

Unit-1

2 marks questions

1. Define cloud computing?

Cloud computing allows renting infrastructure, runtime environments, and services on a pay per-use basis. This principle finds several practical applications and then gives different images of cloud computing to different people. Chief information and technology officers of large enterprises see opportunities for scaling their infrastructure on demand and sizing it according to their business needs.

2. List the different computing paradigms?

1. Parallel Computing
2. Distributed computing
3. Grid Computing
4. Cluster computing
5. Cloud Computing

3. What do you mean by parallel computing?

Parallel computing refers to the process of executing several processors an application or computation simultaneously. Generally, it is a kind of computing architecture where the large problems break into independent, smaller, usually similar parts that can be processed in one go. It is done by multiple CPUs communicating via shared memory, which combines results upon completion.

4. What do you mean by distributed computing?

Distributed computing refers to a system where processing and data storage is distributed across multiple devices or systems, rather than being handled by a single central device. In a distributed system, each device or system has its own processing capabilities and may also store and manage its own data.

5. Give any two advantages of distributed computing?

- **Performance:** Distributed computing can help improve performance by having each computer in a cluster handle different parts of a task simultaneously.
- **Cost-effectiveness:** Distributed computing can use low-cost, off-the-shelf hardware.

6. What do you mean by cluster computing?

A cluster is a group of inter-connected computers or hosts that work together to support applications and middleware (e.g. databases). In a cluster, each computer is referred to as a “node”. Unlike grid computers, where each node performs a different task, computer clusters assign the same task to each node. Nodes in a cluster are usually connected to each other through high-speed local area networks. Each node runs its own instance of an operating system.

7. What is the use of grid computing?

Organizations use grid computing to perform large tasks or solve complex problems that are difficult to do on a single computer. For example, meteorologists use grid computing for weather modeling.

8. What are the different characteristics of cloud computing?

- No up-front commitments
- On-demand access
- Nice pricing
- Scalability
- Elasticity
- Efficient resource allocation
- Seamless creation and use of third-party services

9. Expand CSCs. :Cloud Service Commerce (CSC)

10. Expand CSPs.:

Cloud Service
Provider

11. Compare cloud computing and parallel computing?

In parallel computing, a big task is split into smaller parts and each part is processed simultaneously by multiple processors in a single computer or a group of computers. Cloud computing allows us to access and use different services over the Internet, like databases, storage, servers, and software.

12. Compare parallel computing and distributed computing?

Parallel computing typically requires one computer with multiple processors. Distributed computing, on the other hand, involves several autonomous (and often geographically separate and/or distant) computer systems working on divided tasks.

13. Differentiate between cluster computing and grid computing?

Distributed refers to splitting a business into different sub-services and distributing them on different machines.

Cluster refers to a group of servers that are grouped together to achieve the same business and can be considered as one computer.

14. What is the advantage and disadvantage of cloud computing?

Advantages of Cloud Computing:

Back-up and restore data: Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.

Improved collaboration: Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage

Disadvantage: -

- **Internet Connectivity:** As you know, in cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.
- **Vendor lock-in:** Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

15.What is the disadvantage of cloud computing?

- **Internet Connectivity :** As you know, in cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.
- **Vendor lock-in:** Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

16.List the various applications of cloud computing?

1. **Cloud Computing in Education:** Cloud computing in the education sector brings an unbelievable change in learning by providing e-learning, online distance learning platforms and student information portals to the students.

- Google Meets. • Microsoft Teams

2.**Cloud Computing in Medical Fields:** In the medical field, cloud computing is used for storing and accessing the data through the internet without worrying about any physical setup. It facilitates easier access and distribution of information among the various medical professional and the individual patients.

- Digital libraries • Clinical Decision Support System (CDSS)

17.Mention the different trends in cloud computing?

AI and ML powered cloud

Cloud Security and Resilience

18.List the leading platforms of cloud computing?

Amazon web services (AWS)

Google Cloud Platform (GCP)

Long answer questions

1. Explain in detail about parallel computing with example.

Parallel computing refers to the process of executing several processors an application or computation simultaneously. Generally, it is a kind of computing architecture where the large problems break into independent, smaller, usually similar parts that can be processed in one go. It is done by multiple CPUs communicating via shared memory, which combines results upon completion. It helps in performing large computations as it divides the large problem between more than one processor. Parallel computing is defined as a type of computing where multiple computer systems are used simultaneously. Here a problem is broken into sub-problems and then further broken down into instructions. These instructions from each sub-problem are executed concurrently on different processors.

Examples: -

1. SMARTPHONES

The iPhone 5 has a 1.5 GHz dual-core processor. The iPhone 11 has 6 cores. The Samsung Galaxy Note 10 has 8 cores. These phones are all examples of parallel computing.

2. LAPTOPS AND DESKTOPS

The Intel® processors that power most modern computers are examples of parallel computing. The Intel Core™ i5 and Core i7 chips in the HP Spectre Folio and HP EliteBook x360 each have 4 processing cores.

2. Explain in detail distributed computing with examples.

Distributed computing refers to a system where processing and data storage is distributed across multiple devices or systems, rather than being handled by a single central device. In a distributed system, each device or system has its own processing capabilities and may also store and manage its own data. These devices or systems work together to perform tasks and share resources, with no single device serving as the central hub.

One example of a distributed computing system is a cloud computing system, where resources such as computing power, storage, and networking are delivered over the Internet and accessed on demand. In this type of system, users can access and use shared resources through a web browser or other client software

3. Explain briefly about cluster computing and grid computing with examples.

Grid computing is a distributed architecture of multiple computers connected by networks to accomplish a joint task. These tasks are computeintensive and difficult for a single machine to handle. Several machines on a network collaborate under a common protocol and work as a single virtual supercomputer to get complex tasks done. For example, meteorologists use grid computing for weather modeling. Weather modeling is a computation-intensive problem that requires complex data management and analysis. Processing massive amounts of weather data on a single computer is slow and time consuming.

A cluster is a group of inter-connected computers or hosts that work together to support applications and middleware (e.g. databases). In a cluster, each computer is referred to as a “node”. Unlike grid computers, where each node performs a different task, computer clusters assign the same task to each node. Nodes in a cluster are usually connected to each other through high-speed local area networks. Each node runs its own instance of an operating system. A cluster computing system consists of a set of the same or similar type of processor machines connected using a dedicated network infrastructure.

Example: Data Processing Cluster Imagine a company that needs to process large volumes of data for various analytical tasks, such as data mining, data warehousing, or generating reports. Instead of relying on a single, powerful computer, they use a cluster of computers for data processing.

4. What are the different computing paradigms? Explain briefly.

1.cloud computing: Cloud computing allows renting infrastructure, runtime environments, and services on a pay per-use basis. This principle finds several practical applications and then gives different images of cloud computing to different people. Chief information and technology officers of large enterprises see opportunities for scaling their infrastructure on demand and sizing it according to their business needs.

2.Parallel computing: - refers to the process of executing several processors an application or computation simultaneously. Generally, it is a kind of computing architecture where the large problems break into independent, smaller, usually similar parts that can be processed in one go. It is done by multiple CPUs communicating via shared memory, which combines results upon completion.

3.A cluster computing: - is a group of inter-connected computers or hosts that work together to support applications and middleware (e.g. databases). In a cluster, each computer is referred to as a “node”. Unlike grid computers, where each node performs a different task, computer clusters assign the same task to each node. Nodes in a cluster are usually connected to each other through highspeed local area networks. Each node runs its own instance of an operating system.

4.Distributed computing refers to a system where processing and data storage is distributed across multiple devices or systems, rather than being handled by a single central device. In a distributed system, each device or system has its own processing capabilities and may also store and manage its own data. These devices or systems work together to perform tasks and share resources, with no single device serving as the central hub.

5.Grid computing :-is a distributed architecture of multiple computers connected by networks to accomplish a joint task. These tasks are computeintensive and difficult for a single machine to handle. Several machines on a network collaborate under a common protocol and work as a single virtual supercomputer to get complex tasks done.

5. How does Grid computing works?

A typical grid computing network consists of three machine types: 6

Control node/server: A control node is a server or a group of servers that administers the entire network and maintains the record for resources in a network pool.

Provider/grid node: A provider or grid node is a computer that contributes its resources to the network resource pool.

User: A user refers to the computer that uses the resources on the network to complete the task. Grid computing operates by running specialized software on every computer involved in the grid network. The software coordinates and manages all the tasks of the grid. Fundamentally, the software segregates the main task into subtasks and assigns the subtasks to each computer. This allows all the computers to work simultaneously on their respective subtasks. Upon completion of the subtasks, the outputs of all computers are aggregated to complete the larger main task. The software allows computers to communicate and share information on the portion of the subtasks being carried out. As a result, the computers can consolidate and deliver a combined output for the assigned main task.

6. Compare various computing technologies.

Comparison of various computing technologies

Task	Parallel Computing	Distributed computing	Cluster computing	Grid Computing	Cloud Computing
Task Execution	Concurrent processing	Distributed processing	Concurrent processing	Distributed processing	On-demand resource allocation
Use case	Scientific simulations	Collaborations	HPC, Data analysis	Collaborative research	Versatile application
Architecture	Shared/distributed memory	Networked computers	Cluster of computers	Geographically dispersed resources	Virtualized infrastructure
Scalability	Limited	Scalable	Highly scalable	Highly scalable	Highly scalable
Resource management	Manual	Varies by approach	Managed by middleware	Managed by middleware	Managed by cloud provider
Examples	Supercomputers, MPI	Hadoop, MPI, BOINC	Beowulf cluster	Open science grid, globus	AWS, AZURE, GCP

7. Write a note on history of cloud computing.

Before the advent of computing, client-server architecture was commonly used, where all data and control of clients resided on the server side. In this setup, when a single user needed to access data, they had to connect to the server first before gaining appropriate access. However, this approach had several disadvantages. Subsequently, with the introduction of client-server computing, distributed computing came into existence. In distributed computing, all computers are interconnected, allowing users to share resources as needed. Nevertheless, distributed computing also had its limitations. To address the challenges faced in distributed systems, cloud computing emerged as a solution.

In 1961, John McCarthy delivered a speech at MIT in which he proposed that 'Computing can be sold as a utility, like water and electricity.' Although John McCarthy considered it a brilliant idea, it wasn't widely embraced by people at that time, leading to limited research on the concept. However, as time passed, the technology began to gain traction. In a few years, Salesforce.com implemented this idea in 1999 by delivering enterprise applications over the internet, marking the beginning of the Cloud Computing boom. In 2002, Amazon started Amazon Web Services (AWS), Amazon will provide storage, computation over the internet. In 2006, Amazon launched the Elastic Compute Cloud (EC2) commercial service, which was open for everyone to use. Following that, in 2009, Google Play also began offering cloud computing enterprise applications. As more companies recognized the emergence of cloud computing, they started providing their own cloud services. Consequently, in 2009, Microsoft launched Microsoft Azure, and later on, other companies such as Alibaba, IBM, Oracle, and HP also introduced their cloud services. Today, cloud computing has become a highly popular and important skill

8. Explain the features of cloud computing.

No up-front commitments: -This means you don't have to contractually agree to a specific amount of usage up front. Many contracts have minimums and maximums built in, so even if you don't use a product much, you would still be obligated to a minimum payment.

On-demand access; - The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.

Nice pricing; - Cloud providers offer a variety of pricing models, including pay-per-use, subscription-based, and spot pricing, allowing users to choose the option that best suits their needs.

Scalability: - Cloud scalability in cloud computing refers to the ability to increase or decrease IT resources as needed to meet changing demand.

Elasticity: -Cloud Elasticity is the property of a cloud to grow or shrink capacity for CPU, memory, and storage resources to adapt to the changing demands of an organization.

Efficient resource allocation: - The IT resource (e.g., networks, servers, storage, applications, and services) are shared across multiple applications efficiently when they require. 16

Energy efficiency: -Cloud computing is an internet-based computing which provides metering-based services to consumers. It means accessing data from a centralized pool of compute resources that can be ordered and consumed on demand. One of the most important challenges faced in cloud computing is the optimization of Energy Utilization. There are multiple techniques and algorithms used to minimize the energy consumption in cloud.

Seamless creation: - and use of third-party services Cloud computing helps in seamless creation and use of third-party services. For example, AWS provides EMR Hadoop clusters easily, so we don't have to put much effort on creation. Similar for the Apache Spark engine in Microsoft azure.

9.Explain advantages of cloud computing.

Back-up and restore data: Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.

Improved collaboration: Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage.

Excellent accessibility: Cloud allows us to quickly and easily access store information anywhere, anytime in the whole world, using an internet connection. An internet cloud infrastructure increases organization productivity and efficiency by ensuring that our data is always accessible.

Low maintenance cost: Cloud computing reduces both hardware and software maintenance costs for organizations.

Mobility: Cloud computing allows us to easily access all cloud data via mobile.

Services in the pay-per-use model: Cloud computing offers Application Programming Interfaces (APIs) to the users for access services on the cloud and pays the charges as per the usage of service

10.Explain disadvantages of cloud computing.

Internet Connectivity: As you know, in cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.

Vendor lock-in: Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

Limited Control: As we know, cloud infrastructure is completely owned, managed, and monitored by the service provider, so the cloud users have less control over the function and execution of services within a cloud infrastructure.

Security: Although cloud service providers implement the best security standards to store important information. But, before adopting cloud technology, you should be aware that you will be sending all your organization's sensitive information to a third party, i.e., a cloud computing service provider. While sending the data on the cloud, there may be a chance that your organization's information is hacked by Hackers.

Lack of support staff: Some cloud companies do not provide proper support to their clients; then, you have to only depend on FAQs or online help.

Technical issues: Due to frequent version releases of some applications, you have to constantly upgrade your systems to meet a market need; in between these updates, there is a chance that you may be stuck on some technical problems

11.Explain various applications of cloud computing.

1. Cloud Computing in Education: Cloud computing in the education sector brings an unbelievable change in learning by providing e-learning, online distance learning platforms and student information portals to the students. It is a new trend in education that provides an attractive environment for learning, teaching, experimenting, etc. to students, faculty members, and researchers. Everyone associated with the field can connect to the cloud of their organization and access data and information from there.

- Google Meets Provide a lecture hall-like environment to the learners as well as to the teachers, where they can interact and clear their doubts. Authorizing the teachers with some grants brings a sense of discipline.

- Microsoft Teams A cloud-based application that provides an educational-friendly environment for universities, colleges, and schools.

2. Cloud Computing in Medical Fields: In the medical field, cloud computing is used for storing and accessing the data through the internet without worrying about any physical setup. It facilitates easier access and distribution of information among the various medical professional and the individual patients. With the assistance of cloud computing, offsite buildings and treatment facilities, such as labs, doctors making 20 emergency house calls, and ambulance information, can be readily accessed and updated remotely, eliminating the need to wait until they can access a hospital computer.

- Digital libraries Libraries are an important asset and source of knowledge for medical students, practitioners, and researchers. Cloud-based libraries have massive file storage, query languages, and indexing service. With cloud-based libraries, medical students and practitioners can access information on demand to stay up to date on the latest research. Additionally, physicians can access useful information to understand the progress in the healthcare industry and improve their work practice.
- Clinical Decision Support System (CDSS) CDSS is an advanced system that uses the knowledge and behavior of a medical professional to provide advice on the patient record analysis. This system is used for diagnosing conditions and prescribing medication. Cloud computing can be used to create such systems that provide better patient care.

3. Entertainment Applications: Many people get entertainment from the internet, in that case, cloud computing is the perfect place for reaching to a varied consumer base. Therefore, different types of entertainment industries reach near the target audience by adopting a multi-cloud strategy. Cloud based entertainment provides various entertainment applications such as online music/video, online games and video conferencing, streaming services, etc. and it can reach any device be it TV, mobile, set-top box, or any other form. It is a new form of entertainment called OnDemand Entertainment (ODE). With respect to this as a cloud, the market is growing rapidly and it is providing various services day by day. So other application of cloud computing includes social applications, management application, business applications, art application, and many more. So in the future cloud computing is going to touch many more sectors by providing more applications and services.

- Google stadia- It is a cloud gaming service that provides a video gaming experience at 4K resolution and within 60 frames.
- Project Atlas - Is one of the top examples of cloud entertainment apps.

4. E-commerce Application: Cloud-based e-commerce allows responding quickly to the opportunities which are emerging. Users respond quickly to the market opportunities as well as the traditional ecommerce responds to the challenges quickly. Cloud-based e-commerce gives a new approach to doing business with the minimum amount as well as minimum time possible. Customer data, product data, and other operational systems are managed in cloud environments.

- Amazon
- eBay.

5. Anti-Virus Applications: Previously, organizations were installing antivirus software within their system even if we will see we personally also keep antivirus software in our system for safety from outside cyber threats. But nowadays cloud computing provides cloud antivirus software which means the software is stored in the cloud and monitors your system/organization's system remotely. This antivirus software identifies the security risks and fixes them. Sometimes also they give a feature to download the software.

- Kaspersky endpoint protection
- Sophos endpoint protection.

6. Bigdata Analysis: We know the volume of big data is so high where storing that in traditional data management system for an organization is impossible. But cloud computing has resolved that problem by allowing the organizations to store their large volume of data in cloud storage without worrying about physical storage. Next comes analyzing the raw data and finding out insights or useful information from it is a big challenge as it requires high-quality tools for data analytics. Cloud computing provides the biggest facility to organizations in terms of storing and analyzing big data. • Hana

- Hadoop
- Apache. 22

7. Online Data Storage : Cloud computing allows storing data like files, images, audios, videos etc. on the cloud storage. The organization need not set physical storage systems to store a huge volume of business data which costs so high nowadays. As technology continues to advance, the generation of data is also increasing over time, and storing this data is becoming a challenge. In this situation, cloud storage offers a solution by providing the ability to store and access data as needed at any time.

- Box.com Allows its users to store different files such as Excel, Word, PDF, and images on the cloud. It provides drag & drop service for the files, and gets integrated with office 365, salesforce, and more than 1400 tools.
- Google G Suite Is one of the top cloud storage solutions, it offers cloud storage, various management tools, and Google services like Google Calendar, Docs, and Forms. One of the wellknown G Suite apps is email, which offers customers free email services

12.Explain various trends in cloud computing.

AI and ML powered cloud :-Artificial Intelligence and Machine Learning are two technologies that are closely related to cloud computing. AI and ML services are more cost-effective since large amounts of computational power and storage space are needed for data collection and algorithm training. They are a solution for managing massive volumes of data to improve tech company productivity.

Cloud Security and Resilience :-Organizations and companies face a new range of cyber security threats when they migrate to the cloud. Cloud migration offers many benefits, efficiencies, and conveniences but presents several security risks. Further, the increasing pile of legislation around data storage and use means that businesses are at risk of being fined or (even worse) losing the trust of their customers. Because of it, investing in cyber security and building resilience against everything from data loss to the impact of a pandemic on global business will become a priority increasingly during the coming year.

Edge Computing:- Edge Computing is one of the biggest trends in cloud computing. Here, data is stored, processed at the edge of the network, and analyzed geographically closer to its source. Faster processing and reduced latency can be achieved due to the increasing use of 5G. Edge computing has major benefits which include more privacy, faster data transmission, security, and increased efficiency.

Kubernetes: -The key trend is the increased adoption of container orchestration platforms like Kubernetes and Docker. This technology enables large-scale deployments that are highly scalable and efficient. It is an extensible, open-source platform that runs applications from a single source while centrally managing the services and workloads.

Multi and Hybrid Cloud Deployment: -The businesses now understand that data management involves combining a variety of appropriate cloud deployment strategies rather than relying solely on one cloud platform or architecture. A lot of businesses will want more than one vendor for hybrid or multicloud

deployment to get the most out of each solution. A hybrid cloud architecture offers a combination of public and private clouds dedicated to a specific company whose data is their key business driver, such as insurance, banks, etc.

Serverless Computing: - Serverless Computing came into the computing industry as a result of the emergence of the sharing economy. Here, compute resources are provided as a service rather than installed on physical servers. This means that the organization only pays for the resources they use rather than having to maintain its servers. In addition, serverless cloud solutions are becoming popular due to ease of use and ability to quickly build, deploy and scale cloud solutions. Overall, technology is an emerging trend that is growing in popularity over the years.

13.Explain any most leading platforms of cloud computing.

Amazon web services (AWS) : AWS or Amazon Web Services, a subsidiary of the American multinational Amazon, is one of the most well-integrated and widely adopted cloud platforms in the world. AWS offers comprehensive cloud IaaS (Infrastructure as a Service) services ranging from virtual compute, storage, and networking to complete computing stacks. AWS is mostly known for its compute and storage-on-demand services, namely Elastic Compute Cloud (EC2) and Simple Storage Service (S3).

Google Cloud Platform (GCP) : GCP is one of the most popular cloud platforms that integrates an array of advanced features and solutions. GCP is a suite of cloud computing services that runs on the same infrastructure that Google uses internally for its end-user products, such as Google Search, Gmail, Google Drive, and YouTube. Google lists over 100 products under the Google Cloud brand.

Microsoft Azure : Microsoft Azure is a cloud operating system and a platform for developing applications in the cloud. It provides a scalable runtime environment for Web applications and distributed applications. Azure facilitates the development, testing, deployment, and management of services and applications through data centers owned and managed by Microsoft. Microsoft Azure offers access, management, and development of applications and services through global data centers. It provides a range of capabilities, including software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS).

Hadoop :-Apache Hadoop is an open-source framework that is suited for processing large data sets on commodity hardware. It is a collection of open-source software utilities that facilitates using a network of many computers to solve problems involving massive amounts of data and computation. It provides

a software framework for distributed storage and processing of big data using the MapReduce programming model.

Force.com and Salesforce.com : Force.com is a Platform as a Service (PaaS) product designed to simplify the development and deployment of cloud-based apps. Developers can build application using the cloud IDE (integrated development environment) and deploy changes rapidly to Force.com's multi-tenant servers. The platform is the basis for SalesForce.com, a Software-as-aService solution for customer relationship management (CRM) in the cloud.

IBM Cloud : IBM Cloud is one of the most reliable full-stack cloud platforms, which features a robust cloud computing suite. The cutting-edge platform offers Infrastructure as a Service (IaaS), Platform as a service (PaaS), and Software as a Service (SaaS) to enterprises via the private, hybrid, and public cloud models. The industry-leading services of the IBM Cloud include VMware, Analytics, IoT, AI, Blockchain, Dev Tools, Cloud Packs, Database, Migration, Integration, Security, Management, Storage, Network, and Compute.

Oracle Cloud : One of the most trusted cloud platforms, the Oracle Corporation's Oracle Cloud, offers PaaS (Platform-as-a-Service), DaaS (Data-as-a-Service), SaaS (Software-as-a-Service), and IaaS (Infrastructure-as-a-Service). Oracle Cloud's Infrastructure-as-a-Service includes FastConnect, Ravello, DNS Monitoring, Load Balancing, Database, Networking, Storage, and Compute. The Platform-as-a-Service offerings incorporate Data Management, Business Analytics, Application Development, Cybersecurity, Content Management, and Integration.

Manjrasoft Aneka : Manjrasoft Aneka is a cloud application platform for rapid creation of scalable applications and their deployment on various types of clouds in a seamless and elastic manner. It supports a collection of programming abstractions for developing applications and a distributed runtime environment that can be deployed on heterogeneous hardware (clusters, networked desktop computers, and cloud resources). Developers can choose different abstractions to design their application: tasks, distributed threads, and mapreduce. These applications are then executed on the distributed service-oriented runtime environment, which can dynamically integrate additional resource on demand