exit(NULL);
}
```

Output

```
$gcc test.cpp -lpthread
$./a.out
main() : creating thread, 0
main() : creating thread, 1
main() : creating thread, 2
main() : creating thread, 3
main() : creating thread, 4
Hello World! Thread ID, 0
Hello World! Thread ID, 1
Hello World! Thread ID, 2
Hello World! Thread ID, 3
Hello World! Thread ID, 4
```

Conclusion:

References:

1.Unix Network Programming by W. Richard Stevens. Published by Prentice Hall.

2.Beej's Guide to Network Programming http:/beej.us/guide/b

Review questions:

1) What is socket?
2) What are the system calls for socket?
3) What is thread?
4) What are the differences between thread and socket?
5) What is multi-threaded?
6) What is multi-threaded echo server?

ASSINGMENT NO.	2
TITLE	Inter-process communication
PROBLEM STATEMENT /DEFINITION	Implementation of RPC Mechanism.
OBJECTIVE	Understand client server communication using RPC
OUTCOME	Interprocess communication between client and server

S/W PACKAGES AND **HARDWARE APPARATUS USED**	C Unix Programming, Java Ubuntu 10.04,Fedora
REFERENCES	1. Remote procedure call,http://www.linuxjournal.com/article/2204 2. https://www.ibm.com/docs/en/aix/7.1?topic=concepts-remote-procedure-call
STEPS	Refer to student activity theory.
INSTRUCTIONS FOR **WRITING JOURNAL**	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/ Analysis

Objective: Study of RPC mechanism.

Theory:

RPCGEN is an interface generator pre-compiler for Sun Microsystems RPC. It uses an interface definition file to create client and server stubs in C.

RPCGEN creates stubs based on information contained within an IDL file. This file is written in a language called RPCL - remote procedure call language. This language closely mimics C in style.

An RPC specification contains a number of definitions. These definitions are used by RPCGEN to create a header file for use by both the client and server, and client and server stubs.

RCPL Definitions: Constant, Enumeration, Struct, Union, and TypeDef, Program.

Remote Procedure Call (RPC) is a **protocol** that one program can use to request a service from a program located in another computer in a network without having to understand network details. (A *procedure call* is also sometimes known as a *function call* or a *subroutine call*.) RPC uses the **client/server** model. The requesting program is a client and the service-providing program is the server. Like a regular or local procedure call, an RPC is a **synchronous** operation requiring the requesting program to be suspended until the results of the remote procedure are returned.

When program statements that use RPC are **compiled** into an executable program, a **stub** is included in the compiled code that acts as the representative of the remote procedure code. When the program is run and the procedure call is issued, the stub receives the request and forwards it to a client **runtime** program in the local computer. The client runtime program has the knowledge of how to address the remote computer and server application and sends the message across the network that requests the remote procedure. Similarly, the server includes a runtime program and stub that interface with the remote procedure itself. Results are returned the same way.

Remote procedure calls (RPC) extend the capabilities of conventional procedure calls across a network and are essential in the development of distributed systems.

They can be used both for data exchange in distributed file and database systems and for harnessing the power of multiple processors.

Linux distributions provide an RPC version derived from the RPC facility developed by the Open Network Computing (ONC) group at Sun Microsystems.

RPC and the Client/Server Model:

- **Caller**: a program which calls a subroutine
- **Callee**: a subroutine or procedure which is called by the caller
- **Client**: a program which requests a connection to and service from a network server
- **Server**: a program which accepts connections from and provides services to a client

There is a direct parallel between the caller/callee relationship and the client/server relationship. With ONC RPC (and with every other form of RPC that I know), the caller always executes as a client process, and the callee always executes as a server process.

The Remote Procedure Call Mechanism

In order for an RPC to execute successfully, several steps must take place:

1. The caller program must prepare any input parameters to be passed to the RPC. Note that the caller and the callee may be running completely different hardware, and that certain data types may be represented differently from one machine architecture to the next. Because of this, the caller cannot simply feed *raw* data to the remote procedure.
2. The calling program must somehow pass its data to the remote host which will execute the RPC. In local procedure calls, the target address is simply a machine address on the local processor. With RPC, the target procedure has a machine address combined with a network address.
3. The RPC receives and operates on any input parameters and passes the result back to the caller.
4. The calling program receives the RPC result and continues execution.

External Data Representation

As was pointed out earlier, an RPC can be executed between two hosts that run completely different processor hardware. Data types, such as integer and floating-point numbers, can have different physical representations on different machines. For example, some machines store integers (C ints) with the low order byte first while some machines place the low order byte last. Similar problems occur with floating-point numeric data. The solution to this problem involves the adoption of a standard for data interchange.

One such standard is the ONC external data representation (XDR). XDR is essentially a collection of C functions and macros that enable conversion from machine specific data representations to the corresponding standard representations and vice versa. It contains primitives for simple data types such as int, float and string and provides the capability to define and transport more complex ones such as records, arrays of arbitrary element type and pointer bound structures such as linked lists.

Most of the XDR functions require the passing of a pointer to a structure of ``XDR" type. One of the elements of this structure is an enumerated field called **x_op**. It's possible values are **XDR_ENCODE**, **XDR_DECODE**, or **XDR_FREE**. The **XDR_ENCODE** operation instructs the XDR routine to convert the passed data to XDR format. The **XDR_DECODE** operation indicates the conversion of XDR represented data back to its local representation. **XDR_FREE** provides a means to deallocate memory that was dynamically allocated for use by a variable that is no longer needed.

RPC Data Flow

The flow of data from caller to callee and back again is illustrated in Figure 1. The calling program executes as a client process and the RPC runs on a remote server. All data movement between the client and the network and between the server and the network pass through XDR filter routines. In principle, any type of network transport can be used, but our discussion of implementation specifics centers on ONC RPC which typically uses either Transmission Control Protocol routed by Internet Protocol (the familiar TCP/IP) or User Datagram Protocol also routed by Internet Protocol (the possibly not so familiar UDP/IP). Similarly, any type of data representation could be used, but our discussion focuses on XDR since it is the method used by ONC RPC.

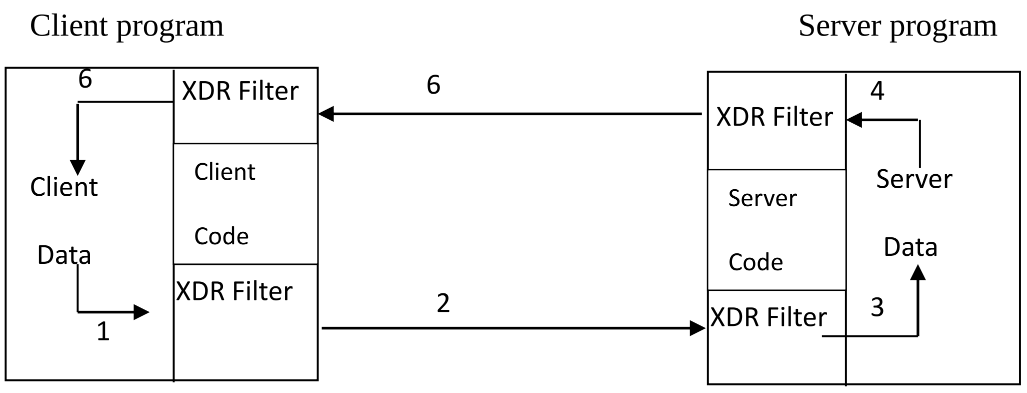


Figure 1. RPC Data Flow

1. Client encodes data through XDR filter.
2. Client passes XDR encoded data across network to remote host.
3. Server decodes data through XDR Filter.
4. Server encodes function call result through XDR Filter.
5. Server pass XDR encoded data across network back to client.
6. Client decodes RPC result through XDR Filter and continues processing.

Review of Network Programming Theory

In order to complete our picture of RPC processing, we'll need to review some network programming theory. In order for two processes running on separate computers to exchange data, an **association** needs to be formed on each host. An association is defined as the following 5-tuple: *{protocol, local-address, local-process, foreign-address, foreign-process}*

The *protocol* is the transport mechanism (typically TCP or UDP) which is used to move the data between hosts. This, of course, is the part that needs to be common to both host computers. For either host computer, the *local-address/process* pair defines the endpoint on the host computer running that process. The *foreign-address/process* pair refers to the endpoint at the opposite end of the connection.

Breaking this down further, the term *address* refers to the network address assigned to the host. This would typically be an Internet Protocol (IP) address. The term *process* refers not to an actual process identifier (such as a Unix PID) but to some integer identifier required to transport the data to the correct process once it has arrived at the correct host computer. This is generally referred to as a **port**. The reason port numbers are used is that it is not practical for a process running on a remote host to know the PID of a particular server. Standard port numbers are assigned to well known services such as TELNET (port 23) and FTP (port 21).

RPC Call Binding

Now we have the necessary theory to complete our picture of the RPC binding process. An RPC application is formally packaged into a *program* with one or more *procedure* calls. In a manner similar to the port assignments described above, the RPC program is assigned an integer identifier known to the programs which will call its procedures. Each procedure is also assigned a number that is also known by its caller. ONC RPC uses a program called **portmap** to allocate port numbers for RPC programs. It's operation is illustrated in Figure 2. When an RPC **program** is started, it registers itself with the portmap process running on the same host. The portmap process then assigns the TCP and/or UDP port numbers to be used by that application.

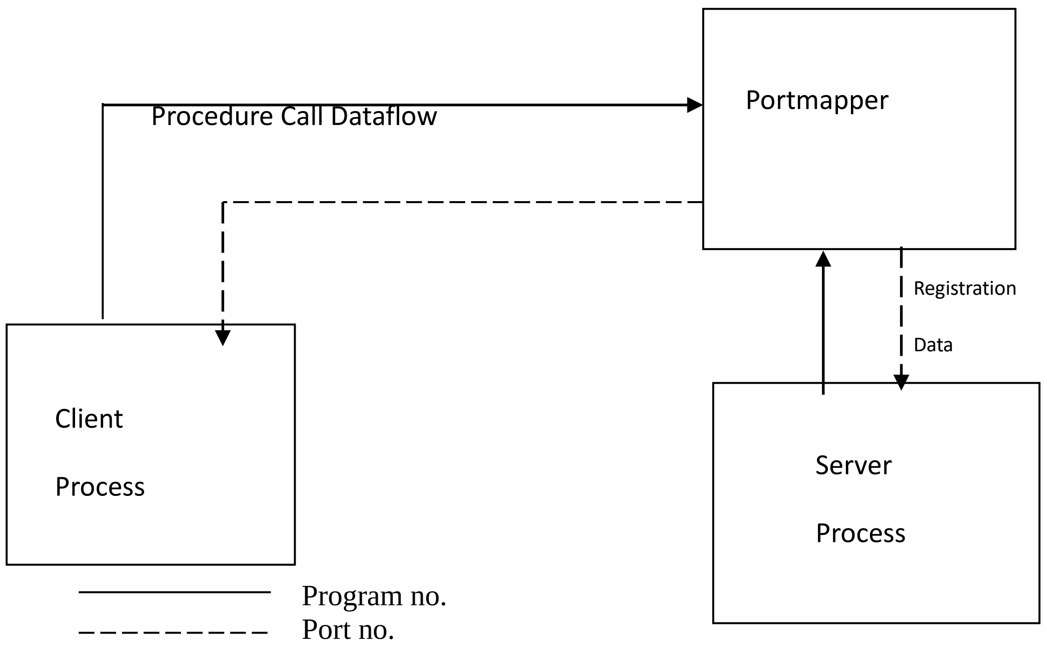


Figure 2. Portmap Operation

The RPC application then waits for and accepts connections at that port number. Prior to calling the remote procedure, the *caller* also contacts portmap in order to obtain the corresponding port number being used by the application whose procedures it needs to call. The network connection provides the means for the caller to reach the correct program on the remote host. The correct procedure is reached through the use of a dispatch table in the RPC program. The same registration process that establishes the port number also creates the dispatch table. The dispatch table is indexed by procedure number and contains the addresses of all the XDR filter routines as well as the addresses of the actual procedures.

MTRPC is a standard linux librpc.a SUN RPC modified to implement a multi threaded execution environment for remote procedure calls. It will make your rpc servers become multi-threaded by just compiling them with -lmtrpc) if you use TCP transport).

References: Remote procedure call,http://www.linuxjournal.com/article/2204

ASSINGMENT NO.	3
TITLE	Coordinator election
PROBLEM STATEMENT /DEFINITION	Simulation of election algorithms (Ring and Bully). (Unix C programming/Java)
OBJECTIVE	To study the use of coordinator
OUTCOME	To understand process synchronization
S/W PACKAGES AND HARDWARE APPARATUS USED	C Unix Programming, Java Ubuntu 10.04, Fedora

REFERENCES	[1] Tanenbaum A.S, Distributed Operating System, Pearson Education. [2] Sinha P.K, Distributed Operating Systems Concepts and Design, Prentice-Hall of India private Limited, 2008. [3] Sandipan Basu / Indian Journal of Computer Science and Engineering (IJCSE)," An Efficient Approach of Election Algorithm in Distributed Systems"
STEPS	Refer to student activity theory.
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/ Analysis

Title: **Simulation of election algorithms**
a. Bully
b. Ring

Objective: Deciding Coordinator for accessing shared resource.

Aim: Simulation of Bully and Ring election algorithms.

Theory:

Many distributed algorithms require one process to act as coordinator, initiator, or to perform some other special role. In the centralized mutual exclusion algorithm, one process is elected as the coordinator. For instance, the process running on the machine with the highest network address might be selected. Whenever a process wants to enter a critical region, it sends a request message to the coordinator stating which critical region it wants to enter and asking for permission. If no other process is currently in that region, the coordinator sends back a reply granting permission.

It does not matter which process takes on this special responsibility of coordinator, but one of them has to do it. In general, election algorithms attempt to locate the process with the highest process number and designate it as coordinator. It is assumed that every process knows the process number of every other process. What the processes do not know is which ones are currently up and which ones are currently down. The goal of election algorithm is to ensure that when an election starts, it concludes with all processes agreeing on who the new coordinator is to be.

Bully Election Algorithm

The Bully Algorithm was devised by Garcia-Molina in 1982. When a process notices that the coordinator is no longer responding to requests, it initiates an election. Process P, holds an election as follows:

1) P sends an ELECTION message to all processes with higher numbers.
2) If no one responds, P wins the election and becomes coordinator.
3) If one of the higher-ups answers, it takes over. P's job is done.

At any moment, a process can get an ELECTION message from one of its lower-numbered colleagues. When such a message arrives, the receiver sends an OK message back to the sender to indicate that it is alive and will take over. The receiver then holds an election, unless it is already holding one. Eventually, all processes give up but one, and that one is the new coordinator. It announces its victory by sending all processes a message telling them that starting immediately it is the new coordinator.

If a process that was previously down comes back up, it holds an election. If it happens to be the highest-numbered process currently running, it will win the election and will take over the coordinator's job. Thus the biggest guy in town always wins, hence the name "Bully Algorithm".

Ring Election Algorithm

This election algorithm is based on the use of a ring. We assume that the processes are physically or logically ordered, so that each process knows who its successor is. When any process notices that the coordinator is not functioning, it builds an ELECTION message containing its own process number and sends the message to its successor. If the successor is down, the sender skips over the successor and goes to the next number along the ring, or the one after that, until a running process is located. At each step, the sender adds its own process number to the list in the message.

Eventually, the message gets back to the process that started it all. That process recognizes this event when it receives an incoming message containing its own process number. At that point, the message type is changed to COORDINATOR and circulated once again, this time to inform everyone else who the coordinator is (designated by the list member with the highest number) and who the members of the new ring are. When this message has circulated once, it is removed and everyone goes back to work.

ASSINGMENT NO.	4
TITLE	Clock Synchronization
PROBLEM STATEMENT /DEFINITION	Implementation of Clock Synchronization (C/C++/Java/Python): a) NTP b) Lamports clock.
OBJECTIVE	• Understand the logical clock implementation in DS • Understand the need for logical clock in DS • Understand the Lamport’s clock synchronization algorithm

OUTCOME	The students will be able to • Demonstrate the need for logical clocks in DS • To demonstrate the need for logical clock synchronization in DS • To implement happened before relationship among the various events in DS • To implement Lamport's algorithm for synchronization of logical clocks
S/W PACKAGES AND HARDWARE APPARATUS USED	C Unix Programming, Java, Python Ubuntu 10.04, Fedora
REFERENCES	1. Distributed O.S Concepts and Design, P.K.Sinha, PHI 2. Advanced concepts in Operating Systems , Mukesh Singhal & N.G.Shivaratri, TMH 3. Distributed System Principles and Paradigms, Andrew S. Tanenbaum, 2nd edition , PHI http://www.ntp.org/ https://www.tecmint.com/synchronize-time-with-ntp-in-linux/
STEPS	Refer to student activity theory
INSTRUCTIONS FOR WRITING JOURNAL	1. Date 2. Assignment no. 3. Problem definition 4. Learning objective 5. Learning Outcome 6. Concepts related Theory 7. Algorithm 8. Test cases 9. Conclusion/ Analysis

Aim: Implementation of Clock Synchronization

a. NTP
b. Lamports clock.

Prerequisite:

- Clock synchronization in distributed systems.
- Physical clock synchronization.
- Programming in Linux environment.

Learning Objectives:

- Understand the logical clock implementation in DS
- Understand the need for logical clock in DS
- Understand the Lamport's clock synchronization algorithm

Learning Outcomes:

The students will be able to

- Demonstrate the need for logical clocks in DS
- To demonstrate the need for logical clock synchronization in DS
- To implement happened before relationship among the various events in DS
- To implement Lamport’s algorithm for synchronization of logical clocks

Theory:

Network time protocol

NTP is a protocol designed to synchronize the clocks of computers over a network.

NTP is implemented in the majority of Linux and Windows based operating systems, widely used in the control systems.

NTP stand for **Network Time Protocol**, which synchronizes the clock between computer systems over the network.

NTP server keep all the servers in-sync with accurate time to perform time based jobs in an organization. NTP client will synchronize its clock to the network time server.

What is NTP server?

NTP stands for Network Time Protocol.

It is a networking protocol that synchronize the clock between computer systems over the network.

In other hand we can say, It will keep the same time to all the systems which are connected to NTP server through NTP or Chrony client with more accuracy.

NTP can usually maintain time within tens of milliseconds over the public Internet and can achieve better than one millisecond accuracy in local area networks under ideal conditions.

It uses “User Datagram Protocol” (UDP) on port number 123 for send and receive timestamps. It is a client/server application which send and receive timestamps using the User Datagram Protocol (UDP).

What is NTP Client?

NTP client will synchronize its clock to the network time server.

To keep all the servers in your organization in-sync with an accurate time to perform time-based jobs.

Let us consider scenario, we have two servers (Server1 and Server2). The server1 usually complete the batch jobs at 10:55 and the server2 needs to run another job at 11:00 based on the server1 job completion report.

If both the system is having different time then we can’t perform the task as we planned. To achieve this, we should setup NTP.

NTP SERVER SIDE: How to install NTP Server in Linux?

There are no different packages for NTP server and NTP client since it’s a client/server model. The NTP package is available in distribution official repository so, use the distribution package manger to install it.

For `Fedora` system, use **DNF Command** to install ntp.

```
$ sudo dnf install ntp
```

For `Debian/Ubuntu` systems, use **APT-GET Command** or **APT Command** to install ntp.

```
$ sudo apt install ntp
```

How to configure the NTP server in Linux?

Once you have installed the NTP package, make sure you have to uncomment the following configuration in the `/etc/ntp.conf` file on server side.

By default the NTP server configuration relies on `X.distribution_name.pool.ntp.org`. If you want you can use the default configuration or you can change it as per your location (country specific) by visiting https://www.ntppool.org/zone/@ site.

Say for example. If you are in India then your NTP server will be `0.in.pool.ntp.org` and it will work for most of the countries.

```
# vi /etc/ntp.conf

restrict default kod nomodify notrap nopeer noquery
restrict -6 default kod nomodify notrap nopeer noquery
restrict 127.0.0.1
restrict -6 ::1
server 0.asia.pool.ntp.org
server 1.asia.pool.ntp.org
server 2.asia.pool.ntp.org
server 3.asia.pool.ntp.org
restrict 192.168.1.0 mask 255.255.255.0 nomodify notrap
driftfile /var/lib/ntp/drift
keys /etc/ntp/keys
```

We have allowed only `192.168.1.0/24` subnet clients to access the NTP server.

NTP CLIENT SIDE: How to install NTP client on Linux?

```
# vi /etc/ntp.conf

restrict default kod nomodify notrap nopeer noquery
restrict -6 default kod nomodify notrap nopeer noquery
restrict 127.0.0.1
restrict -6 ::1
server 192.168.4.121
driftfile /var/lib/ntp/drift
keys /etc/ntp/keys
```

Run the following commands to verify the NTP server synchronization status on Linux.

```
# ntpq –p
```

Run the following command to get the current status of ntpd.

```
# ntpstat
```

```
synchronised to NTP server (192.168.1.8) at stratum 3
   time correct to within 508 ms
   polling server every 64 s
```

Finally run the `date` command.

```
# date
Tue Mar 26 23:17:05 CDT 2019
```

If you are observing a significant offset in the NTP output. Run the following command to sync clock manually from the NTP server. Make sure that your NTP client should be in active state when you perform the command.

```
# ntpdate –uv CentOS7.2daygeek.com
```

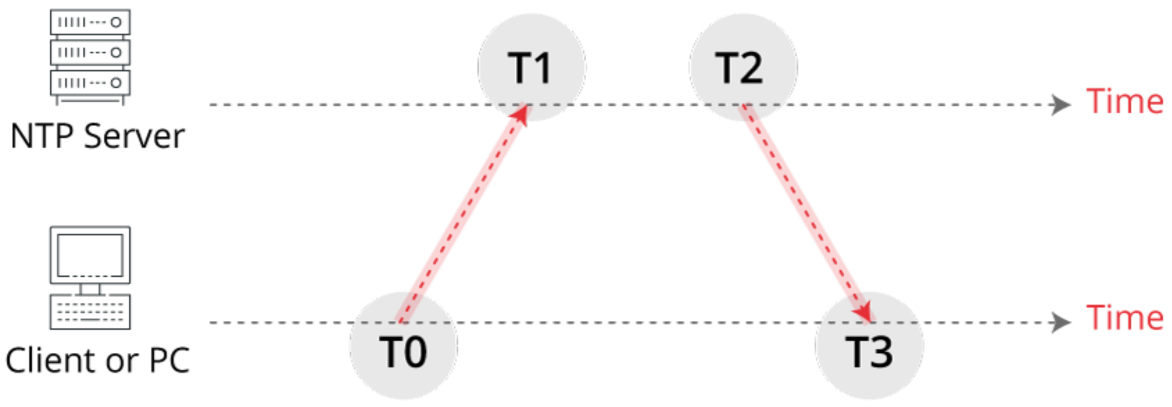


Figure: Exchange of messages in the NTP protocol

1. Assume no central time source/global clock.
2. Each system maintains its own local clock.
3. No total ordering of events.
4. No concept of happened-when.
5. Solution proposed by Leslie Lamport was the concept of logical clocks.

1. To implement "->" in a distributed system, Lamport introduced the concept of logical clocks, which captures "->"numerically.
2. Each process Pi has a logical clock Ci.
3. Clock Ci can assign a value Ci (a) to any event a in process Pi.
4. The value Ci (a) is called the timestamp of event a in process Pi.
5. The value C(a) is called the timestamp of event a in whatever process it occurred.
6. The timestamps have no relation to physical time, which leads to the term logical clock.
7. The logical clocks can be implemented by simple counters.

Conditions satisfied by Logical Clocks

1. Clock condition: if a->b, then C(a)<C(b).

2. If event a happens before event b, then the clock value (timestamp) of a should be less than the clock value of b.
3. Note that we cannot say: if C(a)<C(b), then a->b.
4. Correctness conditions (must be satisfied by the logical clocks to meet the clock condition above):
5. [C1]: For any two events a and b in the same process Pi, if a happens before b, then Ci (a) < Ci (b).
6. [C2]: If event a is the event of sending a message m in process Pi ,and event b is the event of receiving that same message m in a different process Pk, then Ci (a) < Ck (b).

Implementation of Logical Clocks

1. Implementation Rules (guarantee that the logical clocks satisfy the correctness conditions):
2. [IR1]: Clock Ci must be incremented between any two successive events in process Pi :Ci := Ci + 1.
3. [IR2]: If event a is the event of sending a message m in process Pi ,then message m is assigned a timestamp tm =Ci (a).
4. When that same message m is received by a different process Pk, Ck is set to a value greater than current value of the counter and the timestamp carried by the message is, Ck := max(Ck , tm+1).

FAQs/ Review Questions:

- Why logical clocks are implemented in distributed systems?
- What is happened-before relationship among the events?
- What is total ordering?
- What are conditions to be satisfied by the logical clock?
- What are the simple implementation rules in Lamport’s algorithm?
- State the applications where logical synchronization is essential?
- Demonstrate the correctness of Lamport’s algorithm.