

# **UNIVERSITY OF ENGINEERING AND TECHNOLOGY TAXILA (UET)**

## **COMPUTER SCIENCE ENGINEERING DEPARTMENT**

### **Project**

### **Grid Computing and Clustering**

**For  
Fifth Semester**

**INSTRUCTOR: Sir. Asim Raheel**

**Submitted by: Muhammad Subhan, Jawad Asghar, Zabiullah**

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# GRID COMPUTING AND CLUSTERING

## 1. Problem Statement:

The demand for large scale computational resources is constantly increasing, making it challenging for a single computer to handle complex computational tasks. Grid computing provides a solution by pooling resources from multiple computers to perform a task. However, the current process of grid computing is manual and lacks efficiency, with no automatic method of distributing tasks and aggregating results from the computers in the grid.

## 2. Aims:

1. To develop a new and efficient methodology for grid computing.
2. To improve the efficiency of grid computing by automatically distributing tasks and aggregating results from multiple computers on the local network.

## 3. Objectives:

1. To implement a method for acquiring a list of all computers on the local network.
2. To gather information about each computer's CPU and memory.
3. To execute tasks on worker computers.
4. To aggregate the results from each compute.
5. To return the aggregated results to the main computer for printing.
6. To develop the code in Python.
7. To test the code to demonstrate its efficiency and effectiveness in grid computing.

## 4. Abstract:

Grid computing harnesses the power of a network of interconnected computers to tackle complex computational problems. By dividing a task into smaller subtasks and distributing them across the grid, this form of distributed computing can achieve results faster and more effectively than a single computer working alone.

Scheduling in grid computing involves carefully organizing and managing the allocation of tasks to each computer in the grid, ensuring that each machine is used efficiently and effectively. This results in a streamlined, highly efficient computing system capable of tackling even the most demanding computational challenges.

## 5. Introduction:

Grid computing is a powerful and innovative solution for harnessing the collective power of multiple computers in a network to accomplish complex tasks or operations. It involves linking several computers together to form a virtual supercomputer that can solve problems that would be challenging for a single computer to handle. With grid computing, businesses can maximize their computing resources and efficiently allocate tasks to individual machines in the network. This not only saves time but also results in more accurate and effective outcomes.

One of the major benefits of grid computing is its ability to distribute tasks across several computers, making it possible to complete complex operations in a much shorter time than it would take on a single computer. By breaking down the task into smaller sub-tasks and allocating them to different computers in the network, grid computing enables businesses to leverage the full potential of their computing resources. This helps businesses to save time and money while providing better results.

Another advantage of grid computing is that it makes it possible to tap into unused computing resources. Many businesses have computers that are not being fully utilized, and grid computing provides a way to put these idle resources to work. By pooling computing resources from different machines, grid computing increases the overall processing power available to the system and enables the completion of complex tasks more rapidly.

The process of scheduling in grid computing involves the efficient allocation of tasks to the various computers in the network. This is done in a manner that balances the workload and ensures that each computer is working at its maximum capacity. Effective scheduling also involves ensuring that the computers are working together in a coordinated manner, which helps to minimize latency and maximizes the speed and efficiency of the system.

In conclusion, grid computing is a revolutionary solution that offers businesses a new way to harness the power of multiple computers to solve complex problems and conduct large-scale operations. By pooling resources and efficiently scheduling tasks, grid computing provides businesses with a powerful and cost-effective solution for solving complex problems and optimizing their computing resources.

## 6. The Grid Revolution: Understanding the Key Components of Grid Computing:

Grid computing is a computing infrastructure that combines resources from multiple computers to achieve a common goal. The key components of grid computing are nodes, grid middleware, and grid computing architecture.

### 1. Nodes:

Nodes are the computers or servers that make up a grid computing network. Each node contributes unused computational resources to the grid network, such as CPU, memory, and storage. You can utilize the nodes for other unrelated operations at the same time. Grid computing has no restriction on the number of nodes. There are three sorts of nodes: control nodes, supplier nodes, and user nodes.

### 2. Grid middleware:

Grid middleware is a specialized software programme that integrates grid computing resources with high-level applications. It processes your request for increased processing power from the grid computing system, for example. It regulates user distribution of available resources to avoid overloading the grid computers. Grid middleware also provides security to avoid resource exploitation in grid computing.

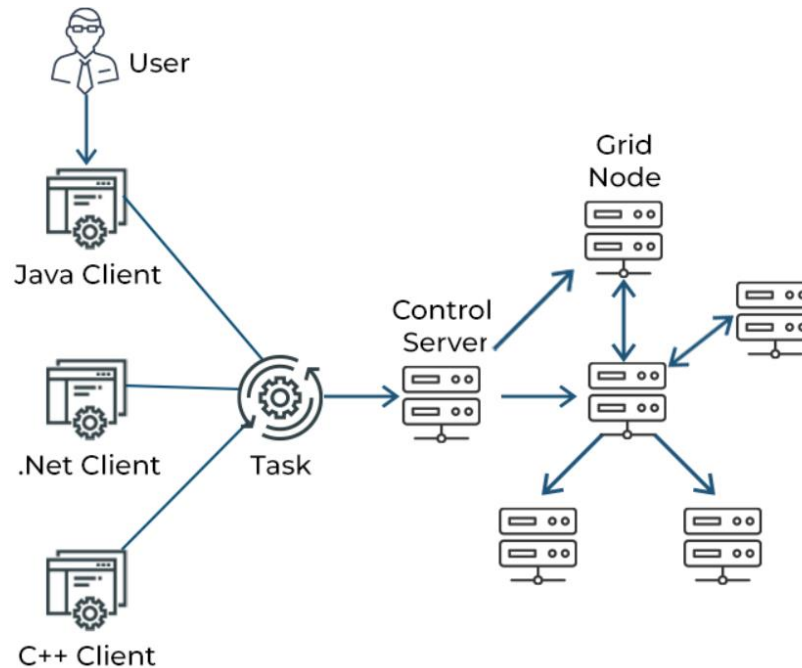
### 3. Grid computing architecture:

The internal structure of grid computers is represented by grid architecture. A grid node contains the following levels in general:

1. The top layer is made up of high-level applications, such as predictive modelling apps.
2. The second layer, often known as middleware, manages and allocates application-requested resources.
3. The third tier includes computer resources such as CPU, memory, and storage.
4. The bottom layer connects the machine to a grid computing network.

## 7. The Collaboration of Components: How Grid Computing Work:

Grid computing is a network of computers working together to solve complex problems or complete large-scale tasks. The three primary components of a grid computing system are user nodes, provider/grid nodes, and control nodes.



1.1.1. Grid Computing Work

### 1. User Nodes: The Resource Seekers:

User nodes are computers that seek out unused resources from other computers in the network. When a user node requires extra computational power, it sends a request through the grid middleware, which acts as a go-between. The middleware then distributes the request to other grid nodes in the network.

### 2. Grid Nodes: The Resource Providers:

Grid nodes, also known as provider nodes, can frequently switch roles between user and provider. They are computers that provide their own unused computational resources to the grid computing network. When a provider node receives a resource request, it carries out the necessary subtasks, such as analyzing data or running simulations. The middleware collects the results from all provider nodes at the end of the process and aggregates them to provide a final solution.

### 3. Control Nodes: The Supervisors:

Control nodes oversee the network and the distribution of resources. They host the grid middleware and manage the assignment of tasks to provider nodes. When a user node requests a resource, the middleware searches for available resources and assigns the task to the most suitable provider node. The control node ensures that the network operates smoothly and efficiently.

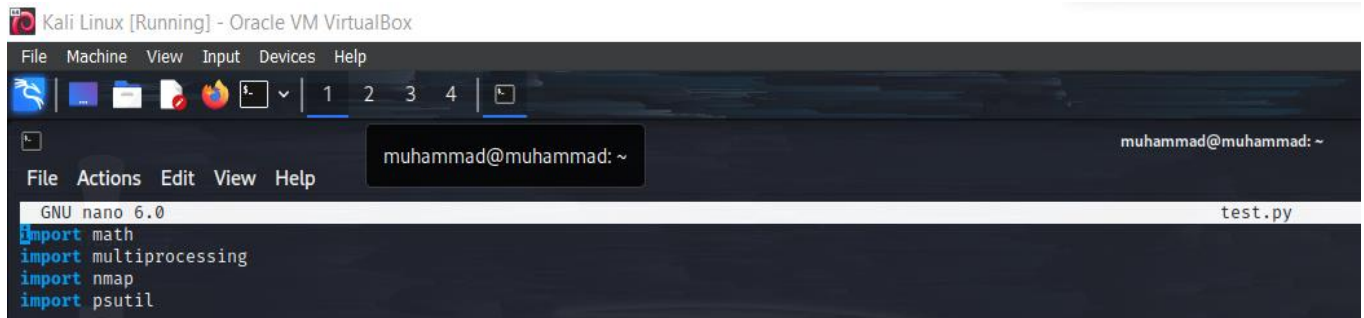
## 8. Methodology: The Step-by-Step Guide to Grid Computing:

In grid computing, several computers are linked together and functions as a single entity to complete a job. When a job is sent to the grid, it is broken into smaller sub-tasks and transferred to a separate computer in the grid to be handled. The findings from each computer are then pooled to provide the task's outcome. Grid computing is what I do. Methodology for the Project Code:

1. To acquire a list of all the computers on the local network, use the **get\_computers()** method. It scans the network with the **nmap** library and returns a list of all accessible hosts.
2. The **main()** function iterates through the list of computers and calls the **get\_info()** function for each computer. This function returns a dictionary containing information about the CPU and memory of the computer. The information for each computer is added to a dictionary **info**, with the computer's name as the key.
3. The **main()** function then prompts the user to enter numbers for the **fibonacci()**, **add()**, and **quadratic()** functions, and stores the user's input in variables **fb\_nb**, **add\_1**, **add\_2**, **quad\_1**, **quad\_2**, and **quad\_3** respectively.
4. As inputs, the **run\_tasks()** function is called using the **fibonacci()** function and the user-entered value for **fb\_nb**. This results in the creation of a pool of worker processes, the number of which is equal to the number of computers on the local network. The user-entered value is then sent to the **fibonacci()** method, which is subsequently executed on the worker processes. The function's output is returned and saved in the variable **result**.
5. The **run\_tasks()** function is called again, this time with the **add()** function and the user-entered values for **add\_1** and **add\_2** as arguments. The **add()** function is run on the worker processes and the result is returned and stored in the variable **result**.
6. The **quadratic()** function and the user-entered values for **quad\_1**, **quad\_2**, and **quad\_3** are sent as arguments to the **run\_tasks()** function a third time. The **quadratic()** function is called on the worker processes, and the result is returned and saved in the **result** variable.
7. The output of the **fibonacci()**, **add()**, and **quadratic()** functions is printed.

## 9. Grid Computing Code: A Step-by-Step Analysis:

Import multiprocessing, nmap, psutil, and math libraries in Python to perform several tasks.



```
Kali Linux [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
1 2 3 4
muhammad@muhammad: ~
File Actions Edit View Help
GNU nano 6.0 test.py
import math
import multiprocessing
import nmap
import psutil
```

**get\_computers():** It uses the nmap library to scan the local network and returns a list of all the connected hosts(computers) on the same internet.

```
def get_computers():
    """Returns a list of computers on the same internet"""
    nm = nmap.PortScanner()
    nm.scan(hosts='127.0.0.1/24', arguments='-sn')
    return nm.all_hosts()
```

**get\_info(computer):** It uses the psutil library to get information about the given computer and store it in the 'data' dictionary, which includes the number of CPUs and the total memory of the computer.

```
def get_info(computer):
    """Returns information about the given computer"""
    data = {}
    data['cpu'] = psutil.cpu_count()
    data['memory'] = psutil.virtual_memory().total
    return data
```

**fibonacci(n):** It is a recursive function which returns the Fibonacci number for the given index

```
# Fibonacci Function
def fibonacci(n):
    """Returns the Fibonacci number for the given index"""
    if n == 0:
        return 0
    elif n == 1:
        return 1
    else:
        return fibonacci(n-1) + fibonacci(n-2)
```

**add(x, y):** It takes two numbers as input and returns the sum of them.

```
# Add Function
def add(x, y):
    """Returns the sum of two numbers"""
    return x + y
```



**quadratic(a, b, c):** It takes the three numbers as input and returns the roots of the quadratic equation  $ax^2 + bx + c = 0$

```
# Quadratic Function
def quadratic(a, b, c):
    """Returns the roots of the quadratic equation ax^2 + bx + c = 0"""
    # Calculate the discriminant
    discriminant = b**2 - 4*a*c

    # Check if the discriminant is positive, negative, or zero
    if discriminant > 0:
        # Two real roots
        x1 = (-b + math.sqrt(discriminant)) / (2*a)
        x2 = (-b - math.sqrt(discriminant)) / (2*a)
        return x1, x2
    elif discriminant == 0:
        # One real root
        x = -b / (2*a)
        return x,
    else:
        # No real roots
        return tuple()
```

**run\_tasks(func, args):** It creates a pool of worker processes using multiprocessing library and runs the given function with the given arguments on the pool of worker processes and return the result.

```
def run_tasks(func, args):
    """Runs a function with given arguments on a pool of worker processes"""
    # Get a list of computers on the same internet
    computers = get_computers()

    # Create a pool of worker processes
    with multiprocessing.Pool(len(computers)) as pool:
        # Run the function on the pool
        result = pool.apply_async(func, args)
```

**main():** It gets information about all the connected computers, prints them and call the three functions(fibonacci, add and quadratic) one by one by providing input from the user and prints the result of each function as output.

```
def main():
    # Get information from the computers
    info = {}
    for computer in get_computers():
        info[computer] = get_info(computer)

    # Print the information
    for computer, data in info.items():
        print(f"Computer: {computer}")
        print(f"CPU: {data['cpu']}")
        print(f"Memory: {data['memory']}")

    # Add tasks to the pool
    print("\n***Call Fibonacci Number Function***")
    fb_nb = input("Enter a number for fibonacci: ")
    fb_nb = int(fb_nb)
    #tasks = [(i,) for i in range(41)]
    # Run the fibonacci function
    result = run_tasks(fibonacci, (fb_nb,))
    print(result)

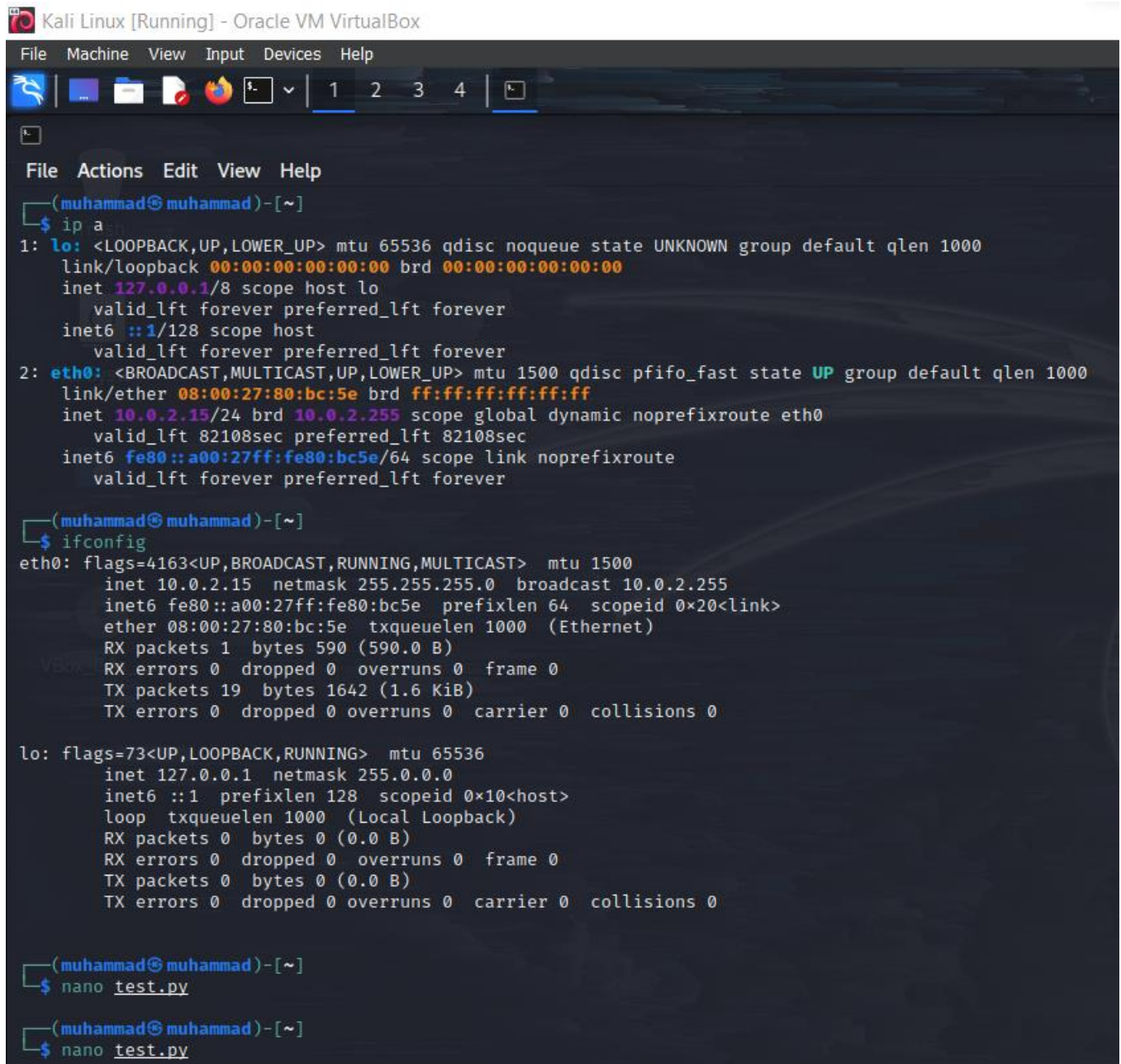
    print("\n***Call add function***")
    add_1 = input("Enter a first number for addition: ")
    add_2 = input("Enter a second number for addition: ")
    add_1 = int(add_1)
    add_2 = int(add_2)
    # Run the Add function
    result = run_tasks(add, (add_1, add_2))
    print(result)

    # Run the Quadratic function
    print("\n***Call Quadratic function***")
    quad_1 = input("Enter a first number for Quadratic: ")
    quad_2 = input("Enter a second number for Quadratic: ")
    quad_3 = input("Enter a third number for Quadratic: ")
    quad_1 = int(quad_1)
    quad_2 = int(quad_2)
    quad_3 = int(quad_3)
    # Run the Add function
    result = run_tasks(quadratic, (quad_1, quad_2, quad_3))
    print(result)

if __name__ == "__main__":
    main()
```

## 10. Grid Computing Code: Running Code in Kali Linux Terminal:

Check IP address and create python file and open its editor to modify them. And then run it.



```
Kali Linux [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
1 2 3 4

(muhammad@muhammad)-[~]
$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:80:bc:5e brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic noprefixroute eth0
        valid_lft 82108sec preferred_lft 82108sec
    inet6 fe80::a00:27ff:fe80:bc5e/64 scope link noprefixroute
        valid_lft forever preferred_lft forever

(muhammad@muhammad)-[~]
$ ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
    inet6 fe80::a00:27ff:fe80:bc5e prefixlen 64 scopeid 0x20<link>
    ether 08:00:27:80:bc:5e txqueuelen 1000 (Ethernet)
    RX packets 1 bytes 590 (590.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 19 bytes 1642 (1.6 KiB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1000 (Local Loopback)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

(muhammad@muhammad)-[~]
$ nano test.py

(muhammad@muhammad)-[~]
$ nano test.py
```

## 11. Findings:

Code gathers information about the machines on the local network, such as the number of CPUs and total RAM. It prompts the user to enter a number for Fibonacci, then executes the Fibonacci function on the worker process pool using the run task function. It invites the user to enter integers for addition before running the add function on the worker process pool with the run task function. It invites the user to enter integers for the quadratic equation, then executes the quadratic function on the worker process pool using the run task function. And for each function, print the result got from the worker process pool.

```
(muhammad@muhammad)-[~]  
$ python test.py  
Computer: 127.0.0.0  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.1  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.10  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.100  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.101  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.102  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.103  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.104  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.105  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.106  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.107  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.108  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.109  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.11  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.110  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.111  
CPU: 4  
Memory: 11561992192  
Computer: 127.0.0.112
```

```
Memory: 11561992192
Computer: 127.0.0.9
CPU: 4
Memory: 11561992192
Computer: 127.0.0.90
CPU: 4
Memory: 11561992192
Computer: 127.0.0.91
CPU: 4
Memory: 11561992192
Computer: 127.0.0.92
CPU: 4
Memory: 11561992192
Computer: 127.0.0.93
CPU: 4
Memory: 11561992192
Computer: 127.0.0.94
CPU: 4
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Memory: 11561992192
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CPU: 4
Memory: 11561992192
Computer: 127.0.0.97
CPU: 4
Memory: 11561992192
Computer: 127.0.0.98
CPU: 4
Memory: 11561992192
Computer: 127.0.0.99
CPU: 4
Memory: 11561992192

***Call Fibonacci Number Function***
Enter a number for fibonacci: 21
10946

***Call add function***
Enter a first number for addition: 10234543
Enter a second number for addition: 48568
10283111

***Call Quadratic function***
Enter a first number for Quadratic: 6
Enter a second number for Quadratic: 17
Enter a third number for Quadratic: 12
(-1.3333333333333333, -1.5)
```



## 12. Challenge of Grid Computing:

### 1. Security:

Grid computing systems often involve the sharing of resources among multiple organizations, which can create security risks. Ensuring that sensitive data is protected and preventing unauthorized access to resources is a major concern.

### 2. Resource management:

Allocating and maintaining resources in a grid computing system can be difficult since demand for resources fluctuates fast. Furthermore, various applications may have varied resource requirements, making efficient resource management problematic.

### 3. Scheduling:

Choosing which jobs to execute on which resources and in what sequence may be a difficult challenge, especially when dealing with many jobs and limited resources.

### 4. Network Latency:

The fundamental problem in grid computing is communication between distant resources due to network latency. The grid may be dispersed across numerous physical places, which means that nodes can be positioned far apart from one another. High latency due to long-distance communication can degrade grid performance and efficiency.

### 5. Data Management:

Grid systems often involve the transfer of large amounts of data between resources, which can create significant challenges in terms of data management and storage. Ensuring that data is properly backed up and protected is a major concern.

## Conclusion:

The conclusion of the grid computing and scheduling project serves as a cornerstone for future advancements and improvements. Our code serves as a foundation, providing a basic implementation of a grid computing system. However, there is still room for growth and customization to better fit the needs of specific use cases.

The code provided in the project report serves as a spark, igniting the imagination and inspiring the next generation of computing pioneers. The algorithms at the heart of this technology could be optimized to work even more efficiently with massive data sets, reducing computation time and making grid computing and clustering accessible to an even wider range of users. With the integration of machine learning techniques, the accuracy and performance of these algorithms will continue to soar.

The future of grid computing and clustering is not just about solving complex problems, it's also about democratizing access to computing power. A more user-friendly interface could be developed, making it possible for people without technical expertise to use these tools, unlocking their full potential and enabling more people to solve complex problems.

Imagine a future where task distribution is optimized and seamless, where data transmission is secure and confidential. These advancements can be achieved through the implementation of sophisticated scheduling algorithms and robust security measures. These updates will elevate the functionality and reliability of the system, propelling it towards real-world applications.

As technology evolves and the demand for efficient computing solutions increases, it is exciting to think about the limitless possibilities for this project. With each improvement, we inch closer to realizing the full potential of grid computing and establishing it as a go-to solution for all types of computing needs.

So, imagine a future where you can solve complex problems with the click of a button, where you have access to supercomputing power from the comfort of your own home. That's the future of grid computing and clustering, and the project report is just the beginning. Get ready for a computing revolution!

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