UNIT 8 : BASIC CONCEPTS OF PARALLEL PROGRAMMING

ARADHYA TUTORIALS (Regd.)
.....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

Parallel Computing

The process in which many calculations can be performed simultaneously and independently is called parallel computing. In this method a large problem is divided into smaller problems which are later solved independently. A computer which helps us to solve the problem in the above mentioned manner is called a parallel computer.

Motivating factors for parallel computation:

1. Demand for computational speed:

Programs which are used to perform complicated task are expected to finish the job as soon as possible. Some of engineering calculation needs high speed computation to obtain the result: Eg: Weather forecast.

TUTORIALS(R) ARADHYA

• Accessing the memory / disk

For the data to be processed, it must be stored in the primary memory. The data can be accessed in a parallel manner from the large data base to save time.

• Data communication:

A single computing resource can only do one thing at a time. Multiple computing resources can be shared on a wide area network or internet when local computing resources are not available.

• Solve larger problems:

many problems are so large and complex that one computer would never be able to complete the task. So solve such problems we need parallel computing in which problem would be divided among the computers.

ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

CCP 8

Scope of Parallel computing

- **Engineering And Design Applications:**

Used to solve a variety of problems widely used in electromechanical systems, engines, molecular dynamics

- **Scientific Applications:**

Eg: 1: Sequencing of human genome

2: Analyzing biological sequences in developing new drugs and cures

3: Weather forecasting, flood prediction etc.

- **Commerical Application:**

millions of people around the globe are connected through internet. of. their data has to be shared and transferred in quick time we need parallel computing with parallel computers.

ABC for Java and Testing
Aradhya's Brilliance Centre for java and testing is a sister concern of Aradhya tutorials. We provide quality industry oriented training for final year students and freshers. We also provide immense job opportunities. We have already placed numerous students into the software industry. To know more, like our Facebook page "ABC For Java and testing".
Also visit our website "www.abcforjava.org".

ARADHYA TUTORIALS (Regd.)
....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

• Applications in computer systems:

Eg1: Parallel computing is used in computer security, intrusion detection.

2: Extremely large integers with more than 500 digits have to be manipulated & processed in cryptography.

3: Parallel computing is used in embedded system for performing various mobile task.

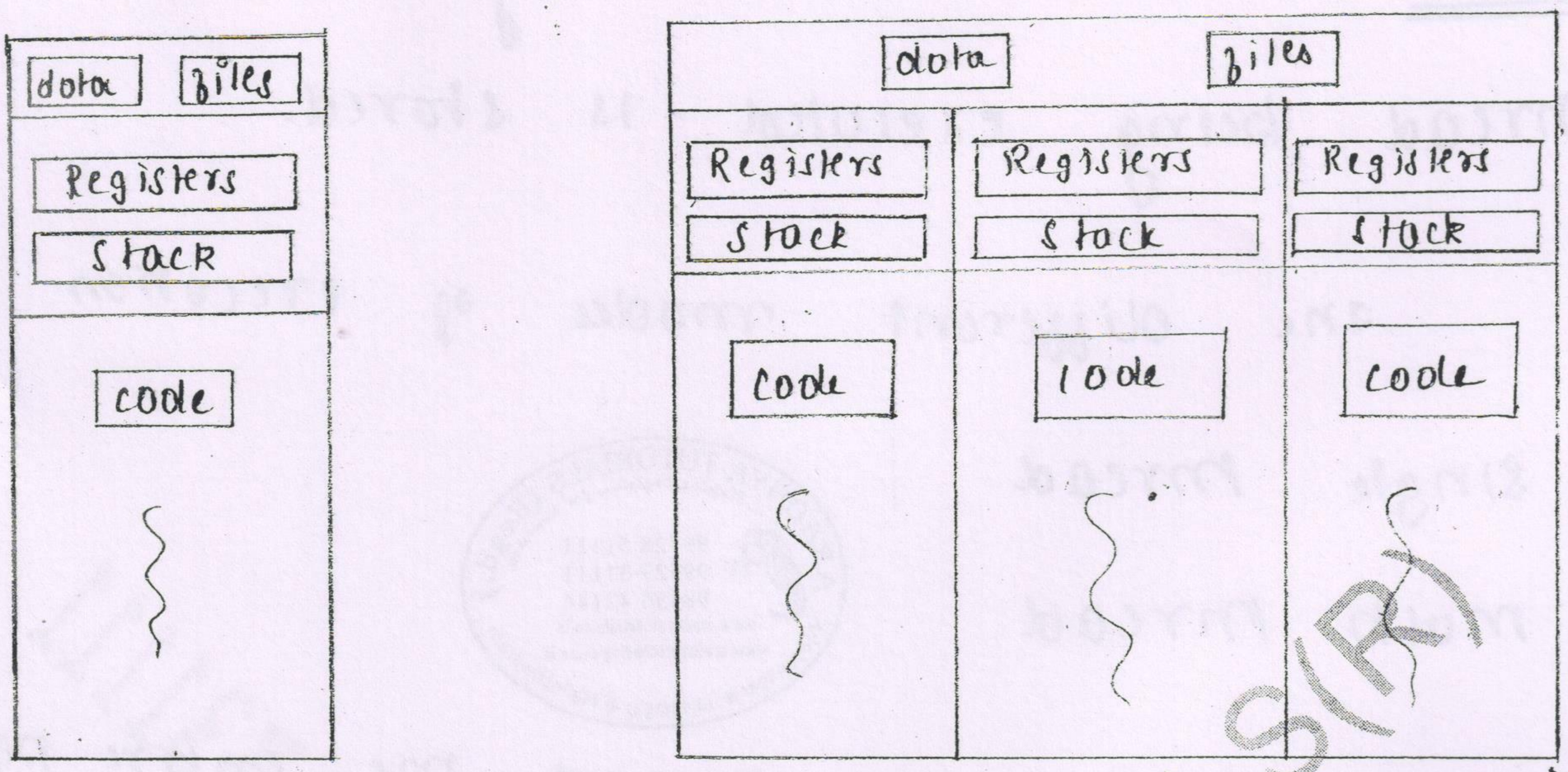
Logical Memory Model of a Thread

A thread is a single sequential flow of control within a program which can execute independently and it runs within a program. A program can have one or more threads. The memory layout for a program with a single thread and a pgm with multiple thread is shown below

ABC for Java and Testing
Aradhya's Brilliance Centre for java and testing is a sister concern of Aradhya tutorials. We provide quality industry oriented training for final year students and freshers. We also provide immense job opportunities. We have already placed numerous students into the software industry. To know more, like our Facebook page "ABC For Java and testing". Also visit our website "www.abcforjava.org".

ARADHYA TUTORIALS (Regd.) Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar Jayanagar Malleshwaram

CCP 8



The memory region is divided into four areas

- **Data and files:** This is the memory area where various types of data and files used by pgm are stored.
- **Registers:** The registers are memory inside the CPU where the data is stored temporarily during execution.
- **Stack:** It is the memory space where the local variables and the parameters that are passed to a function are stored.

ARADHYA TUTORIALS(R)
ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar Jayanagar Malleshwaram

Code: It is the memory area where the thread being executed is stored.

The different modes of execution are

- Single thread
- Multi thread

ARADHYA TUTORIALS (Regd.)
.....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

In a single thread, the entire pgm is one unit. The pgm being executed is itself treated as single thread. A single thread would use data files, registers, stack and memory.

If pgm has multiple threads

- It is divided into number of threads
- The data is shared by all the threads, the concept is called as shared memory.
- The data can be private
- Each thread has its own stack & registers which are not shared.
- Each thread would have it own thread ID.

9845642144 9972731111 9972851111

CCP8

Need For Threads OR ADV OF Threads

- **Software Portability:**

Threaded applications developed on a PC with single processor can be run on parallel machines without any changes.

- **Latency Hiding:**

Memory accessing, I/O operations and communication b/w various units take more time when compared with speed of microprocessor. This can be reduced using threads. For eg: when one thread is utilizing the CPU, other thread may be used to get data from I/P devices.

- **Scheduling And load balancing:** The process of allocating various task to processor is called as scheduling. This can be done by threads.

ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for tomorrow 99728 51111 99727 31111 98456 42144 www.aradhyatutorials.co.in www.aradhyatechnologies.co.in Vijayanagar Jayanagar Malleshwaram

• Ease of programming and widespread use:

Threaded pgm are easy to write using threaded API. "pthreads" are stable, widely used and accepted in the industry.

Disadvantages of Thread APIs

- The Thread API's provided by POSIX are predominantly used by system programmers and by application pgm.
- Thread API's are considered low-level primitives the programmer now to worry about manipulating threads.

These disadvantages can be overcome by OpenMp.

9845642144 9972731111 9972851111

ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

CCP 8

The Open Mp Programming Model

It is a models used for shared memory organisation. In this programmer has full control over the parallel programming.

The properties of Open mp Programming are

- Two or more thread executing in parallel com exchange information by sharing memory.
- Here we have pre-processor directive called # pragma in C and C++. #pragma itself consists of directive name followed by clauses and a block as shown below.

```
# pragma omp directive [clause list]
```

- omp → C/C++ preprocessor
- directive → can be parallel
- clause list → Num of threads, conditional parallelism, Data handling

Open Message Passing Api

ARADHYA TUTORIALS (Regd.) Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar Jayanagar Malleshwaram

Eg:

```
void main()
{
    ==========> serial statements

#pragma omp parallel num_threads()
private(a)
shared b
{
    ==========> statements to be executed
    parallel
}
    ==========> serial statement
}
```

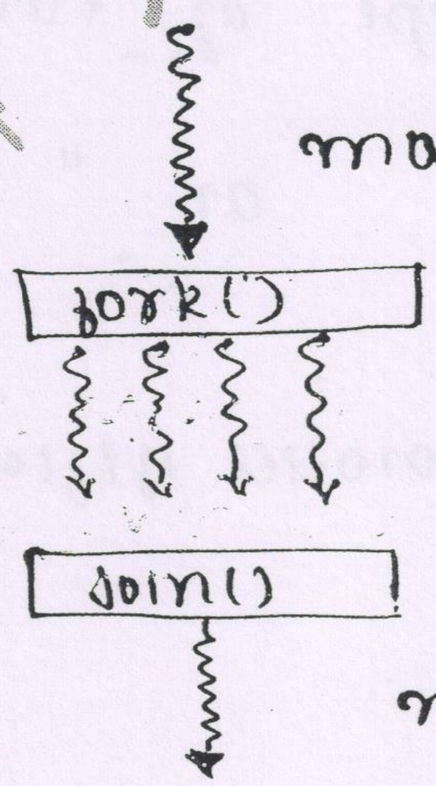
ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for Tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

- Parallel directive: Openmp.. programs executes serially as long as parallel directive is encountered. This directive creates a group of threads using the information given in the clause list.

CCP 8

Working of parallel execution:

OpenMp programs execution begins with a single thread called the master thread. The execution of the master thread would be sequentially as long as the parallel directive is encountered. Once parallel directive is encountered then the creates a group of threads using the fork() function. The exact number of threads can be specified using the clause list.



ARADHYA TUTORIALS (Regd.)
....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

When all the threads complete their task in the parallel region, they synchronize and finally terminate and are joined to form a get a master consisting of one thread.

• Clause list: This mainly specifies the following

•• conditional parallelization: The threads would be created depending upon the condition specified in the "if" clause.

•• Number of threads: specifies the number of threads to be created for parallel execution

•• Data Handling: The variables used can be shared by all the threads in the pgm or in some cases they are used only by a specific thread and is not shared by all the threads. To specify what type of variable is used we can use "private" or "shared".

eg: #pragma omp parallel if(flag==1) num_thread(6)
private (a)
shared (b)

Here six threads are created only if flag is is one and variable is private and b can be shared by all threads.

ARADHYA TUTORIALS (Regd.) ...Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

Achieving concurrency in loops and while performing independent task

concurrency while executing a loop

or while performing independent task is achieved using the "parallel" directive. The two directives provided by openmp are

- for directive ⟶ concurrency in loop
- section directive ⟶ for various tasks.

- **The for directive:**

It is used to split the parallel operations inside a loop and distribute the work among various threads. The general format is

```
#pragma omp for [clause list]
for(i=0; i<n; i++)
{
}
```

ARADHYA TUTORIALS (Regd.) Shaping Engineers for Tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

In the above pgm segment the for directive specifies that the statements inside the for loop should be executed in parallel manner by creating various threads. Programmer need not worry about how the threads are created and jobs are distributed. It is the role of open mp.

- The section directive:

If the pgm consists of various task that are independent of each other, then it can be executed in parallel manner. To execute the tasks independently and simultaneously we need to use the section directive. Using section directive we execute the task parallelly & even if they are not inside a loop. Consider the following example in which tasks A, B, C are independent.

9845642144 9972851111 9972731111

ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

ccp8

```
# progma omp parallel private(a)
{
    # pragma omp sections
    {
        task A();
    }
    # pragma omp sections
    {
        task B();
    }
    # pragma omp sections
    {
        task C();
    }
}
```

ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for tomorrow 99728 51111 99727 31111 98456 42144 www.aradhyatutorials.co.in www.aradhyatechnologies.co.in Vijayanagar Jayanagar Malleshwaram

ARADHYA TUTORIALS(R)

Synchronization Constructs in Openmp

Synchronization among threads are achieved through

- Barrier directives
- single and master directives
- Critical and automatic Directives
- Ordered Directive
- Flush Directive

ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for tomorrow 99728 51111 99727 31111 98456 42144 www.aradhyatutorials.co.in www.aradhyatechnologies.co.in Vijayanagar Jayanagar Malleshwaram

• The barrier Directive: In some programming application the threads which have completed their task must wait till other threads are completely execute. This restriction on a thread can be imposed using "barrier" Directive.

#pragma omp barrier

• The single omp master Directive:

Assume a looping control construct is executed using parallel pgm. After the completion only one thread must updated the shared memory area. For example computing the average of n numbers. This can be done by several threads. But calculating the final average sum/N must be done by only one thread. This can be achived either by "single" or "master" directive.

• #pragma omp single [clause list]

• #pragma omp master [clause list]

9845642144 9972731111

CCP 8

- The critical Directive

If the shared resource like memory is shared by several threads we should see to that at any one point of time only one thread can read or write from the memory. The part of the memory which is shared is referred to as critical section.

#pragma omp critical [name]

- The ordered Directive: It is the program requires that in some cases the threads have to be executed one after the other in a serial manner then we need to use "ordered" Directive.

#pragma omp "ordered"

. The Flush Directive: This identifies a synchronization point at which the implementation must provide a consistent view of memory. Thread visible variable as written back to memory at this point.

TUTORIALSRY
ARADHYA
ARADHYA TUTORIALS (Regd.) Shaping Engineers for Tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar Jayanagar Malleshwaram

Data Handling IN Openmp

- How data can be manipuloled by various threads in Openmp?

OR

- Briefly explain various classes supported in Openmp to manipulate the data.

ARADHYA TUTORIALS (Regd.)
Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

Sol: The data by the thread can be manipulated by the following data classes

- private: If a specific variable is used only by a single thread then we need to specify the variable as private. In this case a copy of the local variable would be given to the thread and the variable would be declared as private.

- first private: If a variable is continiously accessed by a thread, then it is better to place the copy of the variable in thread. This can be done by the declaring the variable as first-private.

cep 8

• Reduction: If multiple threads modify the data we can break these operations into local operation followed by a single global operation. This can be achived by clause reduction.

• shared: The data accessed by all the threads are specified are shared.

Functions controlling and monitoring thread creation.

• void omp_set_dynamic(int dynamic_threads): this method helps the programmer to alter the no. of threads that are created on encountering a parallel region.

• int omp_get_dynamics(): If dynamic adjustment is enabled then this method returns non zero value else returns zero.

• void omp_set_nested(int nested): This method enables nested parallelism. If parameter is 1 it is enabled else it is disabled.

ARADHYA TUTORIALS(R)
ARADHYA TUTORIALS (Regd.) ....Shaping Engineers for tomorrow
99728 51111
99727 31111
98456 42144
www.aradhyatutorials.co.in
www.aradhyatechnologies.co.in
Vijayanagar • Jayanagar • Malleshwaram

• int omp_get_nested(): It is used to query the status of nested parallelism. It returns a non zero value if nested parallesim is enabled and zero otherwise.

Environment Variables in Open MP

• OMP_NUM_THREADS: This variable specifies the number of threads in the parallel region.

• OMP_DYNAMIC: If this is set to true, we can control the number of threads at runtime.

• OMP_NESTED: When set to true, enables the nested parallel pgm.

• OMP_SCHEDULE: The for directive is controlled by this environment variable.

ARADHYA TUTORIALS (Regd.) Shaping Engineers for tomorrow 99728 51111 99727 31111 98456 42144 www.aradhyatutorials.co.in www.aradhyatechnologies.co.in Vijayanagar Jayanagar Malleshwaram