IT & Systems

Advanced Topics in IT

Block

VI

ADVANCED TOPICS IN IT

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BLOCK VI: ADVANCED TOPICS IN IT

The sixth and last block deals with advanced topics in information technology. It deals with cloud computing, business intelligence, big data and analytics. It also covers current trends in software design and architecture in addition to mobile and social technologies. IT and business process management are discussed in the block.

The first unit, *Cloud Computing,* starts with distributed systems and covers cloud features and functionality. Cloud architecture and cloud service models such as Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS) and Anything-as-a-Service (XaaS) are discussed. Cloud business models and pricing models are explained. Examples of commercial clouds in the industry such as Amazon and Microsoft Azure are discussed. The features of grid computing are mentioned.

The second unit, *Business Intelligence and Big Data,* starts with the need for business intelligence. It distinguishes data, information and knowledge. Data warehouse, business intelligence components, business intelligence architecture, business intelligence methodologies and data mining techniques are described. Market intelligence and decision making are explained. Some of the commercially available business intelligence tools and their features are discussed. Big data, Hadoop and business analytics are explained.

The third unit, *Current Trends in Software Design and Architecture,* starts with software design approaches. Object Oriented Analysis and Design (OOAD), component based design and application architectural approaches are discussed. N-Tier architecture, web based architecture and service oriented architecture (SOA) are explained. Web services and agent based architectures are specified. How to do product line architecture is also discussed.

The fourth unit, *Mobile and Social Technologies,* deals with mobile technologies, different generations of mobile technologies, mobile operating systems and advantages of mobile technologies. Risk factors in mobile technologies, future of mobile technologies and handheld devices are discussed. Benefits of social technologies, components, characteristics, challenges and application areas of social technologies are explained. Social networking websites such as Facebook, Twitter and LinkedIn are mentioned.

The fifth unit, *IT and Business Process Management,* deals with process definition, process design and business process reengineering. IT and business process management, MIS and business process reengineering are explained. Communications enabled business processes and commercially available business process management tools are mentioned.

Unit 20

Cloud Computing

Structure

20.1 Introduction

In the previous unit, we discussed CRM, Functions of CRM, E-CRM Architecture, E-CRM Infrastructure Requirements, CRM for E-Customers and Challenges in Implementing E- CRM Projects.

Start-up organizations cannot afford the straight down- payments for resources such as hardware, servers, networks and storage. Now there is a simple solution for this problem. That is cloud computing and cloud services. Using cloud services organizations can pay as per usage of the resources. They do not even have to pay for the resources they acquire in cloud. They have to pay for their usage only. They don't have to pay for the ideal resources. Scaling the applications, ramping up the teams, acquiring infrastructure, platforms, software applications is easy and cost effective for the organizations using cloud computing. This avoids huge investments for the organizations. Organizations can go just in time for the resources, based on need based and based. Just as one pays for electricity, water, and gas as he or she moves into new apartment, organizations can

subscribe to cloud providers and acquire infrastructure, platforms and software applications by sitting from anywhere and connecting to Internet.

The advantages of clouds include reduced cost of software development, reduced time to market, increased productivity because of componentization and reuse, access from anywhere, availability, and portability between different cloud vendors. Virtualization, storage, backup and recovery and cloud management services are provided by the cloud providers. Organizations such as Amazon, Microsoft, IBM, HP, Apple, Oracle and Google are competing with each other in cloud space. Amazon as infrastructure-as-a-service and Microsoft Azure as platform-as-a-service are currently very popular in the market. Cloud computing is changing business models, product development models, product deployment models all together. Now the non-cloud based products are to be deployed or migrated on to the clouds for effective business purposes.

In the unit, the early distributed systems, cloud features and functionality, cloud architecture, cloud deployment models such as public cloud, private cloud, community cloud and hybrid cloud are discussed. Cloud service models such as Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Business process-as-a-Service (BaaS) and Anything-as-a-Service (XaaS) are discussed. Cloud business models, grid computing and Amazon cloud services are discussed in the unit.

20.2 Learning Objectives

The objectives of the unit include:

- Discuss the features of early distributed systems

- Explain cloud computing features and functionality.

- Describe cloud architectures and deployment models such as public cloud, private cloud, outsourced private cloud, community cloud and hybrid cloud.

- Discuss the cloud service models such as Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Business process-as-a-Service (BaaS) and Anything-as-a-Service (XaaS)

- Discuss cloud business models such as pay-per-use and subscription model

- Distinguish between grid computing and cloud computing.

- Discuss the commercial and technical aspects of Amazon Elastic Compute Cloud (Amazon EC2)

- Discuss the best practices in cloud computing and some of the examples.

20.3 Distributed Systems

The origins of highly proficient computer networks known as *distributed systems* dates back to the 1970s . The availability of networking technology coupled with computing power created the distributed systems. Distributed systems were used to solve complex problems in areas such as banking and financial services, telecommunications, remote sensing, geographical information systems and scientific computing. *Distributed system is a system of decentralized computing connecting different computing nodes with powerful network* (Figure 20.1). It reduces the costs of communication and saves lot of processing time and money. The processing of tasks is distributed among different machines in distributed system. Parallelism in executing tasks can also be achieved using distributed systems.

Figure 20.1: Distributed Systems Architecture
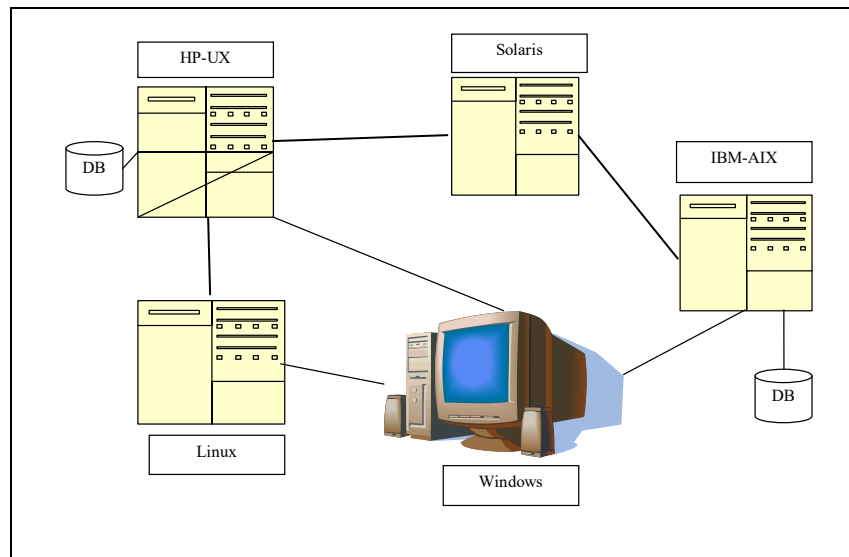
The characteristics of distributed systems include:

- Distributed system consists of collection of autonomous computers, connected with networking and having a middleware to host the business applications.

- Applications running on different machines communicate with each other. These applications might have been developed using different

programming languages on different operating systems. Middleware acts as a bridge between applications on different platforms, operating systems and programming languages.

- Applications in distributed systems cooperate with each other using standard communications protocols such as TCP/IP (Transmission Control Protocol/Internet Protocol), RPC (Remote Procedure Call), IIOP (Internet-Inter ORB Protocol), GIOP (General Inter-ORB Protocol), SNMP (Simple Network Management Protocol), CMIP (Common Management Information Protocol), etc.

- The existence of multiple computers in the distributed system is transparent to the user.

- The applications in distributed systems should be *interoperable, separable, portable*, and *reliable*.

- Different processes in distributed systems communicate with each other through message passing. There are fixed formats for messages to be communicated.

- The other characteristics of distributed systems include:
  - *Fault-tolerance*
  - *Scalability*
  - *Openness*
  - *Transparency*
  - *Security*
  - *Predictability*

- Distributed systems should support transparency characteristics such as access transparency, location transparency, performance transparency, scalability transparency, concurrency transparency, replication transparency, migration transparency and failure transparency.

Middleware standards such as CORBA (Common Object Request Broker Architecture) and DCOM (Distributed Component Object Model) provide services such as naming, transaction, persistence, authentication, event, concurrency and security services to the objects and applications in the distributed systems. CORBA is a standard given by Object Management Group (OMG), USA and DCOM is from Microsoft. An example of a distributed system is shown in Figure 20.1. The applications on different hardware and operating systems such as IBM-AIX, HP-UX, Solaris, Linux and Microsoft Windows communicate with each other and share the tasks to be executed. The data also can be stored at different locations. However this is transparent to the user.

Distributed systems can use the network topologies such as star, tree, ring and bus topology. The problem with star network is if the central processor goes down entire network goes down. The network topologies are as shown in Figure 20.2.

Figure 20.2: Network Topologies
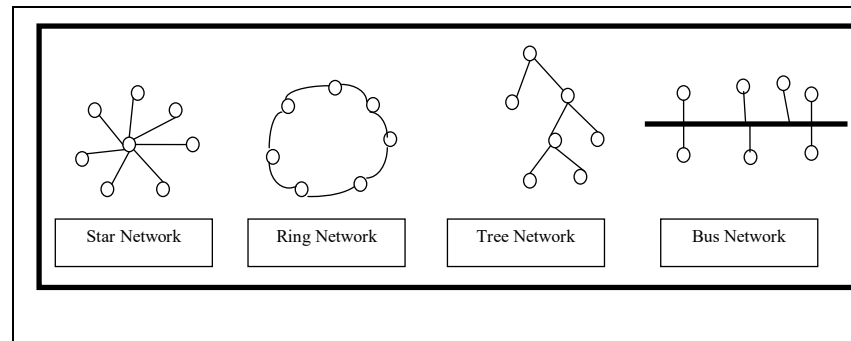
The myths about distributed systems include:

• Bandwidth is infinite in distributed systems.

• Network is reliable always.

• Transport cost in distributed systems is zero.

• Network is homogenous always.

• Network administrator will do everything.

• Network is always secure.

By keeping the above myths in mind, the distributed systems design and development has to happen by fulfilling the needed requirements for the security and reliability of the system. The different applications in distributed system work in client-server model. Example: WWW (World Wide Web) is a huge distributed system connecting millions of computers and devices over the Internet. When an individual is accessing the Internet using his machine, his machine works as a client and there is server machine over the Internet sending the needed content and web pages. The advantages with distributed systems include reduced processing times, shorter response times, decentralized control, high availability, reliability, and high throughput.

Activity: Distributed System for a Multinational Financial Institution

A multinational financial institution has branches in New York, London, Tokyo and Hong Kong. It has stand alone trading systems specific to that country. With globalization and global economy, they are getting requests from customers for the availability of foreign trading systems in their countries. The financial institution decided to achieve

Contd. ......

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interoperability between different trading systems operating in the mentioned locations. Their IT project manager is given this task. How can the IT project manager go about it? What technologies does he need to use to achieve it?

Answer:

Check Your Progress-1

1. Which of the following is/are true?
    i. Distributed system connects different machines having different operating systems.
    ii. Distributed systems require middleware for developing business applications.
    iii. CORBA is a standard for distributed systems development.
    iv. Distributed systems can work without any networking or any connections to each other.
    a. i, ii, and iii
    b. i and iv
    c. i and iii
    d. ii and iv
    e. None of the above
2. _____ is not a network topology.
    a. Star
    b. Bus
    c. Rail
    d. Ring
    e. None of the above
3. RPC stands for _____.
    a. Repair Call
    b. Remote Procedure Call
    c. Remote Person Call
    d. All of the above
    e. None of the above

4. Distributed systems are _____.
    a. Interoperable
    b. Portable
    c. Reliable
    d. All of the above
    e. None of the above

5. _____ is not a characteristic of distributed system.
    a. Fault-tolerance
    b. Scalability
    c. Openness
    d. Transparency
    e. None of the above

20.4 Cloud Features and Functionality

Cloud computing is derived from areas such as distributed computing, Web 2.0, service oriented architecture (SOA), high performance computing, grid computing, utility computing, virtualization and Internet. Cloud computing has its own technical, user experience and economic characteristics. Using cloud computing, organizations can have large scale distributed computing infrastructure without owning it.

Cloud is a logical network of computers, devices, storage and networks with virtualization, backup and recovery facilities providing infrastructure, platforms and software to consumers for development purposes on utility or demand basis.

The *characteristics of cloud computing* include high scalability, security, low cost, availability, reliability, device independence, multi-tenacity, elasticity, location independence, strong fault-tolerance and sustainability. Other characteristics of cloud computing include dynamic acquisition of infrastructure, consumption based billing, self managed platform and self service based usage model.

Features and functionality of clouds include:

- Cloud computing is based on TCP/IP networking; which includes massive processors, huge memory and high speed networks.
- Cloud computing comprises data centers and uses standard protocols for communication between different vendor clouds.
- Clouds are easy to access.
- Cloud is a loosely coupled network. Even if one system fails, other part of the cloud can function.
- Provides user friendly virtualization facilities
- Variety of resources are available over Internet in Clouds

- Pay per use facilities rather than owning the resources are possible in cloud computing.
- Resource optimization can be achieved using cloud computing.
- Different SLAs (Service Level Agreements) are possible between cloud consumers, cloud providers and other cloud stakeholders.
- An application on cloud can be independent, scalable, economical, and flexible.
- In cloud computing, infrastructure is separated from software or business logic while developing applications.
- Cloud computing also works as client-server model.
- Return on investment can be achieved quickly.
- In cloud computing, unused resources are released as per the non-usage or ideal time.
- Cloud middleware software provides services such as resource accounting, monitoring, management, discovery, virtualization, security, reliability, replication and mapping.
- Cloud computing allows management of hardware and software by third party instead of organization developing the actual software applications or the software product.

Example: Clouds commercially available in the market include Amazon Elastic Compute Cloud (EC2), Microsoft Azure, Google Apps Engine and Salesforce CRM.

20.5 Cloud Architectures

National Institute of Standards and Technology (NIST), US has given a reference architecture for cloud computing comprising the stakeholders in cloud computing such as *cloud consumers, cloud providers, cloud brokers, cloud auditors* and *cloud carriers*.

Cloud consumers are the one who subscribe to cloud services from cloud providers.

Cloud providers provide cloud computing infrastructure, platforms and software to the cloud consumers. They can charge fee from the consumers based on the usage, CPU time and memory used.

Cloud brokers aggregate the services from different cloud providers and provide services to cloud consumers. The consumers do not have to go to different providers for different purposes.

Cloud auditors audit the cloud services at both provider and consumer sites with respect to speed, analytics, traffic, bandwidth, quality, reliability, availability and information security.

Cloud carriers are like transmission houses in electric power supply. They enhance or value-add or just transmit the services to cloud consumers.

These are the main stakeholders in cloud computing industry. They can be individuals or organizations. *Cloud Deployment models* include *public cloud, private cloud, community cloud* and *hybrid cloud*.

20.5.1 Public Cloud

Public cloud is accessible by anybody who has subscribed to that cloud of the cloud provider. Public clouds provide cloud infrastructure and computing resources over the Internet. Generally public clouds are accessible over the Internet. One can connect to public cloud using login/password mechanism or some other authentication mechanism. Public cloud is owned and operated by the cloud provider. Public cloud owner serves different types of customers at any point in time. The public cloud architecture is as shown in Figure 20.3. Examples of public clouds include social networking sites, online photo storage services and Internet email services. Amazon EC2 is also a public cloud.

For some of the organizations, security is a concern in public clouds because public cloud providers cater to many different customers. If the other customers of the cloud provider include this organization's competitors, any leakage in protected data or customer data can create disasters for the organization. Thus, having a data center in public cloud has to be done very judiciously for the organizations.

Figure 20.3: Public Cloud Architecture
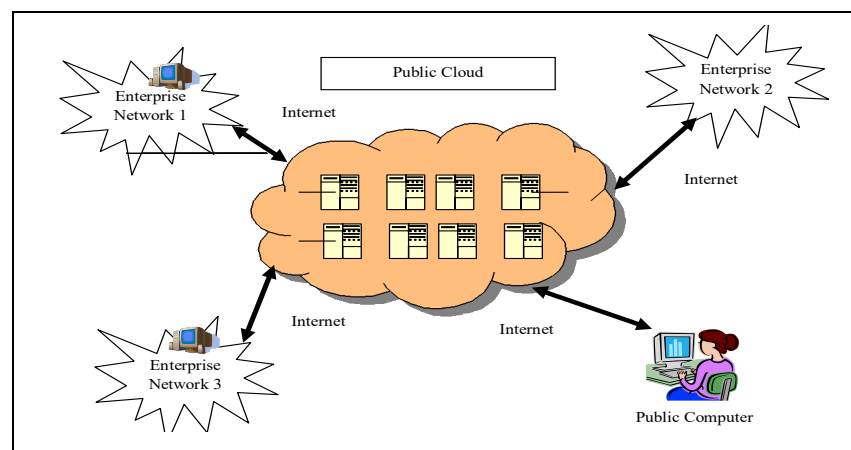
20.5.2 Private Cloud

The ownership of the private cloud is specific to the organization. All the users or consumers of the private cloud are from that organization itself. Outsiders will not have access to private clouds. It is operated and maintained by the cloud owner itself. Otherwise the organizations can outsource the management of the cloud to a third party. The private cloud architecture is shown in Figure 20.4. It is an example of on-site private cloud. Private cloud can also be part of organizational enterprise network. Some organizations take/lease the private cloud space in a public cloud. That is, they outsource the need of private cloud to the public cloud provider and they take a part of public cloud as private cloud with needed authentication. This scenario is shown in Figure 20.5.

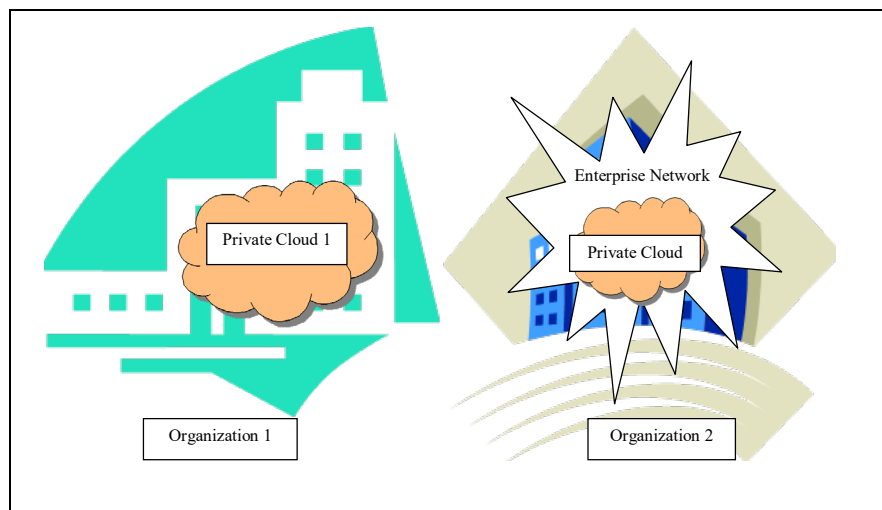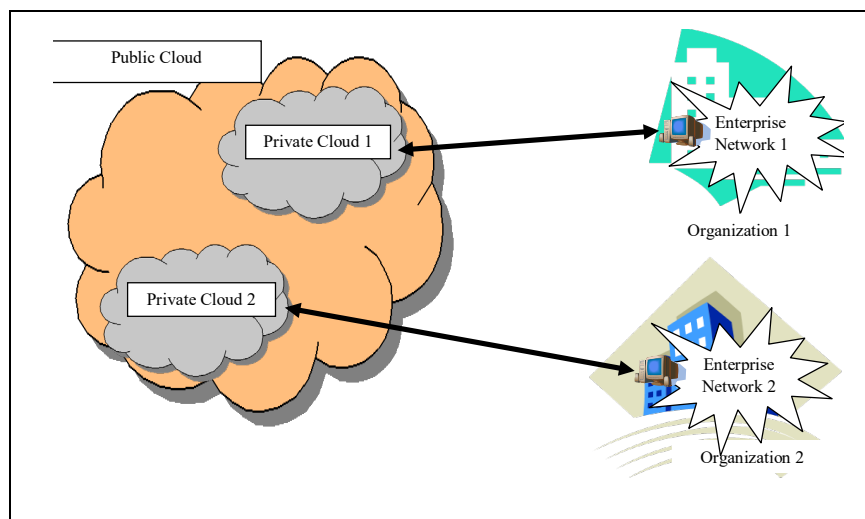**Figure 20.4: Private Cloud Architecture**

Figure 20.5: Outsourced Private Cloud Architecture

20.5.3 Community Cloud

The community clouds are formed based on the common purpose of a group of organizations. Only the members of this group have the access to community cloud and outsiders do not have access to the cloud. The community cloud is owned and operated by that specific group of organizations only. The group may have common interests in mission objectives, data privacy, security and compliance policies. Figure 20.6 consists of an example of *community cloud* which connects Organization 1, Organization 2, Organization 3 and Organization 4. The cloud users can access the resources from local cloud in their organization and also the resources from the other organizations using community cloud. Operating and maintaining the community cloud can also be outsourced to third party organization.

Figure 20.6: Community Cloud Architecture
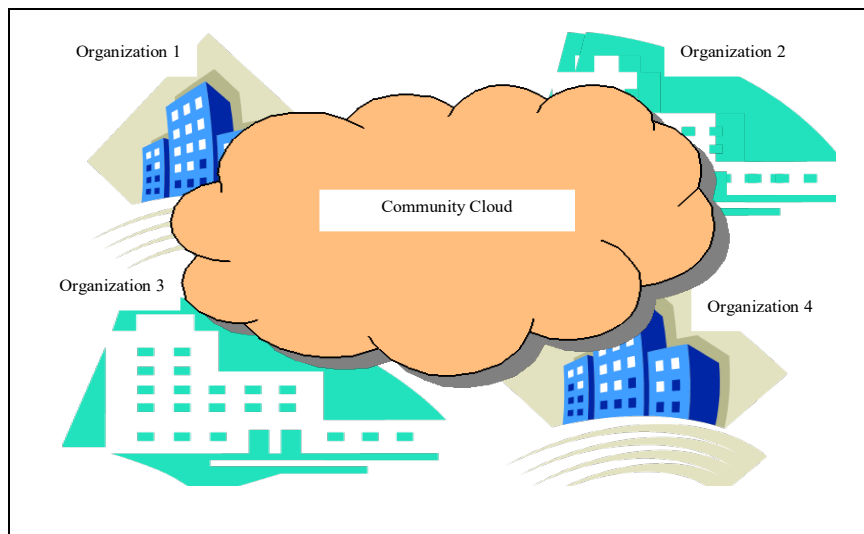
20.5.4 Hybrid Cloud

Hybrid clouds are formed with any combination of private, public and community clouds. It uses combination of different methods of resource pooling. In Figure 20.7, a hybrid cloud is formed with the combination of private cloud of Organization 2, Community cloud of Organization 1 and Organization 2, and the Public cloud. These three clouds are interconnected and form a hybrid cloud. Hybrid cloud combines the different deployment forms of cloud.

Figure 20.7: Hybrid Cloud Architecture
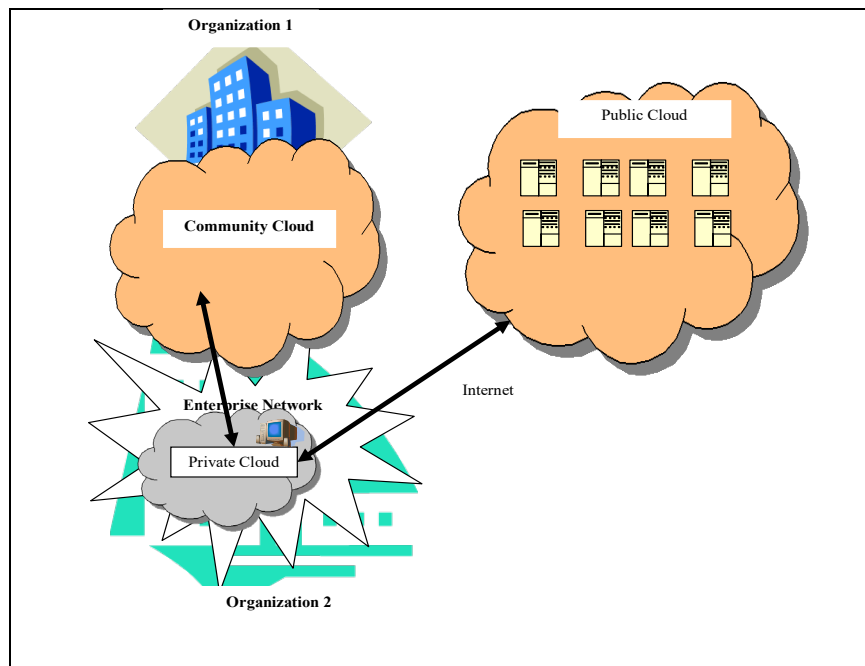
Check Your Progress-2

6. _____ is not a cloud characteristic.
   a. Scalability
   b. Low cost
   c. Availability
   d. Reliability
   e. None of the above

7. _____ is not a stakeholder in cloud computing.
   a. Cloud Provider
   b. Cloud Consumer
   c. Cloud Intruder
   d. Cloud Broker
   e. Cloud Auditor

8. _____ is/are the possible cloud deployment models.
   a. Public Cloud
   b. Private Cloud
   c. Hybrid Cloud
   d. All of the above
   e. None of the above

9. Public clouds can be accessed over Internet.
   [TRUE/FALSE]

10. Community cloud is meant for _____.

    a. Single company

    b. Group of organizations

    c. General Public

    d. All of the above

    e. None of the above

Activity: Cloud Deployment Model for an Indian Bank

An established Indian bank Managing Director read somewhere that cloud computing reduces software application development costs, application distribution times, processing time and turnaround times to customers. He also read that there is a risk for customer financial details using public clouds. However he would like to achieve the operational benefits, reduce the costs and save time for the bank using cloud computing solution. Suggest a cloud computing solution to the Managing Director of this bank. How can he implement cloud computing solution in this bank?

Answer:

20.6 Cloud Service Models

Clouds reduce the complexity of owning the resources and cost of acquiring the resources. Cloud computing frees the software organizations from thinking about resources, hardware, software licenses and they can concentrate on programming, innovation and their core competencies in product development. *Cloud service models* include Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Business process-as-a-Service (BaaS) and Anything-as-a-Service (XaaS) (Figure 20.8).

Figure 20.8: Cloud Service Offerings

Business Process As-a-Service (BaaS)

Workflow Management | Procurement

Software-as-a-Service (SaaS)

Invoicing System | Billing | ERP | CRM | E-mail

Platform-as-a-Service (PaaS)

Programming Languages | Business Platform | Financials

Virtualization | Databases | Development Platform

Operating Systems

Sales

Infrastructure-as-a-Service (IaaS) | Backup & Recovery | Runtime Environ.

CPUs | Storage | Network Communications | CMS

In the Figure 20.8, ERP stands for Enterprise Resource Planning; CRM stands for Customer Relationship Management; CMS stands for Content Management Systems; CPU stands for Central Processing Unit.

20.6.1 Infrastructure-as-a-Service (IaaS)

In this model, cloud consumers can acquire and use hardware resources, storage and network bandwidth over the cloud. The billing will be based on CPU cycles and used storage space. In this model, the consumer gets the hardware resource or processor as a service and he needs to deploy this development platform and applications on to the cloud for his product development purposes. The *infrastructure* services provided by the cloud providers include computing resources, hardware, storage, backup and recovery, platform hosting and services management. IaaS is also known as *Hardware-as-a-Service (HaaS)*.

- Example: Amazon Elastic Compute Cloud (EC2), Compute Engine, Linode., Azure Virtual Machines, DigitalOcean., Virtual Machine Manager., Alibaba Elastic Compute ,Service and Hostwinds are IaaS providers in 2021.

20.6.2 Platform-as-a-Service (PaaS)

In this model, the consumer gets the hardware resource and development platform as a service from the cloud provider. The consumer further has to develop his or her own applications on the chosen platform in the cloud. The *platform* services provided by the cloud providers include databases, business intelligence, development platforms, testing tools, application deployment tools, and integration tools. Example: Microsoft Azure Platform and Google Apps Engine are PaaS providers.

Platforms are of two types. They are *development platform* and *business platform*. *Development platforms* allow developers to upload their code, write their code, compile, assemble and execute their programs. They need not worry about the infrastructure, platform and scalability. Example: Morph Lab and Google App engine. *Business platforms* allow development, deployment and management of tailored or customized business applications on the cloud. Example:. Amazon Web Services (AWS) Elastic Beanstalk, Oracle Cloud Platform (OCP), IBM Cloud Platform, SAP Cloud Platform, Google App Engine, Microsoft Azure, Salesforce aPaaS, Red Hat OpenShift PaaS, Mendix aPaaS, Engine Yard are top 10 PaaS

20.6.3 Software-as-a-Service (SaaS)

In this model, the cloud consumer straight away gets the software applications from the cloud provider from their portfolio of applications. The cloud consumer need not develop any applications. He can straight away start using the applications provided in the cloud. Generally, the *software applications* which are provided over the cloud by cloud providers include ERP, CRM, billing applications, sales applications, email, office automation applications, financial applications, document management, content management, social networking applications and human resources applications . It is targeted at replacing the traditional PC based software applications. Now using cloud SaaS services the desktop PC need not have software applications, they can be accessed from cloud.

Cloud offers multitude of services *like* Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Business process-as-a-Service (BaaS) and Anything-as-a-Service (XaaS). Exhibit 20.1 presents a startup getting benefited by SaaS on cloud

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Exhibit 20.1: SaaS startup with AI engine benefitting Marketing ROI

The **Bengaluru** and **US**-based startup Factors.AI, integrates the customer journey across ad platforms, website, MAP (marketing automation platform), and CRM (customer relationship management) at a contact and account level. Factors.AI, mines customer data for insights through its proprietary AI engine to help marketing teams with resulting in better campaign decisions and amplified ROI for marketing teams. The proprietary AI engine mines the customer data and recommends actions for the marketing team to drive higher conversions, faster, and at higher ACV (annual contract value). In addition, it has a self-serve analytics

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interface along with pre-defined checklists, which gives instant insights or all - removing dependencies on data experts. The AI engine can automatically analyse customer journeys at the user and account level, identifying anomalies and root causes for any outcome or KPI.

Source: https://yourstory.com/2021/09/kunal-shah-cashback-rewards-startup-happy-credit-ecommerce/amp?utm_pageloadtype=scroll, Sept 2021

Example: Apple's App store, Amazon's Kindle book store, Google Docs and SalesForce CRM.

20.6.4 Business Process-as-a-Service (BaaS)

In this model, the *business processes* such as procurement, business travel management, employee benefits management and industry specific processes are provided by the cloud providers to the consumers. These are on top of software applications.

20.6.5 Anything-as-a-Service (XaaS)

In this model, the providers provide infrastructure, platform, software applications, business applications or any other service to the users over the Internet. Anything as a service includes everything as a service over the Internet. XaaS also includes providing services such as communications, storage, networking and monitoring as a service.

Activity: Cloud Service Model for a Start-up Software Company

A startup software company is into office automation products ,developing products and selling to domestic customers. The company currently has 25 developers. They would like to scale it to 200 by the end of the year. The company does not have enough funds for down payment for hardware and platforms. The known platforms are very expensive. However they would like to scale quickly at low costs. They want to reduce cycle time and market times. The developers also would like to work from anywhere using Internet. Suggest the kind of cloud service models suitable for this organization. Also suggest some of the cloud service providers in this area.

Answer:

| |
| |
| |
| |
| |

20.7 Cloud Business Models

Following are some of the business models operating in cloud computing area:

- *Pay-per-use business model* is the popular business model in cloud computing area. As in utility services such as electricity, water and gas, the consumers can pay as per their usage of the CPU time, number of processors, memory consumed, storage taken (Giga Bytes), bandwidth taken, number of users and time spent on the cloud. It is also known as *utility based pricing model.*

- *Subscription based pricing model* is followed by some of the cloud providers. In this model, the user is charged per month fixed subscription charges.

- *Leasing IT facilities* online is another approach of companies such as IBM, HP, Dell and EMC.

- *Broker-based models* reduce the costs to both the cloud providers and the cloud consumers. The consumer does not have to pay different rates to different cloud providers. He can pay flat rates to cloud brokers.

- *Free models*: Some providers whose clouds are in beta testing stage are even providing access to their clouds freely to attract the customer base and to stabilize their technology by gaining user experience. For example, the free cloud services on the Internet include Google Search, Facebook social networking and Hotmail email services.

- *Dynamic pricing models* are based on *auctions* and *negotiations*. Prices are decided dynamically based on the usage patterns.

- The traditional hardware and software based business models evolve into IaaS, PaaS, SaaS and BaaS business model.

Check Your Progress-3

11. PaaS stands for _____.

    a. Personal Service
    b. Platform-as-a-Service
    c. Passport Service
    d. All of the above
    e. None of the above

12. _____ is not a cloud service model.

    a. IaaS

    b. PaaS

    c. SaaS

    d. All of the above

    e. None of the above

13. _____ is an example of infrastructure-as-a-service provider.

    a. Amazon Elastic Compute Cloud

    b. Microsoft

    c. Salesforce CRM

    d. All of the above

    e. None of the above

14. Salesforce CRM is an example _____.

    a. IaaS

    b. PaaS

    c. SaaS

    d. All of the above

    e. None of the above

15. Pay-per-use business model is different from subscription based model.   [TRUE/FALSE]

With large knowledge force in IT, India is also taking advantage of the cloud environment. Exhibit 20.2 identifies the cloud adoption in India at the end of 2020

Exhibit 20.2: Cloud Computing Adoption in India
Cloud computing usage is gaining momentum in India mainly because of service models and pricing plans, and proven best practices such as cloud security followed by cloud service providers and support from the Government. CIOs in India are planning to adopt cloud computing on top priority.
As per Gartner Study (Nov 2020)[1], spending on cloud computing in India is forecast to total $4.1 billion in 2021, an increase of 29.4% from
Contd. .....

2020. Indian businesses are willing to spend over 8% of their IT costs on public cloud services due to its business flexibility and low costs. In 2021, cloud system infrastructure services (IaaS) will experience the largest growth at 44.6%, although spending on the cloud application services (SaaS) segment which is forecast to be the largest segment in the public cloud services market in India. Gartner predicts that growth in cloud computing adoption is constant at compound annual growth rate (CAGR) of 33.2% globally.

The cloud services market has nearly tripled since 2016. India's cloud services (PCS) market, including infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS) solutions, and software-as-a-service (SaaS), touched $1.6 billion for the first half of 2020. According to the International Data Corporation (IDC) report [Dec 2020][2], the overall India's cloud services market is likely to touch $7.4 billion by 2024 growing at a CAGR of 22.2% for 2020-24.

However there is a slow pace of cloud adoption in sectors like finance and banking, advertising, health care, etc., and it can be attributed to certain barriers such as inadequate knowledge of cloud technologies, last mile connectivity issues and lack of customer awareness on benefits offered by cloud adoption in terms of ROI. There is a growing acceptance of cloud based solutions, embracing merging technologies like Internet of things (IoT), big data, mobile technologies (3G, 4G) by the organizations and is fuelled by Indian government's initiatives for a digital India.

The studies and data indicate that cloud adoption is fast catching up in India and transforming IT services to provide a new direction. NASSCOM's Perspective 2020[3] report is highly optimistic about India's progress in cloud computing, mobility, broadband and internet connectivity over the next two years and beyond. Organizations need to unlock and capture both the IT and the business value potential to make a compelling business case for cloud adoption.

Source: https://icfaibytes.in/2021/05/28/cloud-computing-adoption-in-india/- May 2021

20.8 Commercial Clouds in the Industry

There are many cloud services commercially available in the market. Among them the prominent ones are Amazon Elastic Compute Cloud (EC2), Microsoft Azure, Yahoo Hadoop and Eucalyptus. Ramco Systems has ERP on cloud. Indian organizations such as TCS (iON), Tata Communications, CtrlS, Oranges cape, Ramco, NetMagic, PK4 Software and Synage are in cloud computing business.

The top commercial cloud service provider's in2021 are: Amazon Web Services., Microsoft Azure. Google Cloud Platform. Alibaba Cloud. Salesforce. IBM, Digital Ocean, Dell, Adobe, Dropbox.

Amazon Elastic Compute Cloud (Amazon EC2) is a popular and robust infrastructure-as-a-service provider. The users can create an operating system instance called Amazon Machine Image using the web service provided by Amazon EC2 in the cloud. Amazon EC2 supports multiple virtual machine instances. Each virtual machine instance comes with certain processing capabilities and storage capacity. Amazon EC2 supports pay-per-use business model. It can provide virtual machine instances at different geographical locations. It can provide latency optimization, reliability and replication services.

Microsoft Azure provides platform-as-a-service and remote access to clusters. It provides high performance computing, which supports parallel execution of user applications. Azure platform services are used in financial services and scientific applications. Its pricing model is based on amount of data transferred, usage of storage and the number of transactions that took place.

Cloud application areas in science include molecular simulations, earth quake modeling, nanoscience, bioinformatics, weather modeling, remote sensing, image processing, signal processing, security and surveillance. Cloud application areas in government include managing health records, traffic control, urban planning, land documents management, education and agricultural information. Other cloud application areas include e-governance, e-learning, e-commerce, e-banking, e-health, e-environment and e-education. In India, C-DAC is also involved in cloud and grid computing. IIT Delhi, IIT Mumbai and IISc Bangalore have the cloud computing facilities for research purposes.

20.9 Grid Computing

Grid computing is derived from the word *power grid* of electrical engineering. It is because of the characteristics of grids such as simplicity, reliability and pervasiveness. *Grid computing connects geographically distributed high performing clusters, data sources and data storage facilities from different organizations.* Grid implementations include SUN "NI" Grid, IBM's grid solution known as "grid and grow" and Oracle grid, which offers features such as adding dynamic capacity to the computing power.

Characteristics of grid computing include decentralized resource control, reliability, throughput, latency, and standardization through standard protocols and interfaces. Grids work for specific projects and do not allow

flexibility or changes in computations. Grids require middleware over the standard protocols for communication between different computing resources and devices. Example middleware in grid environment include Globus Toolkit 4, gLite and Unicore. One of the standards followed in grid architecture is OGSA (Open Grid Services Architecture).

Table 20.1 defines grid computing and describes the differences between grid computing and cloud computing.

Table 20.1: Differences between Grid Computing and Cloud Computing

Grid Computing	Cloud Computing
Involves sharing of distributed] and heterogeneous computing resources specific to user requirements. It is used where geographically distributed collaborative work is required.	It is a general purpose network of computing resources, storage, networks with virtualization facilities accessible over the Internet.
Widely used in scientific and research community.	Widely used in industry and commercial purposes.
Used in e-commerce and e-science.	Widely used in e-commerce and e-learning
Loose coupling, security, virtualization and fault-tolerance are partially achieved in grid computing.	Loose coupling, virtualization, fault-tolerance, service orientation and ease of use are completely achieved in cloud computing. Information Security is still a concern and emerging area in cloud computing discipline.
Grid computing is based on high performance computing (HPC) and uses service-oriented architecture (SOA).	Cloud computing uses HPC, utility computing, and autonomous computing and achieves parallelism.
Data centers are not widely used in grid computing because of its concentration on scientific computing.	Data centers are widely used in cloud computing because of its concentration on commercial business purposes.
It is supported by governments, academia and research organizations.	It is supported by the industry and big multinational corporations. *Contd. .....*

Grid Computing	Cloud Computing
Users are to be skilled enough to use grid computing. It is relatively hard to use.	User experience is better in cloud computing than in grid computing. It is easy to use.
Uses TCP/IP protocol.	Uses HTTP (Hyper Text Transfer Protocol) and TCP/IP protocols.
It supports batch processing.	It supports interactive systems.
It depends on grid middleware.	It depends on standard web based protocols.
Its business model is based on *sharing*.	Its business model is based on utility based pricing.
It supports decentralized data centers.	It supports centralized data center.
Switching costs from one grid to other grid is less because of standardization.	Switching costs from one cloud to other cloud is more because of incompatibilities.

Activity: Grid Computing for Weather Forecasting
Indian meteorological department would like to provide latest and fastest weather details to the public. They have many locations across coastal regions of the country. They would like to use high performance computing, decentralized data centers, and standard protocols. Also they do not want to give access of their systems to general public. The solution they are looking for should support scientific computing and should provide reliable results. Suggest a solution for this project. Among cloud computing and grid computing, which one would you suggest to them? Justify your answer.
Answer:

The application development is different in both grid and cloud. In grids, an executable is prepared on local machine and then transferred to a remote machine in the grid. Entirely different approach is followed for application development in cloud. In clouds, the user can integrate the existing

functionality on the cloud available as SaaS services and achieve the required new functionality.

Check Your Progress-3

16. _____ is an example of ERP on cloud.

    a. Microsoft Azure

    b. Ramco Systems ERP

    c. Amazon Web Services

    d. All of the above

    e. None of the above

17. _____ is/are commercially available clouds in the market.

    a. Amazon Elastic Compute cloud

    b. Microsoft Azure

    c. TCS iON

    d. All of the above

    e. None of the above

18. Grid computing has _____.

    a. Centralized data center

    b. Decentralized data centers

    c. No data center at all

    d. All of the above

    e. None of the above

19. HPC stands for _____.

    a. High Pressure

    b. Higher Printed Circuits

    c. High Performance Computing

    d. All of the above

    e. None of the above

20. OGSA stands for _____.

    a. Open Grid Services Architecture

    b. Open Gate Services

    c. Omega Systems Architecture

    d. All of the above

    e. None of the above

20.10   Summary

- Cloud computing can be used in universities, educational institutions, e-governance, agriculture, start-ups businesses, meteorology, business organizations, financial institutions and entertainment.

- Business organizations need not worry about IT infrastructure and development environments. They can concentrate on their core competencies in areas such as business requirements development, application development, project management, product management and product development.

- The huge investments required for infrastructure can be avoided using cloud computing. The emerging concerns include information security, bandwidth, availability and accessibility of Internet to access the clouds.

- The cloud deployment models such as public cloud, private cloud, community cloud and hybrid cloud with diagrams are explained. Cloud service models such as Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Business process-as-a-Service (BaaS) and Anything-as-a-Service (XaaS) are discussed.

- Cloud business models, pricing models, commercially available clouds and their features, and differences between grid computing and cloud computing are discussed.

- Examples of the commercially available grid and cloud computing solutions are also mentioned in the unit.

20.11   Glossary

- **Cluster:** It is a collection of loosely coupled or tightly coupled network of computers which appears as a single system.

- **CMIP:** It stands for common management information protocol. It is a protocol used for the communication between different applications in the distributed systems. It is widely used in telecommunications industry.

- **CORBA:** It stands for Common Object Request Broker Architecture. It is a reference architecture given by OMG (Object Management Group) for the development of distributed applications. It consists of object request broker, application objects, common facilities and object services.

- **GIOP:** It stands for general inter-ORB protocol. It is a protocol used for communication between different applications running on different ORBs.

- **IIOP:** It stands for internet-inter ORB protocol. It is based on TCP/IP. This protocol is used for communication between different processes running on different ORBs from different vendors.

- **RPC:** It stands for remote procedure call. It is a TCP/IP based protocol used for communication between different applications in distributed systems. It is the early protocol used in distributed systems development.

- **SOA:** It stands for Service Oriented Architecture. It is designing software systems using services based approach. One application provides services to another. SOA can be implemented using web services.

- **SNMP:** It is simple network management protocol. It is a protocol used for the development of network management software. It is on top of connectionless UDP (User Datagram Protocol).

- **TCP/IP:** It is transmission control protocol/internet protocol. It is connection oriented protocol used in network communications. Entire Internet communication is based on this protocol only. It is a transport layer protocol in OSI (Open Systems Interconnection) framework. There are many protocols developed on top of it.

- **Virtualization:** Using virtualization, consumers can have feel of the actual resources, capabilities and usage in a shared environment. That is, using virtualization software such as VMWare, the consumers can have multiple operating systems such as Windows, Unix and Linux on the same machine/CPU.

20.12 Self-Assessment Test

1. Define distributed system. What are the important characteristics of a distributed system?

2. What are the features and functionality of a cloud? How it is different from earlier days distributed system?

3. Explain about community cloud. What are the advantages of having community cloud instead of having just a private cloud?

4. What kinds of applications are provided by cloud providers under SaaS (Software-as-a-Service) model?

5. How pay-per-use business model is different from subscription based business model?

6. Define grid computing. Distinguish between grid computing and cloud computing.

20.13   Suggested Readings/Reference Material

1. Introduction to Information Technology, V. Rajaraman, PHI learning, 2018

2. Information Technology for Management, 2ed: Advancing Sustainable, Profitable Business Growth, Turban, Volonino, Wood, O.P. Wali, Wiley India Pvt Limited, January 2021

3. Introduction to Information Systems - 6th edition, R. Kelly Rainer; John Wiley & Sons, Inc.2016

4. Information Technology: An Introduction for Today's Digital World, Richard Fox, Chapman and Hall/CRC; 2nd edition (August 21, 2020)

5. Information Technology for Management, Efraim Turban, Carol Pollard, Gregory Wood, Wiley, 2018

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1. Critchley, L., Where Nanotechnology, the IoT, and Industry 4.0 Meet., https://www.mouser.com/blog/where-nanotechnology-the-iot-and-industry-40-meet, 2019

2. Pan India implementation of HMIS over Indian Railways, Ministry of Railways., http://railministry.com/pan-india-implementation-of-hmis-over-indian-railways/ 2020

3. Vossler, C. How Long Does It Take To Order A New BMW? https://www.bmwblog.com/2020/09/28/how-long-does-it-take-to-order-a-new-bmw/2020

4. Jay, A., 10 New ERP Trends & Forecasts for 2020/2021 – A Look Into What's Next. https://financesonline.com/erp-trends/2019

5. Gingiss, D., How Integrating Social Media Into The Rest Of The Business Will Increase Revenue., How Integrating Social Media Into The Rest Of The Business Will Increase Revenue (forbes.com), 2019

20.14 Answers to Check Your Progress Questions

1. **(a).** i, ii, and iii are TRUE. Distributed system connects different machines having different operating systems, distributed systems require middleware for developing business applications and CORBA is a standard for distributed systems development . Hence they are true.

2. **(c).** Rail is not a networking topology. Star, Bus and Ring are networking topologies.

3. **(b).** RPC stands for Remote Procedure Call.

4. **(d).** Distributed systems are interoperable, portable and reliable.

5. **(e).** Distributed systems characteristics include *Fault-tolerant, Scalability, Openness* and *Transparent.*

6. **(e).** Cloud characteristics include scalability, low cost, availability and reliability.

7. **(c).** Cloud intruder is not a stakeholder in cloud computing. Cloud provider, cloud consumer, cloud auditor and cloud broker are stakeholders in cloud computing area.

8. **(d).** Cloud deployment models include public cloud, private cloud, community cloud and hybrid cloud.

9. **TRUE.** Public clouds can be accessed over the Internet.

10. **(b).** Community cloud is meant for group of organizations.

11. **(b).** PaaS stands for Platform-as-a-Service.

12. **(e).** IaaS, PaaS and SaaS are cloud service models.

13. **(a)** Amazon Elastic Compute Cloud provides infrastructure-as-a-service.

14. **(c).** SalesForce CRM is an example SaaS (Software-as-a-Service) provider.

15. **TRUE.** Pay-per-use business model is different from subscription based payment model. Subscription rates would be per user per month basis.

16. **(b).** Ramco Systems ERP is an example of ERP on the cloud.

17. **(d).** Amazon Elastic Compute cloud, Microsoft Azure and TCS iON are commercially available cloud computing solutions in the market.

18. **(b).** Grid computing supports decentralized data centers.

19. **(c).** HPC stands for High Performance Computing.

20. **(a).** OGSA stands for Open Grid Services Architecture.

Unit 21

Business Intelligence and Big Data

Structure

21.1. Introduction

In the previous unit, we discussed Distributed Systems, Cloud Features, Functionality, Architectures, Service Models, Business Models and Grid Computing.

Many business organizations are adopting business intelligence to learn from the past experiences and to predict the future. Intelligence of business is the need of the hour for the current day organizations. Organizations are using human cognition and artificial intelligence techniques for business decision making. Current day organizations are having information about customers, suppliers, competitors, vendors, business partners, operational data and economic environment. Business intelligence is used for competitive advantage of the organizations. With the available data, economic conditions and using business intelligence, organizations extrapolate and predict the future trends required for the organization. The main objective of business intelligence is to provide timely, good quality information and insights to the management for organizational decision making purposes. In a survey done on 50 Finnish organizations, it was

found that organizations do not go for business intelligence for cost and time savings, but they go for it expecting big bang return in future.

Business intelligence can be used to find what products and services customers prefer and in what regions, etc. Credit card frauds can also be found using business intelligence tools. Call centers and e-commerce support are generating huge data for the organizations. Business intelligence can be used in different industries such as airline, retail, manufacturing, financial services, healthcare, bioinformatics, and hospitality industry. There were some forms of business intelligence systems 50 years ago. However, the current day business intelligence systems are replacing decision support systems, management information systems and executive information systems. Organizations such as Tesco, Capital One, CEMEX and Netflix have made intelligent better decisions based on business intelligence.

In the unit, the need for business intelligence and the definition of business intelligence are explained. The distinction between data, information, knowledge and wisdom are explained. The data warehouse, business intelligence architecture, business intelligence components, business intelligence methodologies, data mining techniques and business intelligence tools are described. The usage of business intelligence in market intelligence and its applicability to decision making is highlighted. The data in the organizations is growing much faster than the computing speed in the world. Hence, the importance of big data, Hadoop and big data analytics are also explained in the unit.

## 21.2. Objectives

The objectives of the unit include:
- Explain the need for business intelligence in the organization
- Distinguish between data, information, knowledge and wisdom
- Explain the functionality of data warehouse
- Describe the business intelligence architecture
- Explain different components in business intelligence
- Describe different business intelligence techniques and methodologies.
- Mention data mining techniques used in business intelligence
- Application of business intelligence in market intelligence and decision making
- Mention business intelligence tools commercially available in the market.
- Explain big data architecture and Hadoop.
- Describe big data analytics and big data analysis process.

21.3. Need for Business Intelligence

What is the need for business intelligence systems in the organization? In the absence of data the decision making in the organization would be just guessing instead of judging. Hence, the organizations looking for performance improvements go for business intelligence. The organizations initially have to think about why do they require business intelligence? If they decide to have business intelligence, then they should think which stakeholders get benefited using business intelligence and what are the investment costs? Business intelligence is required for efficient decision making, operational excellence and strategic excellence.

The evolution of information systems over a period of time is shown in Figure 21.1. *Legacy systems* used complex algorithms, mainly used in scientific computing and developed it using procedural and functional programming languages. *Transaction Processing Systems* used some form of data and file based systems and these were used for business purposes. *Decision Support Systems* used data models and interfaces for the users. *Management Information Systems* used relational databases and business logic. *Executive Information Systems* were used in management reporting and data visualization. *Expert systems* were rule based and searched knowledge bases. The current day *Business Intelligence Systems* use data mining techniques, data warehouses and business analytics tools useful for managerial decision making.

Figure 21.1: Evolution of Information Systems
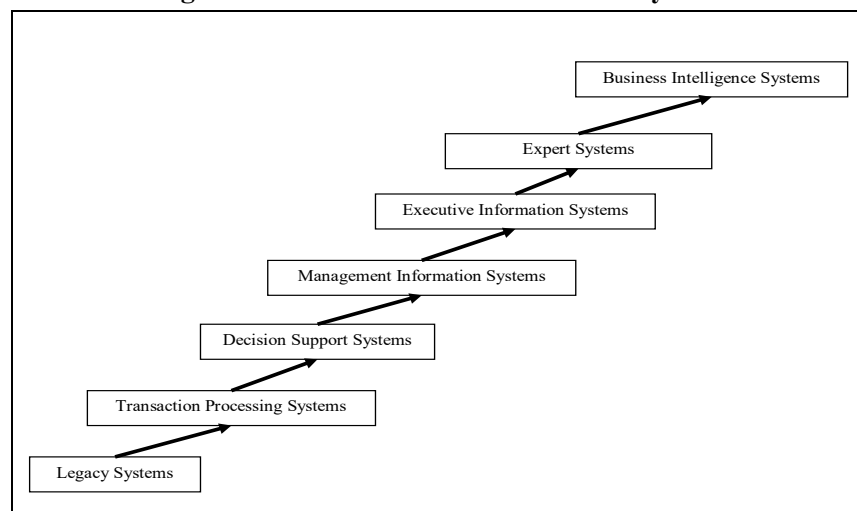
Business intelligence is the application of methodologies, processes and technology in acquiring, integrating, storing, accessing, analyzing and interpreting the data to make enterprise level decisions.

Business intelligence is about extracting the needed information and transforming that information into knowledge. Business intelligence extracts large amounts of data, analyzes it and generates reports needed for daily decision making. Senior management and top management can be benefited from the insights and reports generated using business intelligence. Business intelligence technologies support efficient business operations. Business intelligence uses the technologies such as data warehouses, data mining tools, OLAP tools, web services, XML, J2EE and .Net. Business intelligence includes several software tools for extraction, transformation, load, querying, visualization and reporting. Top 12 business intelligence tools in 2021 are: Board, Domo, Dundas BI, Microsoft Power BI, MicroStrategy, Oracle Analytics Cloud, Qlik, SAS, Sisense, Tableau, Tableau CRM, and Tibco

Business intelligence is different from competitive intelligence. *Competitive intelligence* concentrates only on the external factors of the organization where as business intelligence considers internal factors such as operational details of the organization as well. Business intelligence capabilities include data mining, online analytical processing, decision support, forecasting and statistical analysis.

Business intelligence facilitates effective communication in the organization. The organization can change their strategies and decisions based on the changing economic conditions, customer preferences, product sales, financial situation and supply chain operations using business intelligence. Using business intelligence the organization can find who are their loyal customers, most profitable customers and potential customers. They can also find out the reasons for customer loyalty using business intelligence. Business intelligence enables us to identify the trends, anomalies, obtain insights and run simulations.

Activity: Need for Business Intelligence

A retail chain is operating in different locations in India. It collects data of products being sold, who purchased them and customer profiles. The organization is currently collecting data based on customer surveys. But this process is taking lot of time to find out the results. The organization would like to know who their profitable customers are and what products are being sold most. The organization maintains a relational . At a base. However, the top management needs quick solution every time. What would you suggest to the organization? Which technologies, processes and approaches will solve their problem?

Contd. .....

Answer:

21.4. Data, Information and Knowledge

Human brain contains four types of data. They are *raw data, information, knowledge* and *wisdom*. The journey of data as information, knowledge and wisdom is shown in Figure 21.2.

Raw *data* is the figures and numbers. Data alone cannot make any sense. It cannot give any meaning to the individuals. It has to be processed to understand. The data in spreadsheet or a flat file is an example raw data. Data is frequently shared between the organization and other stakeholders of the organization such as customers, suppliers and partners. *Characteristics of good quality data* include completeness, correctness, current, and consistent.

Information is the processed data. The status reports, trend reports and progress reports in the organization are nothing but the processed data which gives information to the executives. The data tables with column names and row values in relational database management systems provide useful information.

After reading the information, individual understands it. That is individual interprets and stores it. That becomes knowledge. *Knowledge* is the information understood. It is the application of data and information. Further individual does not leave the understood information there itself. He applies his judgment, values and ethics into it and makes it wisdom. For example, remembering the number of defects per release and number of test cases written per release of the product and taking decisions based on that information is nothing but the knowledge on the product. This remembered knowledge is useful in the future journey of the product. Otherwise remembering normal temperature of a human being and temperature of boiling water, etc are examples of knowledge. Human being remembers this knowledge and applies whenever a need occurs. Artificial intelligence systems poses knowledge and they take decisions based on the knowledge. Expert systems search the knowledge bases.

Wisdom state represents the judgmental level of the knowledge. Based on this, individual takes decisions in the organization. He decides whether it is right or wrong, acceptable or unacceptable, correct or incorrect and ethical or unethical. Wisdom also involves future thinking and vision. As data transforms into information, knowledge and wisdom, the level of understanding increases in the individual.

Figure 21.2: Evolution of Knowledge
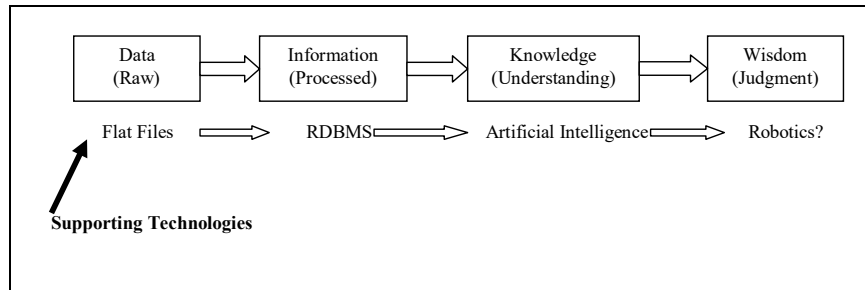
Wisdom comes through systematic practice. Machines may not reach this level. Because judgment has to happen based on facts, data, ethics, vision, values and culture. Inculcating or embedding ethics, culture and values into machines is still a grey area. Robots work based on the fed knowledge and artificial intelligence. They work as rule based systems. They do not have the wisdom as a human being has. Thus business intelligence systems provide knowledge and information useful for decision making in the organization. Business intelligence systems can become part of knowledge management practice of the organization as well. They are useful not only for business decision making but also for knowledge management in the organization.

Activity: Data, Information and Knowledge
A pharmaceutical company would like to improve the sales of their products in rural areas. For this, their marketing strategy team recommended to develop an expert system which can be deployed in rural areas. Using this proposed expert system, without doctor's physical present, prescriptions can be generated by giving the symptoms of disease as input. The IT department is given the job of developing the expert system. The project manager thinks of, what to collect to develop an expert system. The project manager wonders whether to collect data, information or knowledge. Suggest the project manager how he can go ahead in this project.
Answer:

<u>**Check Your Progress-1**</u>

1. Business intelligence is required for _____.
   a. Organizational Performance
   b. Decision Making
   c. Both a and b
   d. Loss of Productivity
   e. None of the above

2. Business intelligence systems make use of _____.
   a. Data warehouse
   b. Data Marts
   c. Both a and b
   d. Data Loss
   e. None of the above

3. Information is processed data.
   [TRUE/FALSE]

4. DSS stands for _____.
   a. Demand Supply Support
   b. Divided Decisions
   c. Direct System Source
   d. Decision Support System
   e. None of the above

5. Knowledge depends on _____.
   a. Understanding
   b. Withstanding
   c. Outstanding
   d. All of the above
   e. None of the above

21.5. Data Warehouse

Data warehouse is the major component of business intelligence. It helps in propagation of data in the organization. It extracts, cleanses, integrates, transforms and stores the data and further transmits the data for query processing and analysis. It extracts, stores, and transmits data for further processing. The sources of data for data warehouse can be the internal enterprise systems, operational databases, relational databases, spreadsheets, and historical databases, market data or the Internet. It integrates the data required for organizational strategic, tactical and

operational decision making. Data received can be in any of the following two forms.

i) Structured Data

ii) Unstructured Data

Structured data can be from the organizational relational databases such as tables, forms and spreadsheets. It is the data which can fit into an organizational relational database. Structured data is easy to search. *Unstructured data* can be email messages, chats, graphs, memos, movies, images, telephone conversations, letters, news items, marketing flyers, presentations, spreadsheet files, web pages, whitepapers, discussion forum messages, pictures, biometrics (finger prints, facial images), plain text files, audio and video files. Some researchers have used the *semi-structured data* to mean the unstructured data. It is the data which cannot fit into a relational database or the structured data. It cannot be representable in rows and columns. Semi-structured data analysis requires classification and taxonomy. It contains the important information needed for organizational decision making. Data warehouse consolidates the data collected from various enterprise systems and the external data.

> The statistics show the banking sector generates unparalleled quantities of data. The amount of data generated each second in the financial industry will grow 700% in 2021. Unstructured and semi-structured data (like JSON) now make up an estimated 80% of data collected by enterprises. This stems from the rise of mobile devices, applications, wearables and the Internet of Things (IoT). Despite the importance of data, only 14% of companies are having it be widely accessible to employees. Most companies only analyze 12% of the data they have, and 88% of data goes unanalyzed. 73.4% of companies still report business adoption of Big Data and AI initiatives as a challenge. Only 26% of companies say they have achieved a data-driven culture. According to statistics based on a survey conducted by Sigma, about 71% of business experts have a desire to improve their data literacy skills.

21.6. Business Intelligence Architecture

The objective of business intelligence systems is to provide quality and timely input data for decision making in the organization. It provides information on demand. They combine the operational systems and data with analytical tools in order to provide complete information to decision making and planning in the organization. *Business intelligence architecture* consists of the data sources, data integration, data storage, data management, operational processes, presentation tools and

applications, querying and reporting as shown in Figure 21.3. This architecture should fit into the enterprise systems architecture. Business intelligence architecture is also part of the enterprise systems architecture. It is not an isolated entity in the organization. It is part of enterprise network of systems.

The *data sources* for business intelligence are heterogeneous. It includes both *internal* and *external data sources*. *Internal sources* of data for business intelligence include Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), legacy systems, flat files, operational systems, decision support systems, executive information systems, knowledge management systems, marketing systems, OLAP, visualization systems, transaction systems, geographical information systems, unstructured data such as messages, video, audio; and *external sources* of data include Internet, blogs, social networking sites, and media. The data warehouse pulls the data from all these sources. The data type can be *structured* or *unstructured data*.

Data integration is done trough data extraction from different sources, data cleansing, data transformation into required format and then data loading into the data warehouse. Here ETL tools known as *Extract, Transform and Load tools* can be used for data integration purpose. There are many commercially available ETL tools in the market. Some of the ETL tool vendors include Informatica, Trillium, Ascential and Ab Initio.

Data warehouse provides the access, storage and integration to the data. The data from data warehouse is loaded into *data marts* specific to the business function. *Data mart* is the tiny database specific to department, business unit, and business process or business function. The advantage with data mart is it provides quick access to data for specific purposes of the group. There can be multiple data marts in the organization. Data marts can also be used for SQL querying, fixed report generation and data mining purposes. There are different data mining techniques which can be applied on data marts. The outputs are pulled from the data marts.

Cubes are derived from data marts. A cube can be a logic view of the data. It provides structured information to the users. It is useful for querying and reporting purposes. The developers can derive multiple cubes from a single data mart. The developers and users will be accessing the data cubes. Data cubes can be used to generate ad-hoc reports.

OLAP (Online Analytical Processors) and other *analytical tools* can access the data marts in the business intelligence framework. These tools apply statistical techniques and derive insights and findings useful for managers.

They can also be used to generate graphs and reports from the data. They can generate trend reports, progress reports and status reports.

Overall business intelligence makes use of both internal and external data, analyze it and prepare reports, graphs, insights and knowledge useful for decision making at different levels in the organization. Business intelligence systems should be transparent, reliable, accessible and secure. They should be able to handle different data types, data formats and data sources. Business dominates the technology in business intelligence architecture. Business intelligence architecture also includes the metadata, standards, business rules and policies. Technical architecture consists of hardware, database management systems, and middleware. The *security* and *scalability* of the business intelligence systems is also to be taken into consideration while architecting business intelligence for the organization. Business intelligence architectures should comply with regulatory requirement of Sarbanes-Oxley Act of 2002.

Metadata repository contains the details about source of data, bibliographic information, data definition, and how it is calculated. It also contains details about reliability and accuracy of data.

Figure 21.3: Business Intelligence Architecture
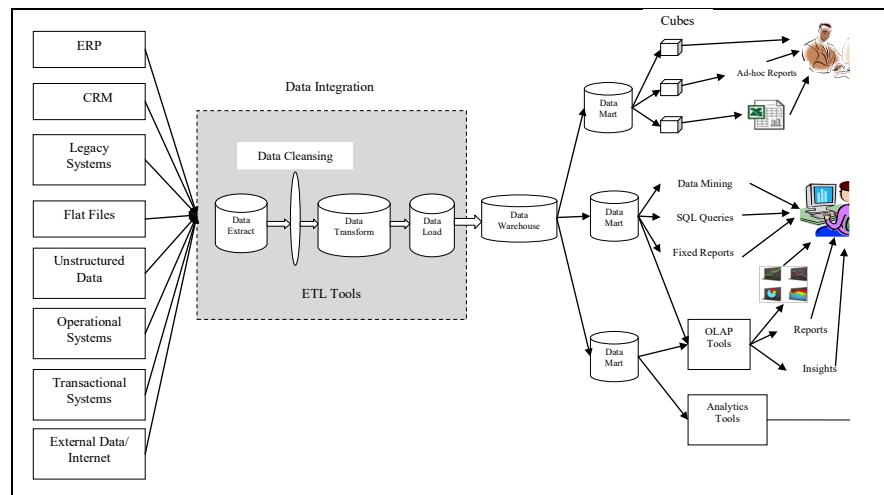
Check Your Progress-3

6. Data can be _____.

    a. Structured data

    b. Unstructured data

    c. Either a or b

    d. Error Data

    e. None of the above

7. Data warehouse functionality includes _____.
   a. Cleansing data
   b. Storing data
   c. Transforming data
   d. All of the above
   e. None of the above

8. Business intelligence architecture includes _____.
   a. Data Warehouse
   b. ETL tools
   c. Data marts
   d. All of the above
   e. None of the above

9. Business intelligence architecture should be _____.
   a. Scalable
   b. Secure
   c. Both a and b
   d. Unreliable
   e. None of the above

10. ETL stands for _____.
    a. Extract, Transform and Load
    b. Enter, Transfer and Leave
    c. Early Transfer Level
    d. All of the above
    e. None of the above

21.7. Business Intelligence Components

The essential *components of business intelligence* systems include data warehouse, data marts, corporate performance management, ETL tools, OLAP, Analytical tools, data visualization, data mining, geographic information system and well defined workflow. *Data warehouse* is the important component of business intelligence. It should be real time data warehouse.

Data mart is an organized collection of data specific to departments. It is a sub-set of data warehouse. That is data mart is formed from extracting data from data warehouse based on the department, specific business function, business process or business unit. This is helpful in making decisions specific to that department. For example, there can be different

data marts for marketing, sales, finance, operations and HR. Each data mart is useful for the efficient decision making of that department. There can be multiple data marts in one enterprise. This data mart is formed to achieve operational excellence through decision making. Functional executives can take decisions based on the data extracted from the data mart. *Virtual data marts* can also be created using database 'views'. Cubes are to be created from data mart.

Corporate Performance Measurement can be done using organizational web portals, dashboards and score cards. *Key performance indicators* (KPI) are also components of business intelligence. KPIs are nothing but the metrics collected weekly, monthly, quarterly and yearly in the organization. *Extract, Transform, and Load (ETL)* tools are also components of business intelligence. Current day ETL tools extract the data very quickly.

OLAP (Online Analytical Processors) provide multi-dimensional views, analyzing, visualizing, reporting, and modeling the data. They can be used to optimize business operations. They work with data warehouses and data marts in accessing the data. They process queries needed to find the trends of the organization. Current day OLAP tools access the data and generate the reports very quickly. OLAP tools take 0.1% of the time of a traditional relational database takes for answering a query. Popular OLAP tool vendors include Cognos and Business Objects.

Analytics tools do the statistical analysis needed for forecasting, data mining and predictive analysis. They predict or provide insights based on certain facts for the organization. The *business intelligence components* for semi-structured data include business process model, business function model, business data model, and metadata repository and application inventory.

Activity: Business Intelligence Components

A manufacturing company has many locations with location specific databases. The organization would like to consolidate all the data and would like to have consolidated reports. For that purpose, they decided to go for a centralized data warehouse with business intelligence capabilities. Business intelligence objective is to acquire data, organize data and analyze data. In that direction, the project manager thinks of how to acquire data from different sources. Suggest the project manager how he can extract the data from different data sources? Suggest him some commercially available tools for this purpose.

Contd……

Answer:

21.8. Business Intelligence Methodologies

Business intelligence can be viewed as application of data mining techniques, usage of complex algorithms and statistical analysis on data. Business intelligence methodologies include predictive analysis, statistical analysis, reporting and ad-hoc analysis. Business intelligence involves the detailed analysis of huge data, application of technologies and analysis practices.

The *methodology* to deal with structured and semi-structured data in business intelligence is to acquire the data, clean up the data and integrate the data. Then, search the data, analyze the data, identify trends, changes and incorrectness, and deliver the results. The management action is based on the provided information and results. The reports generated can be validated, structured and summarized. For structured data, analysts use ETL tools, data warehouse, OLAP and data mining. Semi-structured data requires different and less sophisticated tools to analyze. Semi-structured data can be gathered from business processes and news items.

Complex Analysis makes use of fast and user-friendly OLAP queries. OLAP queries are used in marketing, financial reporting, business process management, sales and forecasting. The OLAP analyst traverses through data warehouse, data marts and change the data orientation. The operations possible in OLAP include *slice and dice*- a capability to combine and re-combine different combinations of data, *drill down/up*- to navigate through data, *pivot* – which changes the dimensions from rows to columns and vice-versa, *nesting* – displays one dimension inside another dimension of data.

Business intelligence *analytical techniques* include modeling, visualization, embedding, monitoring, reporting, data mining, score cards and investigating. Exhibit 21.1 presents the trends of Business Intelligence **(BI)** in 2021.

Exhibit 21.1: Business Intelligence Trends in 2021

Cloud BI is considered a must-have by 95% of enterprise software vendors after Covid and cloud/SaaS adoption is on the rise.

Collaborative and self-service BI are making it easier for users to find insights both together and alone.

Modern BI tools will focus on delivering mobile analytics to where their users are

Accelerated SaaS and Cloud Adoption

The demand for cloud BI continues to grow at a pace. 95% of enterprise software vendors consider it a must-have and 54% of enterprises say it's very important to their business initiatives.

AI Will Be the New BI

Companies across the U.S. are ramping up their AI investments in a post-COVID world, with the ramifications sure to reflect in years to come; 86% of executives surveyed by PWC said that AI will be a mainstream technology at their company in 2021. Whether through personalization driven by machine learning, augmented data prep, auto-charted data visualizations or explanations created via natural language generation, artificial intelligence technologies have made their mark on BI. Modern BI solutions empowered with augmented analytics can detect anomalies, analyze unexpected events and dig even deeper to surface the most relevant and useful information possible.

Self-Service BI is Self-Sufficiency

Self-service BI has ranked consistently high on the Business Application Research Center's annual business intelligence trends survey. Due to user-friendliness and accessibility in the BI tool space, any employee can become a non-skilled citizen data analyst. Self-service BI empowers, users of all technical skill levels to access and utilize data effectively. It lightens workloads and demands on IT staff, as users can sort and analyze data on their own by generating ad-hoc reports without needing to request and then wait for reports.

Collaborative Insights

Collaborative BI is emerging as a trend, as connecting with others becomes more critical than ever. Modern BI tools enable seamless report sharing and collaborative dashboard design; some popular collaborative features include @ mentions, built-in comment systems and easy sharing through links, email or Slack. Seamless sharing of insights and enhanced interactivity are enabling businesses with collaborative BI to accelerate and improve problem-solving.

Moving Towards Mobile

The mobile business intelligence market will be worth more than $20 billion by 2024 according to Mordor Intelligence, due to exponential increase in the usage of smartphones and tablets for business. Mobile

Contd. .....

BI features a responsive, lite version of the main analytics platform, placing the power of insights directly in the hands of the user wherever they go. This on-demand availability of information empowers faster decision-making, shorter workflows and more effective internal communication

Source: https://www.selecthub.com/business-intelligence/business-intelligence-trends/ Apr 2021

21.9. Data Mining Techniques

Data mining is the process of finding patterns in huge data using statistical techniques, artificial intelligence and database management system (DBMS) techniques. Data mining can be used in fraud detection, marketing and supervision. It finds correlations, patterns and trends in data from data warehouse using statistical and mathematical techniques. Data mining can be used for hypotheses proving and knowledge creation.

The main objective of data mining is to find the earlier undetected patterns in large data sets of the organization. *Data mining techniques* include classification, multi-dimensional analysis, correlation, regression, associations, prediction, clustering, time series analysis and outlier analysis. Exploratory data analysis and sequential pattern analysis are other data mining techniques.

Classification determines the characteristics of a particular group. Each group characteristics can be used to design a model. *Clustering* creates the groups of observations having certain common characteristics. *Time series analysis* finds the associations based on time. *Association* finds the relationship between events. *Correlation* finds the relationship between two different variables or events. *Regression* finds the impact of one event on other event. Regression is of two types such as *linear regression* and *non-linear regression*. *Prediction* finds the future values based on huge data sets.

Multi-dimensional analysis requires multi-dimensional database. Multi-dimensional analysis can be done on 3-dimensional cubes. A *Cube* can also be called as multi-dimensional database. Cubes are useful to generate ad-hoc reports and ad-hoc queries. The multi-dimensional setup with cubes should support *pivot analysis* useful for generating ad-hoc reports. An Example 3-dimensional cube can consist of Products, Customers, and Time of product purchased. Master data is used to generate different dimensions in database. Master data is very much important for business intelligence. Examples of master data include Customer Master File, Product Master File, Supplier Master File, etc.

Fixed reports can also be generated using multi-dimensional cubes. However this process does not use standard SQL (Structured Query Language), but it uses a multi-dimensional language known as *Multi-Dimensional Expressions (MDE)*. Hence the best practice to generate fixed reports is to use SQL commands directly from data warehouse and use cubes for multidimensional reports. Data mining tools are based on artificial intelligence, statistical and mathematical techniques, decision trees, neural networks and Bayesian network theory. Commercially available data mining tools include IBM Intelligent Miner, SAS Enterprise Miner, DBMiner, SGI Mineset, and MS SQL Server. There are some text mining tools as well.

Check Your Progress

11. OLAP stands for _____.
    a. Online Application Processing
    b. Online Application Performing
    c. Online Analytical Processor
    d. All of the above
    e. None of the above
12. Data mart is _____.
    a. Sub-set of data warehouse
    b. Specific to business function
    c. Specific to department
    d. All of the above
    e. None of the above
13. Cubes are derived from _____.
    a. Data Fields
    b. Data Marts
    c. Data Entries
    d. All of the above
    e. None of the above
14. Business intelligence methodologies include
    a. Predictive Analysis
    b. Statistical Analysis
    c. ad-hoc analysis
    d. All of the above
    e. None of the above
15. _____ is not a data mining technique.
    a. Classification
    b. Multi-dimensional analysis
    c. Clustering
    d. All of the above
    e. None of the above

21.10. Market Intelligence and Decision Making

Business intelligence implementation in an organization involves the hardware, software, human resources and implementation costs. Training is also required for analysts to use the system. System upgrades also initiate training need in the organization. Business intelligence can be used in deriving competitive intelligence for the organization. *Competitive intelligence is about gathering and analyzing external information useful for devising organizational plans, strategies, operations and decisions.* Market intelligence includes competitive intelligence, competitive strategies, pricing strategies, sales strategies and competitive advantages.

The sources of market intelligence include government websites and portals, online databases, government publications and reports, online databases, surveys, trade associations, user groups, consumer groups, industry bodies, industry consortiums, competitors, suppliers, vendors, partners, customers, distributors, interviews with industry experts, journals, newspapers, magazines, financial reports, and private sector organizations.

The data collected from the above mentioned sources is to be fed into the organizational business intelligence system to gain market intelligence in the industry. The output reports, graphs, knowledge and information of business intelligence are useful in organizational decision making.

21.11. Business Intelligence Tools

Business intelligence tools include AQL (Associate Query Logic), Decision Support Systems (DSS), Executive Information Systems (EIS), Management Information Systems (MIS), Query and Reporting Tools, OLAP tools, Data Mining Tools, and ETL tools.

Most influential commercially available business intelligence tools in 2021 are from the organizations such as: Sisense, Zoho, GrapeCity Inc., Qualtrics, Connexica, Advanced Systems Concepts, Inc., Board International, Salesforce, Looker, Reveal, Yellowfin, Infragistics, Qlik, SAP, Tableau , oftware, SAS, Microsoft, IBM, Infor, and Domo.

Oracle business intelligence applications include Oracle Financial Analytics, Oracle Project Analytics, Oracle Sales Analytics, Oracle Price Analytics, Oracle Marketing Analytics, Oracle Procurement and Spend Analytics, Oracle Supply Chain and Order Management Analytics, Oracle Human Resources Analytics, Oracle Service Analytics, Oracle Loyalty Analytics and Oracle Call Center Telephony Analytics. Oracle business intelligence applications are capable of integrating with Oracle E-Business Suit, JD Edwards Enterprise One, PeopleSoft Enterprise and Siebel CRM.. A proper analytics package comes with data schemas, dashboards,

predefined reports, business views and integrated set of tools. The business intelligence tools for semi-structured data are still maturing.

21.12. Big Data

The amount of data growing in organizations is huge. The data is growing at very fast rate. The huge data requires analysis, modeling, organizing and retrieval. *Big data is nothing but the huge volumes of complex data.* Big handling requires reliable and less expensive storage, and tolls to manage semi-structured or unstructured data. Big data architecture is shown in Figure 21.4. It interacts with the external data sources, the enterprise data sources and the business analytics tools in the organization. Example: Apache Hadoop is a big data management platform.

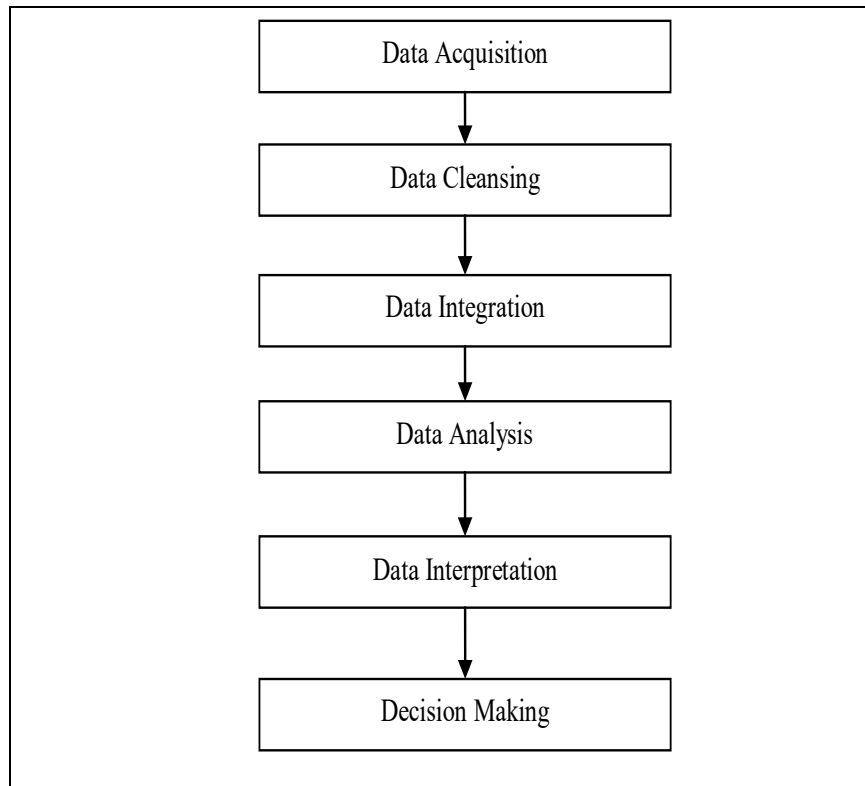**Figure 21.4: Big Data Architecture**
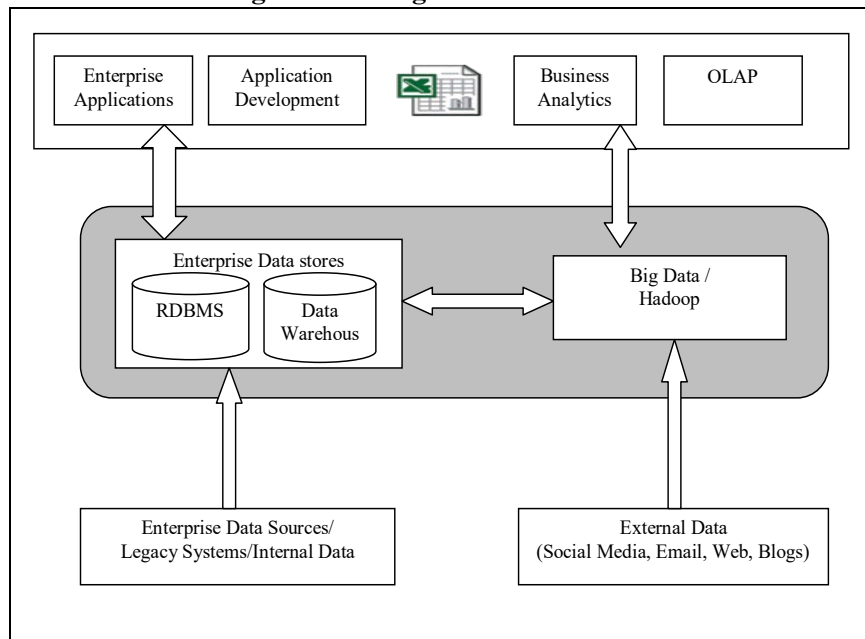
Big data can be used in wide areas such as retail, mobile services, e-commerce, education, financial services, scientific research, manufacturing, life sciences, bioinformatics, physical sciences, and astronomy. Big data applications include traffic management, urban planning, environmental modeling, smart materials, computational social sciences, financial risk analysis, security and intelligent transportation.

The big data challenges include the volume of data (size), speed at which data is received and the variety of data (data type) being received in organizations. The characteristics such as size, speed, and data type distinguish big data from traditional data. Security, privacy, authentication, access and usability are other issues related to big data in organizations. Organizations may use big data for customer retention, risk assessment and brand management. Big data requires different data mining techniques

other than the traditional statistical techniques. Bid data analysis process is explained in Figure 21.5.

Figure 21.5: Big Data Analysis Process

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┌────────────────────────────────────────────────┐
│              ┌─────────────────────┐             │
│              │  Data Acquisition   │             │
│              └─────────────────────┘             │
│                        │                         │
│                        ▼                         │
│              ┌─────────────────────┐             │
│              │   Data Cleansing    │             │
│              └─────────────────────┘             │
│                        │                         │
│                        ▼                         │
│              ┌─────────────────────┐             │
│              │  Data Integration   │             │
│              └─────────────────────┘             │
│                        │                         │
│                        ▼                         │
│              ┌─────────────────────┐             │
│              │    Data Analysis    │             │
│              └─────────────────────┘             │
│                        │                         │
│                        ▼                         │
│              ┌─────────────────────┐             │
│              │ Data Interpretation │             │
│              └─────────────────────┘             │
│                        │                         │
│                        ▼                         │
│              ┌─────────────────────┐             │
│              │   Decision Making   │             │
│              └─────────────────────┘             │
└────────────────────────────────────────────────┘
```

21.12.1 Hadoop

Apache Hadoop is open source platform for the management of big data. It addresses the issues such as low cost, reliable storage and tools for analyzing unstructured data. It is a project of Apache Software Foundation. Hadoop consists of a fault-tolerant system known as *Hadoop Distributed File System* (HDFS). It provides storage infrastructure without loss of data. It creates clusters of machines and coordinates between them. These clusters are built with less expensive hardware machines. HDFS stores three copies of each block of data in three different servers in the cluster. Even if two servers go down in the cluster, still the file can be retrieved without any data loss. It duplicates the data at three different servers in the cluster.

Hadoop tool works at the whole quantity of data in the relational database. It uses a technique known as *MapReduce* which splits the task and pushes it on to different servers and later collates the results achieving the parallelism. It automatically restarts the work if any node goes down in the

cluster. HDFS and MapReduce are the key features of Hadoop providing the reliable and low cost solution to big data.

21.12.2 Big Data Analytics

An organizational business analytics can include customer analytics, supply chain analytics, IT analytics, HR analytics and financial analytics. For example, *Customer analytics* can find what type of customers are profitable to the organization, *Supply chain analytics* can find what inventory optimization levels are suitable for the organization, *IT analytics* can find whether IT services are efficient in the organization or not, *HR analytics* can find what is the cost of recruitment, *Financial analytics* can find what are the cost and revenue drivers of the organization and their impact on the profitability.

Big data analysis process is shown in Figure 21.5. After data acquisition, data cleansing process starts. Data cleansing is followed by data integration, data analysis, data interpretation and finally the decision making.

Some of the *analytical technologies* include genetic algorithms, swarm intelligence, information extraction, text categorization, text mining, audio mining, video mining, rule based engines, data mining tools, simulation tools, spreadsheets and OLAP tools.

Predictive analytics is a technique of predicting the future scenarios for the organization. It gets data from data warehouse and applies mathematical algorithms to predict the future trends of the business. It uses the techniques such as regression, logistic regression, time-series analysis, duration analysis, situational analysis, multivariate analysis, classification, and machine learning techniques such as neural networks, and radial basis functions.

Activity: HR Analytics

HR manager would like to know the impact their organizational culture has on the employee productivity in the organization. For this purpose he wants to have data based evidence. He would like to use the organizational data warehouse maintained by the IT department for this purpose. He seeks the help of IT project manager in finding the impact of organizational culture on employee productivity. The IT project manager tells the HR manager that some tools can be used to do this work. What are those tools? And what statistical technique needs to be applied in this case?

Contd. .....

Answer:

Check Your Progress

16. _____ organizations provide business intelligence tools.

    a. Business Objects

    b. Microsoft

    c. PeopleSoft

    d. All of the above

    e. None of the above

17. _____ is not a big data characteristic.

    a. Size

    b. Speed

    c. Data type

    d. All of the above

    e. None of the above

18. Big data includes huge volumes of semi-structured data. [TRUE/FALSE]

19. Hadoop features include _____.

    a. HDFS (Hadoop Distributed File System)

    b. MapReduce

    c. Both a and b

    d. High Cost Solution

    e. None of the above

20. Big data analysis process does not include _____.

    a.   Data Acquisition

    b.   Data Integration

    c.   Data Analysis

    d.   All of the above

    e.   None of the above

21.13. Summary

- The challenges facing business intelligence include the volume of data (size), security, data retention, performance targets and benchmarking.

- Business intelligence systems are useful for strategic, tactical and operational decision making.

- They are useful in organizational performance management, optimizing resources, managing customer relations, management reporting, monitoring and controlling the business activities.

- Distinction between data, information, knowledge and wisdom are explained.

- The data warehouse and its functionality are discussed. The business intelligence architecture, business intelligence components, business intelligence methodologies and data mining techniques are discussed.

- Usage of business intelligence in market intelligence and decision making are explained. Popular business intelligence tools are mentioned. Big data, Apache Hadoop and analytics are described in the unit.

21.14. Glossary

Data Cleansing

It is the process of removing errors in the data. Incomplete, erroneous and inconsistent data is removed from the data. This process is known as *data cleansing*. It is required after data acquisition.

Expert Systems

These are the systems developed using artificial intelligence techniques. They can be developed using rule based programming language. For

example, Prolog (Programming in Logic) can be used to develop expert systems. Expert systems can be used in medical diagnosis as well.

Legacy Systems

These are the systems developed using first generation programming languages. The extension and reusability of these systems were very complex. They are not extendable like object oriented systems. They were developed using programming languages such as BASIC and FORTRAN.

Metadata

It is the data about the data. The date and time of data creation, who created the data, size of data, the date and time last modified, who has recently accessed the data, etc. are maintained in metadata. There are metadata repositories in business intelligence systems.

Pivot Analysis

Pivot analysis is done to find out the projected *support* and *resistance* levels of data. It is used to generate ad-hoc reports useful for managerial decision making.

Taxonomy

It is a technique of analyzing semi-structured or unstructured data. Usually classification and taxonomy are applied to semi-structured data analysis.

Transaction Processing Systems

These systems were developed using business oriented programming languages such as COBOL. They used to have master file and transaction file. They also support batch processing instead of online processing.

21.15. Self-Assessment Test

1. Distinguish between data, information and knowledge. How are business intelligence systems helpful in knowledge management in the organization?

2. What are the features of data warehouse? Explain.

3. Explain the business intelligence architecture. What are its main components?

4. Briefly describe the data mining techniques. Which techniques can be used to find associations between two events?

5. What is big data? What are its characteristics? What are the important features of Hadoop?

21.16. Suggested Readings / Reference Material

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2. Information Technology for Management, 2ed: Advancing Sustainable, Profitable Business Growth, Turban, Volonino, Wood, O.P. Wali, Wiley India Pvt Limited, January 2021

3. Introduction to Information Systems - 6th edition, R. Kelly Rainer; John Wiley & Sons, Inc.2016

4. Information Technology: An Introduction for Today's Digital World, Richard Fox, Chapman and Hall/CRC; 2nd edition (August 21, 2020)

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1. Critchley, L., Where Nanotechnology, the IoT, and Industry 4.0 Meet., https://www.mouser.com/blog/where-nanotechnology-the-iot-and-industry-40-meet, 2019

2. Pan India implementation of HMIS over Indian Railways, Ministry of Railways., http://railministry.com/pan-india-implementation-of-hmis-over-indian-railways/ 2020

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4. Jay, A., 10 New ERP Trends & Forecasts for 2020/2021 – A Look Into what's next. https://financesonline.com/erp-trends/2019

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21.13 Answers to Check Your Progress Questions

1. **(c).** Business intelligence is required for both organizational performance and decision making.

2. **(c).** Business intelligence systems makes use of data warehouse and data marts.

3. **TRUE.** *Information* is processed data.

4. **(d).** DSS stands for Decision Support System.

5. **(a).** Knowledge depends on understanding.

6. **(c).** Data can be structured data or unstructured data.

7. **(d).** Data warehouse functionality includes cleansing data, storing data and transforming data.

8. **(d).** Business intelligence architecture consists of data warehouses, data marts, and ETL tools.

9. **(c).** Business intelligence architecture should be scalable and secure.

10. **(a).** ETL stands for Extract, Transform and Load.

11. **(c).** OLAP stands for Online Analytical Processor.

12. **(d).** Data mart is sub-set of data warehouse, specific to business function, specific to department, specific to business process or specific to a business unit.

13. **(b).** Cubes are derived from data marts.

14. **(d).** Business intelligence methodologies include predictive analysis, statistical analysis and ad-hoc analysis.

15. **(e).** Classification, multi-dimensional analysis and clustering are data mining techniques.

16. **(d).** Microsoft, PeopleSoft and Business Objects provide business intelligence tools.

17. **(e).** Big data characteristics include size, speed and data type.

18. **TRUE.** Big data includes large volumes of semi-structured data.

19. **(c).** Hadoop features include Hadoop Distributed File System (HDFS) and MapReduce.

20. **(e).** Big data analysis procedure includes data acquisition, data integration and data analysis, etc.

Unit 22

Current Trends in Software Design and Architecture

Structure

22.1. Introduction

In the previous unit, we dealt with Big data, Data Warehouse, Data Mining Techniques, Business Intelligence Architecture, Components, Methodologies, and Tools.

Software design is the heart of any software system. If design is not proper, the software would be full of bugs and maintenance costs will zoom up. Integration will be a problem if design is not correct. Traceability in the system cannot be achieved without proper design. The current software design trends include designing for reusability, modularity, accessibility, reliability, cost and availability. These objectives can be achieved in design through object orientation, component orientation, service orientation and parallelism in project activities. In layman terms, *architecture is a very high level design.* It deals with components, interfaces, sub-systems and external interfaces to the system. Architecture involves mainly taking technological and systems decisions. *Design involves considering the low*

level alternatives. Design mostly deals with internal details of the sub-systems by keeping external interfaces in mind.

Since 1970s, so many software design methodologies have evolved. Among them Structured Systems Analysis and Design (SSAD), Object Oriented Analysis and Design (OOAD), Booch notation, OMT (Object Modeling Technique), Object Oriented Software Engineering (OOSE), Objectory, Component Based Design (CBD) and Service Oriented Architecture (SOA) are prominent ones. In this unit, the different software design approaches such as structured system analysis and design, object oriented analysis and design and component based design are explained. Component based specifications such as CORBA (Common Object Request Broker Architecture), DCOM (Distributed Component Object Model) and EJB (Enterprise JavaBeans) are discussed. Different software application architectural approaches such as pipes and filters, message queues, blackboard, event based architecture and client-server architecture are discussed. N-Tier architecture is explained with a diagram. Service Oriented Architecture (SOA), web based architecture and agent based architecture are explained. Product line development and evolution are also described in the unit.

22.2.   Objectives

The objectives of this unit include:

- Explain different software design approaches such as SSAD, OOAD and CBD

- Describe Object Oriented Analysis and Design (OOAD) method

- Explain component based architecture with examples of CORBA, DCOM and EJB

- Describe the application architectural approaches such as pipes and filters, message queues, blackboard, event based and client-server architectures

- Explain N-Tier architecture

- Explain Web Oriented Architecture (WOA)

- Describe Service Oriented Architecture (SOA) and web services

- Discuss agent based architecture

- Explain software product line development with an example

22.3.   Software Design Approaches

Major software design approaches include structured system analysis and design, object oriented analysis and design and component based design.

22.3.1 Structured Systems Analysis and Design (SSAD)

Early structured analysis and design methodologies were very process oriented and did not concentrate on modeling the data. SSAD's approach is modular approach. Its main objective is to have a hierarchical functional decomposition of the software system. SSAD uses tools such as Data Flow Diagrams (DFDs), Functional Decomposition Diagrams (FDDs), Entity-Relationship Diagrams (E-R Diagrams), State Transition Diagram and Structured Charts. DFDs represent the data stores and processes working on them. FDDs represent the hierarchical tree-like structure expressing the functional decomposition of the system by representing each function as a box. E-R diagrams represent the entities and their relationships. State Transition Diagram represents the different states of the system and state transitions using events or messages. Structured Charts are similar to FDDs. However they do not represent control structures such as the sequence, iteration, condition or selection.

The advantage with SSAD is software can be implemented as different interacting modules. Complexity is reduced with modularization. Processes and entities are identified. The disadvantages are extendibility, maintainability and reusability. The cost of maintaining modular code is more expensive than cost of maintaining object oriented code. Modules as such cannot be reused directly. They need customization or modification.

Cutting-edge software technologies, programming languages and other areas are going to gain more power in the software industry during 2021. Exhibit 22.1 presents the new software development trends in 2021.

Exhibit 22.1: Nine Software Development Trends In 2021

1. **Native App Development:** This approach will gain momentum in the banking/fintech industry, multimedia products and other areas with increased demand for flawless performance on mobile devices, reliability, quality and security.

2. **The Internet of Things:** The rise of IoT, like Smart home systems, Bluetooth trackers, car gadgets, point-of-sales beacons, IoT devices for manufacturers and plants, smart wearables for healthcare and fitness, should be mixed with AI and big data for maximum productiveness. As for IoT software development, the need is improving programming skills to write code for energy-efficient connected devices.

3. **Human Augmentation:** Human augmentation is a set of technologies that is used to enhance, replace or complement the natural abilities of people. Human 2.0 technologies exist in the form of implants built into the body, such as devices to restore sight or hearing, or external devices and tools, such as exoskeletons to improve natural capabilities. Google Glass is just the beginning.

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4. **Big Data:** In 2021, a significant part of the job is going to be carried out by the tools that process everything in memory right away instead of storing data after each calculation. Batch processing frameworks are going to be in demand, especially when it comes to social media data, documents and text analysis, and clickstream media. Cybersecurity in this area will remain a challenge.

5. **Artificial Intelligence Expansion:** Deep learning, machine learning, speech processing and more are going to be used more in ecommerce, healthcare, and education and entertainment apps.

6. **Continuous Integration And Deployment:** This practice is aimed to cut down the cycle of feature delivery, make bug fixing more frequent and effective, and allow more flexibility and experiments in software development.

7. **Progressive Web Apps:** Progressive web apps give users to get a full-fledged and full-screen experience with less data usage and shorter loading time. They transfer the app-like features into the browser window, thus marking a revolution of web development.

8. **Low-Code Development:** The low-code development trend simplifies complex programming languages. Low-code platforms revolutionize the software market, avoid a lot of manual work, and provide simple interfaces to help people build new apps at a low investment of money, time, and specific skills.

9. **Cross-Platform and Hybrid Development:** Cross-platform development becomes a major time-saver and facilitator. Back-end code share ability with the native rendering engine will achieve impressive results at a reasonable investment in future.

Source: https://www.forbes.com/sites/forbestechcouncil/2020/10/14/nine-software-development-trends-in-2021-to-watch-for-now/?sh=8ef91352e197

22.4. Object-Oriented Analysis and Design (OOAD)

The disadvantages that came with SSAD methodologies were overcome in object oriented analysis and design methodologies. OOAD methodologies used objects, classes, inheritance, polymorphism, encapsulation and abstractions in analysis and design. With this, the advantages include design reusability, code reusability, design extendibility, code extendibility, maintainability, and reduced development and maintenance costs. The prominent OOAD methodologies include Booch Notation, OMT, Objectory and Object Oriented Software Engineering. All these methodologies combined as an industry standard notation known as UML (Unified Modeling Language) for OOAD, given by OMG (Object Management Group), US in early 1990s. UML has evolved in different versions over a period of time. There are tools such as Rational Rose which support the UML notation.

Object Oriented Analysis finds the objects and classes from the problem domain. It *discovers* the objects and classes from the problem. Whereas, *Object Oriented Design* finds the relations between classes and objects such as inheritance, association, dependency, realization, generalization and specialization. It also *invents* the classes and objects and their relationships from the domain space, if required. The learners can refer to Coad & Yourdon's *Object Oriented Analysis* (Prentice-Hall, 1991), *Object Oriented Design* (Prentice-Hall, 1991) and Grady Booch's *Object Oriented Analysis and Design with Applications,* 3rd Edition (Addison-Wesley, 2007) for basics of object orientation.

UML is a notation for *visualizing, specifying, constructing* and *documenting* the artifacts of a software system. UML provides different diagrams such as class diagrams, object diagrams, sequence diagrams, collaboration diagrams, component diagrams, deployment diagrams, package diagrams, state chart diagrams and activity diagrams. The combinations of different diagrams give different view/perspective of the software system. UML is widely used in software industry. Another design approach, Component Based Design (CBD) is discussed in the next section.

Activity: Object Oriented Analysis Design

A manufacturing plant in UK has given a contract to an Indian software services company to develop their plant management system. The customer told to offshore manager to design the system in such as way that they can reuse some of the objects of the system in future. They want minimal maintenance costs. They would be able to extend the system in future without changing the existing code. The contents of the system should represent the real world objects. The offshore manager was undecided about which design methodology he has to follow to obtain the benefits conveyed by the customer. Suggest the offshore manager in identifying a better design approach.

Answer:

22.5. Component Based Design

A component is an independent replaceable part of a software system. Component is dynamically linkable and has separate interface. Components can interact with each other. *Component Based Design* is nothing but designing a software system using interactive components.

Component based design has got several advantages such as reduced time to market, reduced development costs, reduced development times, improved quality, reliability and maintainability. Component works in the given system's architectural context. Component communicates with other components using its interface.

Component based development can be done using life cycle phases such as requirements analysis; architecture analysis, construction and evaluation; component identification and customization; system integration; system testing and system maintenance. Organizations such as IBM, SUN, Microsoft, and BEA systems have developed many components. Microsoft's .Net framework consists of components. SUN's EJB consists of components. The component based design and development for distributed systems can be achieved using CORBA, DCOM and Enterprise JavaBeans (EJB).

22.5.1 CORBA (Common Object Request Broker Architecture)

CORBA is the standard specification for the development of distributed systems from OMG (Object Management Group), US. It is the technology developed in early 1990s. CORBA specifications describe object management architecture consisting of Object Request Broker (ORB), object services, common facilities and application objects. Using CORBA, applications developed using different programming languages running on different operating systems can communicate with each other. For example, an application developed using C++ on Windows can communicate with an application developed using C or Java on a Solaris platform. This is possible with CORBA. CORBA is to achieve interoperability and portability between different applications in distributed environment. It is a *distributed object computing* technology. The CORBA Object Management Architecture (OMA) is shown in Figure 22.1.

Figure 22.1: Object Management Architecture (OMA)
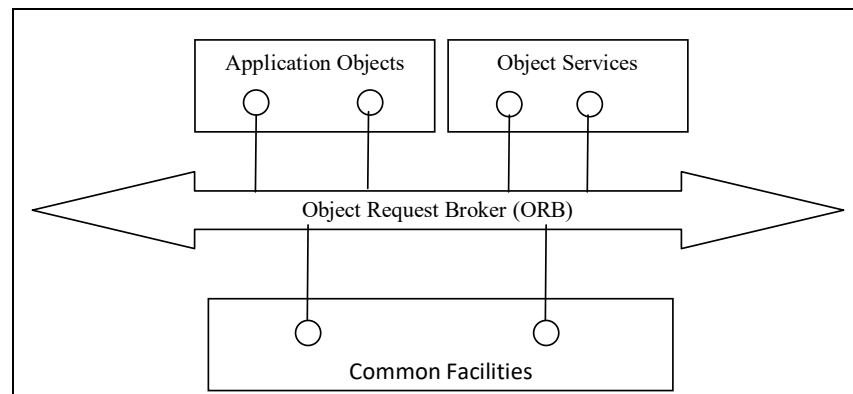
CORBA application development is based on client-server architecture. To develop client and server programs in CORBA, first an interface is to be written in IDL (Interface Definition Language). This IDL code is compiled with IDL compiler to generate *stub* and *skeleton*. The stub is linked to the client program and skeleton is linked to the server program. The server program consists of the remote object. ORB finds the object on the network and provides the object reference to the client program using CORBA naming services. CORBA object services include naming, event, persistence, relationship and transaction, etc. services.

CORBA common facilities are specific to the horizontal facilities applicable across all the domains such as information management and systems management. There are even domain specific CORBA services as well. Using CORBA, client programs invoke the methods of the remote object residing in the server program. CORBA is based on TCP/IP protocol. Different CORBA implementations can communicate with each other using IIOP (Internet-Inter ORB Protocol) and GIOP (General-Inter ORB Protocol). Example CORBA implementations include Orbix and Visibroker. Later on applications under CORBA platform can communicate with Java platforms as well.

22.5.2 DCOM (Distributed Component Object Model)

DCOM is a technology from Microsoft. It is a distributed object computing technology. Using DCOM, different applications developed using different programming languages on Windows platform which can communicate with each other. A client program written in Visual Basic can communicate with a remote object developed in C++ on Windows platform. This is shown in Figure 22.2. The only constraint in DCOM is both the client and server should be on the Windows platform. However, they can be distributed across the geographical locations. DCOM uses protocols such as TCP/IP and HTTP. Both CORBA and DCOM provide reliable communication because they are based on TCP protocol, which is a connection-oriented reliable protocol.

Figure 22.2: Client and Server using DCOM
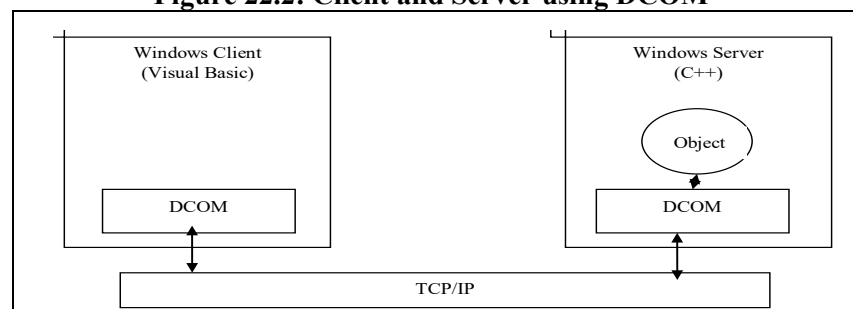
22.5.3 Enterprise JavaBeans (EJB)

Enterprise JavaBeans is a technology from SUN Microsystems which was later merged with ORACLE corporation. It can be used for distributed objects purposes along with Java RMI (Remote Method Invocation). JavaBeans are component based technology from SUN. JavaBeans are of two types. They are *entity beans* and *session beans*. Entity beans are associated with the resources such as databases. Session beans are associated with maintaining user sessions. EJB provides persistency to the objects. A bean can be invoked using an RMI call. RMI is over TCP/IP. To make an RMI call, first an interface to the bean has to be developed using Java interfaces as is done in the case of CORBA (using IDL). This interface can then be compiled to stub and skeleton. RMI uses the registry of remote objects.

Check Your Progress-1

1. SSAD stands for _____.
    a. Soft Story Data
    b. Structured System Analysis and Design
    c. Structure and Design
    d. All of the above
    e. None of the above

2. OOAD uses objects, classes, inheritance and polymorphism. [TRUE/FALSE]

3. _____ does not support component based development.
    a. CORBA
    b. DCOM
    c. EJB
    d. All of the above
    e. None of the above

4. DCOM is the technology from _____ organization.
    a. Microsoft
    b. IBM
    c. SUN
    d. All of the above
   e. None of the above

5. RMI stands for _____.
   a. Remote Member Involvement
   b. Remote Memory Interrupt
   c. Remote Method Invocation
   d. All of the above
   e. None of the above

22.6. Application Architectural Approaches

Different stakeholders of the software system look at the system with different perspective. For example, an architect will look at the system in *logical view*. A designer will look at the system in *process view* and *use case view*. A programmer will look at the system in an *implementation view*. A tester or support engineer will look at the system in *deployment view*. Hence, software systems architecture should be looked in different views such as *logical view, process view, use case view, implementation view* and *deployment view*. Different views give different perspectives to the team. These views help the architect in making right decisions at right time. Different architectural views are shown in Figure 22.3.

**Figure 22.3: Different Architectural Views**
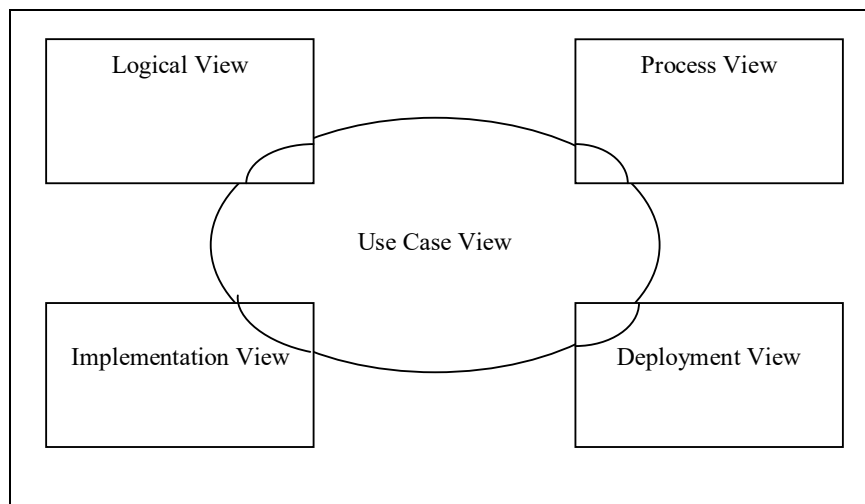
Logical view looks at different systems and interactions. Process view looks at different processes required for the system. Use case view looks at different use cases and the actors working on them. Implementation view looks at how to implement the classes and objects in the systems. Deployment view looks at the number of nodes required. The processes that should go on to which node and the geographical locations of the

nodes, etc. The following sub-sections discusses how individual applications can be architected.

22.6.1 Pipes and Filters

Usage of Pipes and Filters is an architectural style of software applications. In this architecture, the data flows through the pipes, and filters modify or transform the data into required formats. In this architectural style, output of one command becomes input to the next command (Figure 22.4). Thus, final output is the result of processed data. In Figure 22.4, pipe is represented as an arrow ($\rightarrow$) and filter is represented as a rectangular box. For example, in UNIX, the command "$ls | sort | pg" means, the output of "ls" command, that is, the list of files in directory, becomes input to "sort" command, which sorts the data in alphabetical order, and then the output of "sort" command becomes the input to "pg" command. This "pg" command displays the given data in page wise format. Thus the final output is the page wise alphabetical list of files in the directory. The symbol "|" indicates the pipe in UNIX.

Figure 22.4: Pipes and Filters Architecture
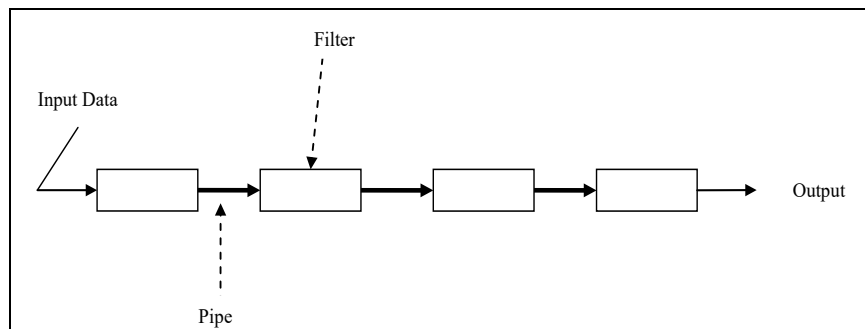
22.6.2 Message Queues

Using message queues, one application sends a message to the queue. If the other application sends another message it is appended to the queue. The message at the front of the queue is processed first. New messages are added at the rear of the queue. This is nothing but achieving batch processing. The disadvantage with this is applications have to wait till the initial messages are processed. The message queue is as shown in Figure 22.5. The messages are processed in first-in-first-out order.

**Figure 22.5: Message Queue Architecture**
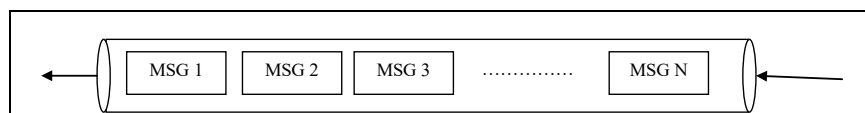
UNIX operating system provides system calls to handle message in message queues. Using these system calls, programmers can create a message queue, add a message to the queue, delete a message from the queue and delete the queue. Message queues are one among the early architectural styles used for inter-process communication.

22.6.3 Blackboard (Shared Memory)

In blackboard architectural style, different processes or different threads access the common shared memory. The processes or threads read/write/update the shared memory. The advantage with this style is processes can communicate with each other using the blackboard. The disadvantage is if two processes update the same memory block at the same time, one update will be lost. To avoid this, mutual exclusion concepts of the operating system is to be used. *Thread is an independent tiny part of the process which gets executed inside the process.* Multiple threads can access the same memory block or multiple processes can access the same memory block. The blackboard architecture is shown in Figure 22.6.

Figure 22.6: Blackboard Architecture
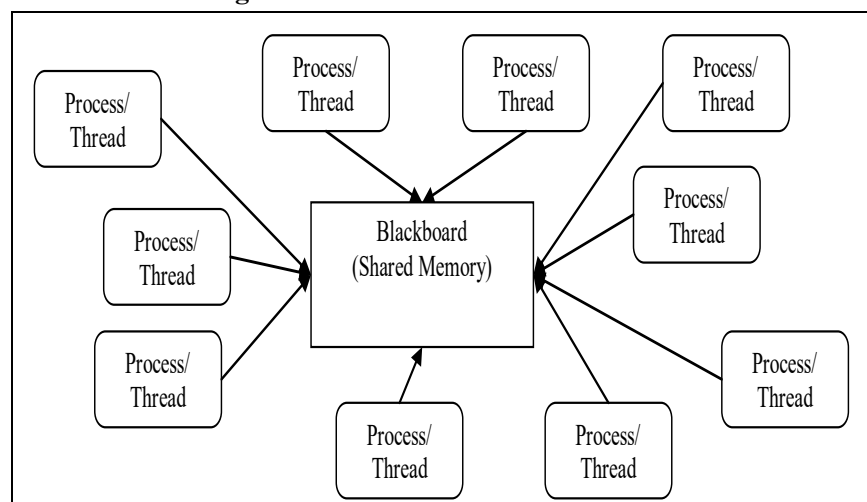
22.6.4 Event Based Architecture (Signals/Call Backs)

To avoid the disadvantages with blackboard style of architecture and to have continuity in the execution of the program, event based architectures are introduced. In this architecture, when events are generated by the external or internal environment, the event is handled using a callback function (Figure 22.7). Example events include mouse click event, I/O interrupts and signals generated in the system. Whenever an event occurs, an event handler is called. All the event handlers are to be registered with the operating system at the beginning of the program. In Unix operating system, for this purpose a system call known as signal () is provided. Using

signal (), one can register the specific signal or event and its corresponding handler in the form of a callback function.

Figure 22.7: Event Based Architecture
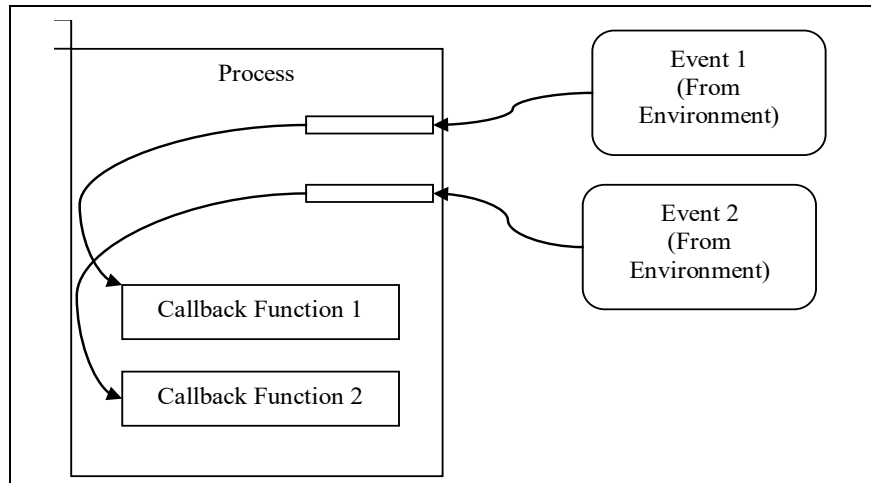
22.6.5 Client-Server Architecture

Another architectural style after mainframes (monolithic architectures), is the invention of client-server architecture. Using client-server architecture, server deals with database access and business logic. Client deals with presentation logic (Figure 22.8). With this the advantage is client does not have direct access to the database, which is an improvement with respect to data security. Also the data traffic between all clients and database is reduced because server is taking care of it. The advantage here is lot of saving of bandwidth .Also if the business logic gets changed, the client program need not be changed. Only the server can be changed. This is huge savings in time and effort.

Figure 22.8: Client-Server Architecture
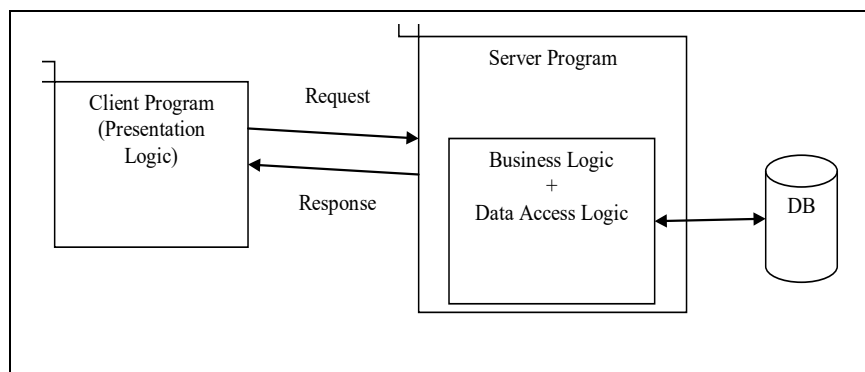
Early systems have client and server on the same machine. The improvement over it is server can be on one machine and clients can be on

different machines. The client program sends the request to the server. Server processes the business logic, accesses the data and sends the response to the client. The client program further formats the data into presentable form and displays on the client machine. This is nothing but the 2-tier architecture. There are further improvements over 2-Tier architecture. Those improvements are discussed in the next section.

Check Your Progress-2

6. _____ is not an architectural view.
   a. Logical View
   b. Implementation View
   c. Deployment View
   d. Process View
   e. None of the above

7. _____ transforms the data.
   a. Filter
   b. Pipe
   c. Both a and b
   d. Paper
   e. None of the above

8. Message queue follows first-in-first-out approach in executing messages.   [TRUE/FALSE]

9. _____ shares the blackboard or shared memory.
   a. Processes
   b. Threads
   c. Both a and b
   d. Pipes
   e. None of the above

10. _____ is not an application architectural approach.
   a. Pipes and Filters
   b. Event based architecture
   c. Message Queues
   d. Client-Server
   e. None of the above

22.7. N-Tier Architecture

N-Tier architecture is an improvement over 2-tier architecture. N-tier consists of multiple tiers such as database server, application server, and presentation server or web server (Figure 22.9). *Database server* connects to database using JDBC (Java Database Connectivity), ODBC (Open Database Connectivity) or any other database connectivity API. *Application server* consists of the business logic and business components. *Presentation server* consists of the data presentation logic and client logic. The client can be an installable application on client machine or it can just be an Internet browser. If the client is a browser, it connects to the web server, which in turn connects to the application server. The application server further connects to the database server. The advantage with web client is even if business logic gets changed or presentation logic gets changed, client need not be installed. It is only the URL the client machine accesses.

Figure 22.9: N-Tier Architecture
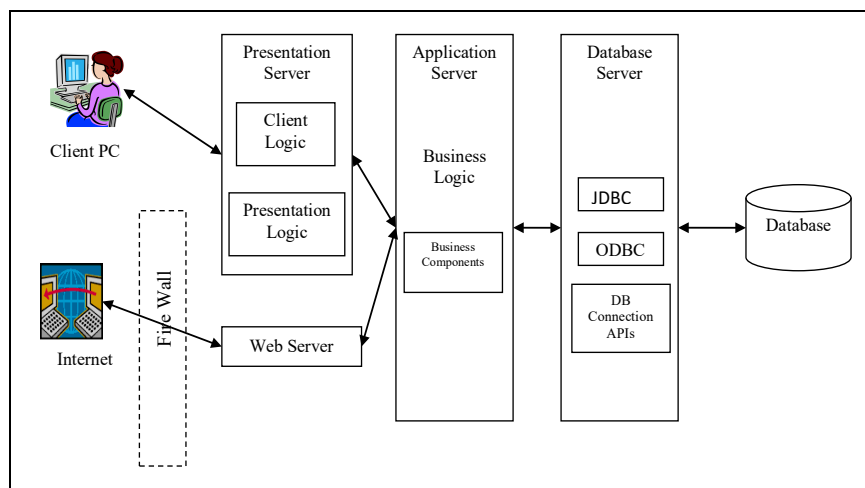
In case of installable client, if the presentation logic gets changed, the client executables need to be installed on all client machines. There can also be a firewall when web client connects to the web server and application server. N-tier architecture reduces the maintenance costs and increases the data security. It also saves lot of deployment, installation and configuration times of client programs in case of web clients. Client need not worry about the business logic or data access logic. There are many financial applications developed using N-tier architectures.

Activity: N-Tier Architecture

A US based retail store asked their offshore vendor in Hyderabad to develop a customer relationship management system. They do not want everybody to access the database. There should be restricted access to the data. They want user machines to have only presentation logic. The system should support more than 500 client connections. Information security is to be ensured. To achieve parallelism they have funds for many servers. They will be providing the business logic and business process to the offshore vendor. The offshore project manager is undecided about the type of architectural style which suits this requirement.

Answer:

22.8. Web Oriented Architecture (WOA)

Web oriented architectures are based on Web 2.0 technologies such as HTTP (Hyper Text Transfer Protocol), SSL (Secure Socket Layer) and XML (Extensible Markup Language). WOA represents specialized service oriented architecture. WOA can be built on existing SOA models. Web oriented architecture consists of layers such as infrastructure, service implementation (logical services), business processes, and presentation. It maintains an *integrator* which integrates all external web APIs. It implements the layers as individual services obtained from the web. It uses web services. The steps involved in web oriented architecture includes: defining the process models, refining the process models, provisioning the process models with data and implement the process models in development environment or workflow engine. Next section discusses the Service Oriented Architecture (SOA).

22.9. Service Oriented Architecture (SOA)

In service oriented architecture, the components are provided in the form of collaborating services. Each component of the system provides certain service with a specified interface. Thus, a *service* has a defined contract or interface to interact with or to access the services. An *interface* is nothing but the declarations of the operations or methods corresponding to a class. A service can be implemented as a component. From the Figure 22.3, Order Processing Service realizes the interfaces Customers and Products. Customers interface is dependent on Customer Class and Products interface is dependent on Product class. The interfaces contain the get () and set () methods for the data members of the class.

Figure 22.10: Order Processing Service
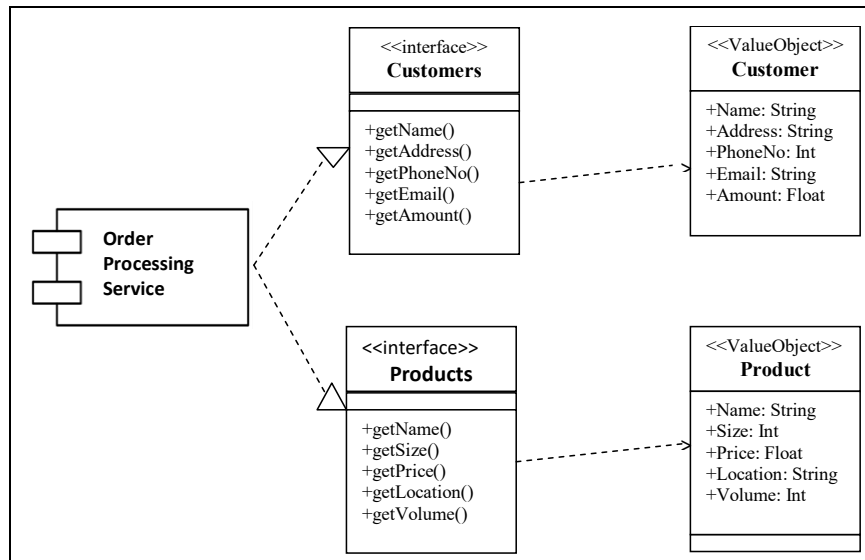
Thus, service oriented architecture consists of multiple collaborating services with well defined interfaces. Service oriented architecture can be implemented using web services. Service oriented architecture includes the service requester, service locator, service broker and service provider. Each service has to be registered first in order to access it.

22.9.1 Web Services

Web Services are the services provided over the Internet. They can be accessed using XML messages. There are two standards for the definition and discovery of web services. They are usage of WSDL (Web Services Definition Language) and UDDI (Universal Discovery, Description and Integration). Web services use XML messages with SOAP (Simple Object Access Protocol) headers. Web services use technologies such as SOAP, HTTP, MIME (Multipurpose Internet Mail Extensions), SMTP (Simple Mail Transfer Protocol), SSL, XSD (XML Schema Definition), XDSIG (XML Signature). Web services provide scalability, reliability and performance. An example of a web service can be customer management, which internally accesses the services such as customer and order management.

Activity: Web Services

A start-up organization is in a hurry to launch their online music store. The team is in the architecture stage. The architect is very enthusiastic to use Service Oriented Architecture (SOA). However CEO is in a hurry and he says that all services should not be developed from scratch. He

Contd. ....

suggests them to get services available over the Internet and develop the product quickly. The architect thinks about the kind of technologies and services that can be used from Internet. Help the architect and suggest what he has to use to develop this system.

Answer:

Check Your Progress-2

11. N-Tier architecture does not have _____ layer.
    a. Database server
    b. Application server
    c. Presentation server
    d. All of the above
    e. None of the above

12. _____ can be used for Database connectivity.
    a. JDBC
    b. ODBC
    c. DB Connection APIs
    d. All of the above
    e. None of the above

13. WOA stands for _____.
    a. WhatsApp
    b. Web Oriented Architecture
    c. Web App
    d. All of the above
    e. None of the above

14. A Service has interface to interact with.
       [TRUE/FALSE]

15. Web services use _____ messages.
    a. SMS Messages
    b. Pop Up Messages
    c. XML messages

    d.   All of the above

    e.   None of the above

22.10. Agent Based Architecture

Agent based architecture is based on designing the systems using loosely coupled interacting collection of agents. These agents can solve complex problems. Each agent does a specific task. An agent cannot do the entire complex task alone. As a group of agents, they together achieve the complex task. One agent does not know the work of the other agent. Collectively they can finish complex tasks like human engineering. Agents communicate based on the concepts derived from the linguistics theory. The prominent languages used in agent communication include Foundation for Intelligent Physical Agents, Agent Communication Language (FIPA-ACL) and Knowledge Query and Manipulation Language (KQML).

Agent architecture includes an *agent executive* who plans and controls the agent. Input and output messages of the agent are handled by the message handler. Agent maintains a record of its *capabilities*. It maintains its current state in *belief state* in a declarative form. It maintains conversation policy, role, goals and plans. Agent based architectures are used in distributed information systems. For example, if a distributed system uses CORBA and agent based development, there will be an agent corresponding to each CORBA application object.

22.11. Product Line Architectures

Product line is a series of related products with common components.
Product line can be developed in multiple ways. They are

i)   Revolutionary development of product line from scratch

ii) Evolutionary development of product line from scratch

iii) Evolving existing products into a product line

In revolutionary development of product line, entire product core components and products are developed at the same time. For this the requirements of all products are to be ready. In the evolutionary product development, first development starts with core components, then a product is developed. Based on the feedback further products are evolved. The third approach is based on the existing products, commonality is found out and core components are evolved from it. Then further components are

developed. The product line architecture is shown in Figure 22.11. First the product platform and core components are developed. Then customized components are developed for the respective product. Finally, integration of respective product with platform, core component and customized components happen.

Figure 22.11: Product Line Architecture
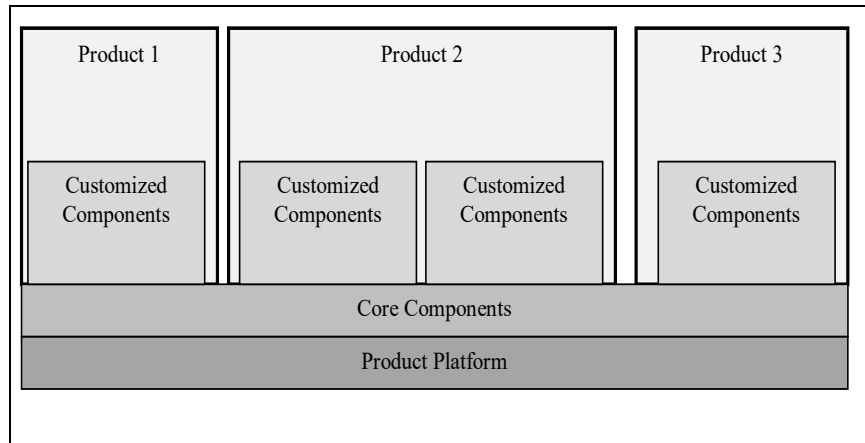
The best example for a product line is Microsoft Office Suite of products (Figure 22.12). It is based on Windows platform. On top of it core components such as COM (Component Object Model) and OLE (Object Linking and Embedding) components reside. Individual packages such as MS Office, MS Excel, MS Project, MS Publisher, MS Access and MS Power Point are made using the COM components. All these individual packages combined together comprises of MS Office family of products.

Figure 22.12: MS Office Family of Products
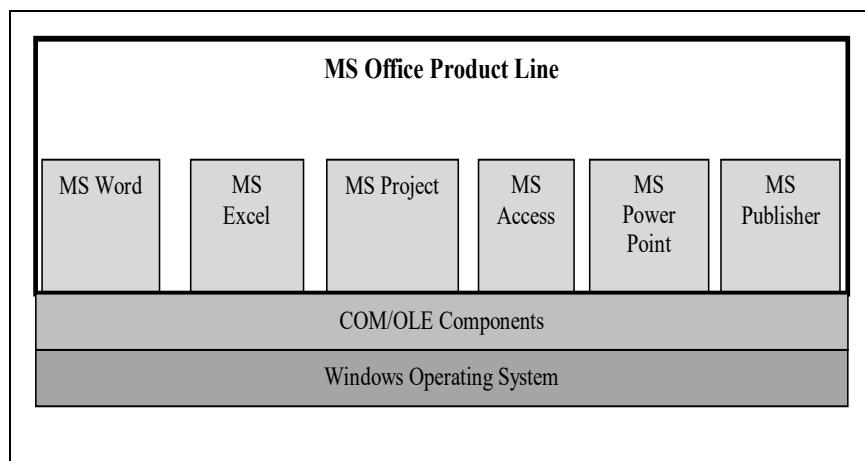
Check Your Progress-3

16. _____ is not a characteristic of an agent.

    a. An agent has a specific task

    b. Agents are loosely coupled

    c. Agents communicate with each other.

    d. All of the above

    e. None of the above

17. Agents can be used in distributed information systems development. [TRUE/FALSE]

18. _____ is an example of product line.

    a. MS Office

    b. Hot mail

    c. Apache Tomcat

    d. All of the above

    e. None of the above

19. Product line should have _____.

    a. Product Platform

    b. Core Components

    c. Both a and b

    d. Beautifying Components

    e. None of the above

20. Product line can be developed using _____.

    a. Revolutionary development from scratch

    b. Evolutionary development from scratch

    c. Evolving from existing products

    d. All of the above

    e. None of the above

22.12. Summary

- Software design is very vital for any software system.
- *Design is nothing but a blue print.* The importance of design and architecture is highlighted in the unit.
- Major methodologies, approaches, techniques of design and architecture are discussed.
- The structured system analysis and design, object oriented analysis and design and component based design are discussed.
- Different application architectural approaches such as pipes and filters, message queues, blackboard (shared memory), event based architecture and client-server architecture are explained.
- The N-tier architecture, which is an improvement over 2-tier architecture, is described.
- Web Oriented Architecture, Service Oriented Architecture and web services are explained. The agent architecture and agent based design for distributed information systems are described.
- The product line development with an example is explained in the unit.

22.13. Glossary

Component Object Model (COM)

It is the component based technology from Microsoft. COM components are used for communication between different applications developed in different programming languages running on same Windows platform/machine.

Java Database Connectivity (JDBC)

It is a driver technology used to connect Java program to a database. A Java program can connect to and query the database using JDBC. There are APIs (Application Programming Interface) provided by JDBC. It was developed by SUN Microsystems.

Object Linking and Embedding (OLE)

It is the technology from Microsoft. It is useful to embed different objects into a document. This technology allows embedding different data and objects into a document to make it a compound document.

Object Modeling Technique (OMT)

It is an object oriented analysis and design methodology. It was developed by Rumbaugh, Blaha, Premerlani and others in early 1990s at General Electric Corporation. This methodology describes a software system to have *object model, dynamic model* and *functional model*.

Open Database Connectivity (ODBC)

ODBC is used for connection of program to a database management system such as Oracle. It provides APIs. ODBC drivers are available in the market. It was originally developed by Microsoft in early 1990s. Programs written in different programming languages can connect to database using ODBC APIs.

Process

A process is a program under execution. There will be many processes running on an operating system. UNIX and Windows support multi-processes.

Signal

Signal is an event which happens either internally or externally to an application. Signals can be handled using signal handlers. That is a signal handler is to be registered at the initiation of the program.

Thread

A thread is an independent tiny part of a process. It is part of a process. There can be multiple threads inside a process running simultaneously. Threads can communicate with each other.

22.14. Self-Assessment Test

A small educational institution would like to have computerized student database management system. The only users for this system are around 6 employees of the institution who are in the same location. Suggest architecture for this system.

1. How is OOAD different from SSAD? What are its advantages over SSAD?

2. Explain any two standards supporting component based design and development.

3. What application architectural approaches can be applied to UNIX based software systems design? (Hint: use the content in the unit itself)

4. Explain N-Tier architecture. What are its advantages over 2-Tier architecture?

5. How is product line different from a single product? Explain.

22.15. Suggested Readings/Reference Material

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22.16. Answers to Check Your Progress Questions

1. **(b).** SSAD stands for Structured System Analysis and Design.

2. **TRUE.** OOAD makes use of objects, classes, inheritance, polymorphism, encapsulation and abstraction.

3. **(e).** CORBA, DCOM and EJB support component based development.

4. **(a).** DCOM is a technology from Microsoft.

5. **(c)**. RMI stands for Remote Method Invocation.

6. **(e).** Architectural views include logical view, process view, implementation view, deployment view and use case view.

7. **(a).** Filter transforms the data and pipe transmits the data.

8. **TRUE.** Messages in message queue are executed in first-in-first-out order.

9. **(c).** Both processes and threads share the shared memory or blackboard.

10. **(e).** Application architectural approaches include pipes and filters, message queues, blackboard, event based architecture and client-server architecture.

11. **(e).** N-Tier architecture has database server, application server and presentation server.

12. **(d).** JDBC, ODBC and DB Connection APIs can be used for database connectivity.

13. **(b).** WOA stands for Web Oriented Architecture.

14. **TRUE.** A *service* has an *interface* to interact with.

15. **(c).** Web services uses XML messages.

16. **(e).** Agent has a specific purpose. Agents are loosely coupled. Agent interacts with other agents.

17. **TRUE.** Agents can be used in distributed information systems development.

18. **(a).** MS Office is an example of product line or family of products.

19. **(c).** Product line should have product platform and core components.

20. (d). Product line can be developed using revolutionary approach from scratch, evolutionary approach from scratch or evolve from the existing products.

Unit 23

Mobile and Social Technologies

Structure

23.1   Introduction

In the previous unit, we learnt about Software Design Approaches, Object-Oriented Analysis and Design (OOAD), N-Tier Architecture, Web Oriented Architecture, Service Oriented Architecture (SOA), Agent Based Architecture and Product Line Architectures.

In 1890, Tesla introduced concept of wireless communication to the world G. Marconi well known as father of radio invented transatlantic electromagnetic waves for radio transmission in 1901. Since then mobile and wireless technologies have undergone a lot of changes. Those electromagnetic waves supported small quantity of data and data transmission speed was very slow. The coming up of 5G mobile technologies assure 20 Gigabits-per-second (Gbps) peak data rates and 100+ Megabits-per-second (Mbps) average data rates. Mobile devices having sensors are able to exchange information and data with clouds over the Internet. Mobile devices are becoming smarter and context sensitive. They are getting integrated to social networking sites as well. Mobile technologies reduce costs, increase efficiency and accuracy of data transmission.

In this unit, different generations of mobile technologies, advantages of mobile technologies and risks with mobile technologies are discussed. Mobile operating systems, advanced mobile technologies and future of

mobile technologies are discussed. The benefits of social technologies, components of social technologies, characteristics of social technologies and challenges with social technologies are explained. The application areas of social technologies and social networking sites are mentioned in the unit.

23.2   Objectives

The objectives of this unit include:

- Describe different generations of mobile technologies
- Mention advantages of mobile technologies
- Describe mobile operating systems
- Explain risk factors involved in mobile technologies
- Explain the future of mobile technologies
- Mention about handheld and wearable devices
- Describe benefits of social technologies
- Explain the components of social technologies
- Specify the characteristics of social technologies
- Specify the challenges with social technologies
- Mention the application areas of social technologies
- Mention social networking sites

23.3   Mobile Technologies

5G is the fifth generation of wireless technology. It has one of the fastest, most robust technologies the world has ever seen. That means quicker downloads, much lower lag and a significant impact on how we live, work and play. The connectivity benefits of 5G are expected to make businesses more efficient and give consumers access to more information faster than ever before. Connected cars, smart communities, industrial IoT, immersive education—they all will rely on 5G networks. Samsung, Huawei, Nokia, LG, Ericsson, Qualcomm, ZTE, Orange, Verizon, AT&T, NEC Corporation, and Cisco are 5G hardware manufacturers.

Mobile technology is basically preferred in cellular communication. It works on frequency and uses single frequency to communicate. Multiple users can share this frequency using frequency division techniques. Early ear mobile were used as standard device for communication purpose but within short span of time its role has diversified as multitasking device. Along with cellular phone it acts as GPS navigator, Gaming console,

entertainer device, device to brows world wide web, and like such countless number of application handler. Experts believe that future of computer lies within mobile devices. This wireless technology gave new dimension to computing devices.

Currently, Sprint, China Mobiles, T-Mobile, AT & T & Verizon like companies are working towards 5G technology. The speed of 5G technology is 100 times faster than the current 4G technology

23.3.1 Different Generations of Mobile Technologies

There are four different generations of mobile technologies. They are:

23.3.1.1 1st Generation Mobile Technologies

1st generation mobile technologies supported only voice services. 1st generation mobile technologies were first introduced in car phones in the 1940s in US and in the 1950s in Europe. They have restricted capacity, mobility, poor speech quality and limited services. 1st generation systems include Nordic Mobile Telephone (NMT), Advanced Mobile Phone System (AMPS) and Total Access Communication System (TACS). The standards used in 1st generation mobile technologies include cordless telephones (CTI, CTO), private mobile radios, cordless telephone cell, paging systems, cellular systems (AMPS, NMT) and mobile satellite systems (INMARSAT).

23.3.1.2 2nd Generation Mobile Technologies

2nd generation mobile technologies supported data, message and fax services. 2nd generation mobile technologies in Europe used GSM (Global System for Mobile communications). GSM used digital modularization, improved data quality and limited data services.. 2nd generation systems used microwave technologies and semiconductor technologies supporting digital transmission. Encryption of data and fraud prevention were introduced in 2nd generation. 2nd generation supported cellular systems include Digital AMPS, Personal Digital Communication (PDC) and Code Division Multiple Access (CDMA). *2G architecture* includes the core network consisting of servers, switches and trunks. The standards used in 2nd generation mobile technologies include cordless telephone (DECT, PACS), WLL, paging systems, private mobile radio (TETRA), cellular systems (PDC, GSM, D-AMPS) and mobile satellite systems (IRIDIUM, GLOBALSTAR and ICO).

In between 2G and 3G there is 2.5G. It supported GPRS (General Packet Radio Service). It can send text and graphics at high speed. It helped in different stakeholders preparing for 3G.

23.3.1.3 3rd Generation Mobile Technologies

3^{rd} generation mobile technologies added multimedia services to 2^{nd} generation mobile technologies. It supports audio, video, and graphics. One can watch streaming video using 3G technologies. The main objective of 3G is to use single network standard across US, Europe and Asia. 3G supports speed up to 2Mbps. It supports higher data rates and many Internet applications. It supports both packet switched and circuit switched data transmission. It has high spectrum efficiency. 3G cellular services are known as UMTS (Universal Mobile Telecommunications System). UMTS supports packet switched digital audio, video, text and multimedia transmission.

Today's cellular systems are based on circuit switched type supporting services such as alternative billing methods and video conferencing. 3G has increased bandwidth up to 384 kbps. 3G works in US, Europe and Asia. The single standard used in 3^{rd} generation mobile technologies includes MC-CDMA, IMT-2000, TD-SCDMA or UMTS. There were financial challenges in addition to technical challenges for 3G.

23.3.1.4 4th Generation Mobile Technologies

More advanced features are available in 4^{th} generation mobile technologies. These were expected to be in the market by 2010. 4G supports data transfer up to 20 Mbps. NTT Docomo and HP are working on 4G technologies. 4G supports 3-D virtual reality. In 4G, people, products and places can interact as a real world objects. Using 4G, the smart card in phone can pay the bill for goods by the time one passes through the kiosk. The mobile phone can send signal to a car to warm up by the time the driver is about to leave the home using 4G. 4G can overcome the bandwidth problem of 3G.

4G provides better quality images than TV quality. It uses technologies such as HTTP, Java, HTML and GIF. 4G is built on 3G combining W-CDMA, EDGE and CDMA2000. 4G wireless systems support the protocol suit given by Department of Defense consisting of transport layer protocols, medium access protocols, error control protocols, physical test bed, simulation test bed and mobility management. The main concern in 4G is due to high network speed, it can experience disturbance from other network objects. Another concern is the in-compatibility of different applications.

23.3.1.5 5th Generation Mobile Technologies

Deployment of 5G technology has already started in 2019. This is wireless digital cellular network of 5th generation. Service providers are providing 5G services into smaller geographical regions. These small geographical regions are known as cells. All 5G wireless devices in a cell are communicating using radio waves or microwaves. Important features of 5G technology include higher speed of communication, low latency rate and its ability to connect more number of devices operating at high speed simultaneously.

5G wireless technology is the result of high demand of video based applications over wireless networks and growth of Internet of Things (IoT). Major Technologies which enables 5G are – Device to Device (D2D) connectivity, Machine to machine (M2M) communication, Multiple- input-multiple-output (MIMO) technology, All-spectrum access (ASA), mm Wave communication, Ultra-dense network (UDN) and Orthogonal frequency division multiplexing (OFDM).

Major applications of 5G Technology are – Cloud based applications, Blockchain, 3D and ultra-high definition (HD) video applications, driverless cars, Virtual reality and Internet of Things (IoT).

23.3.2 Mobile Operating Systems

Current day mobile operating systems support the *cognitive* capabilities in mobile devices. *Cognition* is nothing but taking action based on understanding, knowledge, thought and senses. This is possible for mobile devices using sensor technologies. *Mobile operating system* consists of different layers such as core operating system layer, core services layer, media layer and user interface (UI) layer. The advancements in mobile operating systems are coming in areas such as information security, storage, powerful processing, high speed connectivity, image resolution and tighter integration.

The improvements on mobile operating systems include support for media protocols, multi-tasking and improved security. Android from Google and iOS from Apple are representative mobile operating systems having advanced features. Different releases of starting from 1.5 to 9 are named after sweets or dessert include 1.5 – Cupcake, 1.6 – Donut, 2.0-Éclair, 2.2.x – Froyo, 2.3 - Gingerbread, 3.0 - Honeycomb, 4.0- Ice Creame sandwich, 4.1 - Jelly Bean, 4.4.4 – KitKat, 5.x- Lollipop, 6.0 – Marshmallow, 7.x – Nougat, 8.0 – Oreo, 9.0 pie. Android include Gingerbread, Honeycomb, Jelly Bean and Ice Cream Sandwich. Different releases of iOS include iOS3, iOS4, iOS5 and iOS6. Both Android and iOS account for more than 90% mobile operating system market. There are many innovations coming

up in mobile operating systems driven by market intelligence. In each new release of the operating system, organizations are making nearly 30 new enhancements. 3/4th of these enhancements are being done in core services layer and User Interface (UI) layer.

23.3.3 Advantages of Mobile Technologies

Mobile technologies bring the advantages such as *mobility* and *flexibility*. Smartphones are capable of learning user experiences. They can work as digital assistants. Cloud computing and huge data (big data) analysis are being integrated into mobile technologies. Sensors, powerful processors, memory (DRAM), storage, display and high speed networks are being used in mobile devices. Wearable devices such as smart watches can sense the human movements. These devices are being integrated into clouds. The sensors in wearable devices capture data and bring actionable insights to the users.

Do You Know?

In 2026, 5G networks will carry more than half of the world's smartphone traffic. Globally, the average usage per smartphone now exceeds 10GB, and is forecast to reach 35GB by the end of 2026.Video traffic currently accounts for 66 percent of all mobile data traffic and is expected to increase to 77 percent in 2026.Populous markets that launch 5G early are likely to lead traffic growth, with large variations between regions.

Mobile data traffic is growing at 66% per year.

Mobile devices can transmit data *fast* and *accurately*. Mobile devices can make use of Internet access points in airports, public building, hotels and educational institutions. RFID (Radio Frequency Identification) is another technology used in transporting products and supply chain management. Mobile devices can be used in rural areas to train the farmers in agriculture and to counsel the patients seeking healthcare. Instant messaging services can be used for this purpose. Mobile technologies reduce the costs and provide the greater ease of use. Mobile technologies can be used for social transformation in developing and underdeveloped countries. Mobile technologies can be used in changing behaviors of the affected people such as drug users and HIV effected people as was done in South Africa. Mobile devices can be used in education, environment, healthcare, democracy, citizen media and humanitarian relief projects.

23.3.4 Risk Factors in Mobile Technologies

The risks associated with mobile technologies include *exploitation, intrusion* and *leeching.* The risk factors such as *safety* and *security* are to

be looked at by the users while using mobile technologies for personal purposes. End users are to be careful while transmitting photos, images, audio and video files over the mobile networks. Many people make private conversations in public places creating threat for them. It will exploit security vulnerabilities. *Accidental intrusion* is also possible in mobile networks. The risks associated with mobile technologies include loss of data, theft of mobile devices, theft of capacity, and possible system integrity problem. There can be *active* or *passive* attacks on the mobile devices and networks. Unauthorized access to the network can be used for sending spam and any other illegal content.

23.3.5 The Future of Mobile Technologies

It is true that mobile technology has changed our lives. Mobile Industry has shown tremendous rate of growth. The most striking aspect of mobile technology development is exhibited by the rate at it blends with daily life of human beings. Best example of this is Internet of Things (IoT), in which personal devices are connecting to each other to make life comfortable and safer. Virtual Reality and Augmented Reality can enhance different life experiences.

4G systems in Japan uses i-mode technology. AT&T in US has launched m-mode services based on Wireless Application Protocol (WAP) technology. By 2016, there will be more innovations in mobile operating systems. They include better security, ultra high definition video, cloud access points, integration with social networks, ubiquitous high speed connectivity, tighter integration, cognitive capabilities, integration with sensors and web. The sensors can capture context and situational information. The future mobile telephones can capture the context information and can suggest the user about actions to take. They can understand his social network, relationships to objects, places and people. The mobile phones can come up with cognitive capabilities having *contextual awareness*. *Contextual awareness* is having knowledge and understanding about place, product, people and situation. This contextual awareness transforms the mobile phones into digital assistants. It can find the user's needs, desires and intentions. Predictive models used in context aware technologies extract information from three different sources such as mobile device, user and environment.

The innovations in mobile computing depend on integration of applications, communication networks with the sensor devices. The applications in mobile devices draw information from virtual, physical and social environments of the users. The mobile devices start exchanging data and information from the sensor devices embedded in physical objects with the clouds over the Internet. In Future, smart phone can take picture

of the food ordered in the restaurant, calculate the calories going to be consumed and suggest how the remaining calories have to be taken by the user on that specific day.

Mobile is a pervasive technology and According to <u>Statista</u>, 7 billion people will be mobile users by 2021. According to <u>App Annie</u>, by 2020's second quarter, streamed hours increased by 40% and Banking applications downloads hit a new record of 4.6 billion downloads. Exhibit 23.1 presents the future trends on mobile technology

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Exhibit 23.1: Top 10 Mobile Technologies to Look Out for in 2021

1. Instant Apps for The Android Users: These instant apps are software that enables the users to test run a native android application without having to install it.

2. Cloud-based Mobile Applications: Both users as well businessmen claim that these cloud-based applications such as Dropbox and Google Drive have helped them with their IT strategies, and hence will be on rise.

3. Artificial Intelligence: There have been some advances in artificial intelligence, mainly in the telephonic industry, like Siri, Google Assistant, Alexa, and Cortana. Face and speech recognition features are some of the few artificial intelligence enhancements.

4. Healthcare Focused Application: These applications benefit health professionals and health conscious people. An example of a healthcare-focused application is Fitbit. Some examples of healthcare-focused software are: Fitness bracelets, Smartwatches, Healthcare monitors.

5. Cross-Platform Development: Cross-Platform Mobile applications are the new advancements in the mobile technology world.

6. Applications for Foldable Devices: Foldable phones are coming back to the world. Samsung recently introduced the Samsung Galaxy Fold while other devices are still on their way.

7. IoT for Smart Devices: Fitbit had focused on wearable devices that helped the development process of mobile applications i.e. integration of phones with other smart devices.

8. Reality or Augmented Reality? Many mobile companies are now adopting augmenting reality in their businesses like Snapchat, Instagram, and Pokémon Go.

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9. Mobile Payments
   Another trend is increased online mobile payments as mobile security has improved over the years

10. Virtual Reality
    People would eventually adapt to this and start using goggles or helmets. Each user would have a separate controller that could be paired with the mobile applications.

Source: https://www.techfunnel.com/martech/mobile-technology/ July 2021

23.4   Handheld and Wearable Devices

Handheld devices include iPod, iPad, Tablet, Palm Pilots, iPhone, etc. Using handheld devices one can store and transmit audio and video data. Wearable devices record the physical activity. They monitor health and wellness as well. Smart glasses capture audio, video and images. Mobile innovations are redefining the market opportunities, customer demand and customer expectations in the mobile market. Handheld and wearable devices are able to communicate with sensors, social technologies and clouds. For example, NTT Docomo has launched a wellness phone which integrates pedometer and health monitoring software. The data collected through sensors is analyzed and health related insights are provided to the user.

Activity: Mobile Technologies for Counseling

A government faces the challenge of a lot of HIV infected people in the country. It does not have the money to provide healthcare support services or counseling. However, they came to know that by educating infected people the impact can be reduced. They have volunteers to serve the purpose. The government is looking for quick and cost effective solution. The system should also maintain privacy of infected people. Suggest a technology to this government in order to fight with the epidemic.

Answer:

Check Your Progress-4

1. _____ Generation of mobile technologies can do faster data transfer.
   a. 1st Generation
   b. 2nd Generation
   c. 3rd Generation
   d. 4th Generation
   e. None of the above

2. GSM stands for _____-.
   a. Global System for Mobile Communications
   b. General Systems Manual
   c. Global Sync Mode
   d. All of the above
   e. None of the above

3. Give two examples of mobile operating systems available in the market.

4. Future mobile phones have context aware capabilities.
   [TRUE/FALSE]

23.5   Social Technologies

The popularity of the social technology is growing day by day in the society. The term 'social technology' is often referred to digital social networks like Facebook, Twitter, LinkedIn, WhatsApp, etc. but its scope is more than that.

Social technologies can be defined as digital technologies used by people to interact socially together to create, enhance and exchange content. These social technologies distinguish themselves through the following three characteristics –

1. They are enabled by information technology.
2. They provide distributed rights to create, add and/or modify contents and communications.
3. They enable distribution access to consume content and communication.

Social technologies (fig 4.1) incorporate various technological instruments. These instruments are used by people for interaction purpose. It can be classified as social media, Web 3.0 and collaborative tools.

These technologies can be described using three dimensions –

1. Richness – The ability to convey verbal and nonverbal cues, and facilitate shared meaning in a timely manner.
2. Interactivity – The extent to which rapid feedback is allowed.
3. Social presence – The degree to which virtual team members feel close to one another.

Amongst these technologies some may applicable for conveying data-information-knowledge (e-mail) while others may better suited for convergence-related tasks such as decision making (videoconferencing).

Below figure lists social collaborative tools and technologies with three separate groups – e-business tools, e-government tools and e-community tools. This separation is only conditional because every tool used in certain sphere has a potentiality to be used in other one.

Social technology is a way through which social process is influenced by human, intellectual and technology resources.

Social technologies are being used widely across the globe by both individuals and businesses. They are being used for customer relationship management, customer support, product promotion, corporate communications and e-commerce. Business houses are creating value out of social technologies. In 2021, there are **4.48 billion people** actively using social media in the world, and this is an increase of 13.13% year-on-year from 3.69 billion in 2020. Social technologies have impact on organizational business strategy, organizational performance, financial performance, business decision making, team work, individual productivity, team productivity and individual careers (Figure 23.1).

Figure 23.1: Impact of Social Networking on Organization
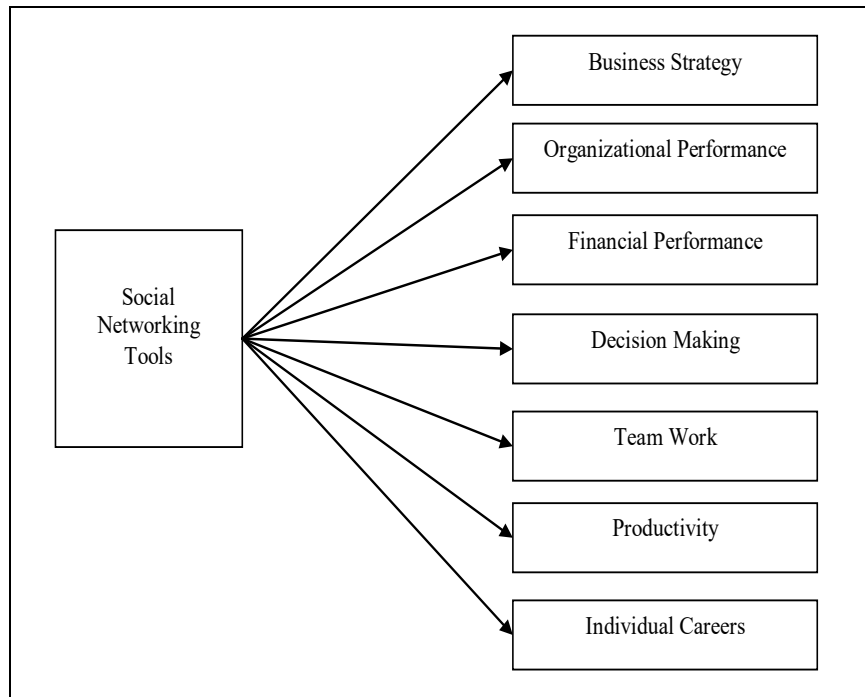
The benefits of social technologies are discussed in the next sub-section.

23.5.1 Benefits of Social Technologies

The benefits of social technologies include:

- Organizations are using crowd sourcing for getting product ideas and for identifying new features and enhancements for existing products.

- Social technologies enable users to publish, consume and share content over the Internet.

- Social technologies record the relationships and interactions happening on the sites.

- Some users can socially influence others using social technologies.

- Social technologies enable organizations to be connected both technically and behaviorally.

- Organizations can get insights from customer conversations on social networking sites and use those insights for product marketing purposes.

- Social technologies provide distributed rights to consumers to add, share, modify and consume the content.

- Social technologies can create sales leads for the organization.

- Social technologies can provide customer support and customer care.

- Social technologies can be useful for social transformation.

23.5.2 Components of Social Technologies

The components of social technologies include social networks, social gaming, social commerce, blogs, micro blogs, Wikis, discussion forums, document sharing, media sharing, crowd sourcing, workspace sharing, rating and reviews of products. These can be used by consumers as well as organizations.

23.5.3 Characteristics of Social Technologies

The characteristics of social technologies include:

- They have high potential impact on society.

- Social features can be embedded into any technology which requires people interaction.

- Social technologies impact the social behaviors online with scale and speed of Internet.

- Social technologies create platform for content creation, distribution and consumption.

- Social technologies can be disruptive to current organizational structures and governments.

- Social technologies can increase transparency.

- Social technologies enables manufacturers and product consumers to share a common platform where in manufacturer can get insights which he or she won't be able to get directly.

- Social technologies can derive the nature of interaction between individuals.

Do You Know?

It took 13 years for TV to reach 50 million homes. It took 3 years for Internet to have 50 million subscribers. It just took Facebook a year to have 50 million users. Twitter could reach this target in just 9 months. Just observe the speed of growth of social technologies!

23.5.4 Challenges with the Social Technologies

Many people store personal and family photographs and images on the social networking sites. It creates an opportunity for others to misuse the images and photos leading to security vulnerability. The challenges or risks with social technologies include identity theft, data loss, loss of intellectual property, reputation damage, violation of privacy and abuse. Social technologies can also transform the business models. For example, on

social networking sites, unknown people comment on ones posts and blogs. This may also lead to bullying as well. The other risks include employees chatting about management or organization on social networking sites and employee commenting on fellow employees on external sites. Breach of consumer policies is also possible over social networking sites.

23.5.5 Application Areas of Social Technologies

The application areas of social technologies include healthcare, consumer products, banking, manufacturing, retail, education, software, telecommunications, energy, insurance, utilities, construction, chemicals, food and beverages, government, pharmaceuticals, media, entertainment and transportation. The latest social media statistics show that there are 3.78 billion social media users worldwide in 2021 – and this number is only going to continue growing over the next few years. Among companies, high growth companies are mostly likely to use social technologies for organizational benefits.

23.5.6 Social Networking Websites

Social networking sites on Internet include LinkedIn, Facebook, Twitter, Google+ and Whatsapp, etc. In 2020, Out of its 2.85 billion monthly active users: 98.5% / 2.8 billion access Facebook through mobile devices like phones and tablets. 81.8% / 2.33 billion access Facebook only through a mobile phone. Individuals also benefit from social technologies. They get satisfaction over the relationships they maintain. Social networking sites play major role in providing humanitarian help and disaster recovery. To deal with social technologies, organizations should have open, flat (non-hierarchical) and knowledge sharing culture. Social technologies also impact organizational culture and organizational structures. This is because organization such as Infosys has internal social networking site or discussion forum to encourage employee communication. Social networking sites reduce cultural and organizational barriers, if risks are handled well.

Activity: Customer Insights on Product

A manufacturing organization is facing the challenge of many returns of a specific product. Many customers are returning the product without giving any reason. The product revenues are going down. However, the organization does not want to withdraw the product from the market. It would like to improve the quality of the product and re-launch the

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improved version in near future for long term benefits. They would like to know what customers are talking about the product in the market. At the same time, they do not want to conduct a direct customer survey through questionnaire, which has the negative impact on the organization. Suggest how this organization can get the customer insights for the product using technology?

Answer:

Check Your Progress-5

5. Social Technologies have impact on _____.
   a. Business strategy
   b. Productivity
   c. Decision Making
   d. All of the above
   e. None of the above

6. _____ is/are benefits of social networking for the organizations.
   a. Improved productivity
   b. Marketing insights
   c. Crowd sourcing for product ideas
   d. All of the above
   e. None of the above

7. Mention few application areas of social technologies.

8. _____ is not an example of social networking site.
   a. Facebook
   b. Twitter
   c. LinkedIn
   d. All of the above
   e. None of the above

23.6 Summary

- Mobile and social technologies are useful for business organizations, society, community and governments. These

technologies can be used for social transformation in developing countries.

- With the advancements in technologies, the data transfer quantity and speed are increasing in mobile networking. They are leading to the need for data analysis and analytics.

- The sensor devices in physical objects are able to exchange information and data with the clouds over the Internet. Useful actionable insights can also be drawn from this data.

- Different generations of mobile technologies, mobile operating systems, advantages of mobile technologies and risks with mobile technologies are discussed.

- The future of mobile technologies and advance mobile technologies are also highlighted.

- The social technologies, advantages of social technologies, challenges with social technologies, components of social technologies, characteristics of social technologies, application areas of social technologies and some of the social networking sites have been discussed. .

23.7   Glossary

Business Model

It represents how the product gets marketed, sold and priced. It involves the identification of revenues, expenditure and a look at the margins as well. It also includes the supply chain, contract handling, vendor pricing and customer pricing, etc. Overall, it looks at how the profits can be made to the organization, how revenues can be generated and what are the expenses. Business model consists of portfolio of products and services.

Product Promotion

It is about making the product and its features to the wider audience, who can become the probable customers for the organization. The traditional way of product promotion is done through trade shows and exhibitions. The modern way of promoting product is through mobile and social technologies.

Sales Lead

It is getting a tip of information on potential customer. That is, getting a bit of information about individual or organization, who can purchase the organization's product.

Sensors

These are the tiny devices embedded in physical objects. For example, embedding a GPS device in shoe or watch, can gather data from the user and environment and provides useful insights such as providing direction and number of calories burnt while jogging to the end user.

Wireless Application Protocol (WAP)

It is the protocol used by wireless applications to access data and exchange data over the wireless network.

23.8   Self-Assessment Test

1. A backward state in India would like to increase their literacy rate drastically. They need cost effective and technology based solution for that purpose. Suggest a technology and devices for their purpose.

2. What are the advantages of 3G over 2G mobile technologies? Explain.

3. What the areas of impact of social technologies and social networking sites in the organization?

4. Mention the industries in which social technologies can be used.

23.9   Suggested Readings/Reference Material

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23.10 Answers to Check Your Progress Questions

1. **(d).** 4th generation mobile technologies can do faster data transfer.

2. **(a).** GSM stands for Global System for Mobile communications.

3. Android from Google and iOS from Apple are best examples of mobile operating systems.

4. **TRUE.** Future mobile phones have context aware capabilities.

5. **(d).** Social technologies have impact on organizational business strategy, productivity and organizational decision making.

6. **(d).** The benefits of social technologies include marketing insights, improved productivity and crowd sourcing for product ideas.

7. The application areas of social technologies include healthcare, consumer products, banking, manufacturing, retail, education, software, telecommunications, energy, insurance, utilities, construction, chemicals, food and beverages, government, pharmaceuticals, media, entertainment, and transportation.

8. **(e)** Facebook, Twitter and LinkedIn are examples of social networking sites.

Unit 24

IT and Business Process Management

Structure

24.1.   Introduction

In the previous unit we discussed about Mobile Technologies, Handheld and Wearable Devices and detailed about Social Technologies.

The objective of business process management is to deliver value to both internal and external customers by using information technology. Business processes are defined and reengineered to reduce costs, increase revenues, reduce processing times, reduce turnaround times and increase customer satisfaction. There should be commitment from the top management team in managing business processes. This is because process management leads to change management in the organization. The senior management should be managing the resistance from people in the organization. In case of business process reengineering (BPR), there should be dedicated team for BPR activities. Organizations such as American Express, AT & T and Ford have managed and reengineered business processes and saved millions of dollars.

In this unit, business process management process is explained. The steps in business process management such as process definition, process design and process reengineering are discussed. The business process flow design is represented as business process model. Business process model and notation for an example business process are explained. The role of IT in business process management is highlighted. The combination of usage of MIS in the organization with business process management systems is

explained. Communication enabled business process functionality is described. Example business process management tools available in the market are mentioned.

24.2. Objectives

The objectives of this unit include:

- Explain the Business Process Management procedure in the organization

- Discuss Business Process definition

- Explain designing Business Process

- Explain reengineering Business Process

- Mention example Business Process Model and Notation (BPMN).

- Highlight the role of IT in Business Process Management

- Explain the organizational MIS collaboration with business Process Management System

- Describe Communications Enabled Business Process (CEBP)

- Specify Business Process Management tools used in the industry

24.3. Business Process Management

The origins of Business Process Management in the industry was with the landmark article of Michael Hammer (1990) titled "Reengineering Work: Don't Automate, Obliterate" published in *Harvard Business Review.* Later on more on business process reengineering was explained with many case studies in Michael Hammer and James Champy (Harper Business, 1993) *Reengineering the Corporation.*

Business process is sequence of activities or tasks executed in order to deliver value to either internal or external customer.

Examples of *business processes* include order processing, payment processing, invoice processing, billing the customer, invoice generation, transporting or shipping goods, credit card processing, debit card processing, and cheque processing, etc. Every organization has many interacting business processes in running their day to day business. Unmanaged business processes leads to delays, non-payments, contract violations, non-performance and dissatisfied customers. The *characteristics of business process* includes factors like it's substantial, measurable, adds value to customer and that it should have defined customer (internal or external).
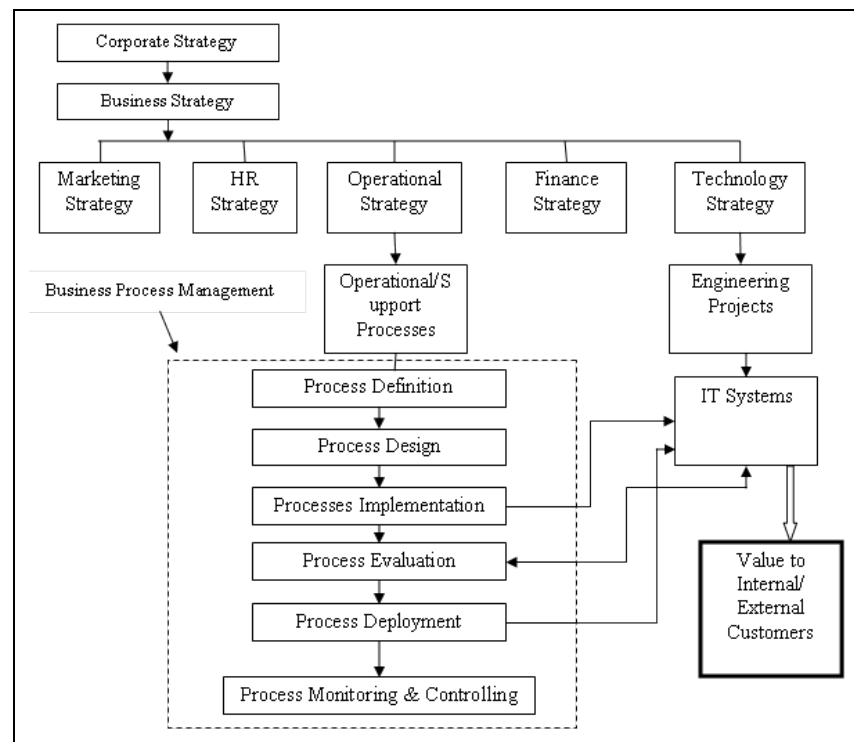
For organizational benefits, business processes are to be managed. Every organization has its corporate strategy. From this corporate strategy, respective business strategy is derived. From business strategy, functional strategies such as marketing, HR, finance, operations and technology are derived. From operational strategy, operational processes and support processes are derived. These are the processes to be managed in the organization.

Business Process Management procedure includes business process definition, business process design, business process implementation, business process evaluation, business process deployment and business process monitoring and controlling (Figure 24.1). The output of business process management becomes input to IT department for implementation. Business and IT have to work together in order to reach the objective. At the end, business process deployment takes place with the successful installation of IT system which reduces the time and which delivers the accurate results to the customer. There should be efficient communication between both business and IT teams.

Business process monitoring and controlling is a continuous process. It has to happen throughout the duration of the organization. There are also other processes in the organization other than operational processes related to specific business function of the organization such as finance, marketing, HR, engineering, etc. These are known as *core processes*.

Figure 24.1: Business Process Management


Activity: Business Process Management

An organization has a habit of issuing gifts to employees after completion of each project. For this, HR department sends the gift document to dispatch section to procure it, and it sends a copy of documents to finance department. The dispatch section sends the purchase order to vendor. Vendor sends the invoice and also the gift to dispatch section. The dispatch section then sends the invoice to finance department and hands over the gift to HR department. The finance department then pays to the vendor. Then, HR department presents the gift to respective employee. All this process takes minimum of two weeks. The gift reaches two weeks after project completion. How can this processing time be reduced? Suggest to the organization.

Answer:

24.4. Process Definition

The first step in business process management is *process definition*. This starts with identification of key business processes in the organization. This is possible with first defining the goals of the organization to be achieved. After defining the goals, identify the measures for those goals. Then think about how to achieve each measure. That is, the process or procedure to reach that figure. This will become the *business process*. This process has to be well documented. Different views of a business process include function view, data view, control view and deliverable view. Business processes are not isolated entities in the organization. They interact with the organizational business functions (Figure 24.2). The business processes interact with business functions such as HR, finance, marketing, IT, operations, and engineering. All the defined business processes are stored in the *business process factory,* which is a repository of business processes. The processes of an organization can be *internal processes* or *collaborative processes*. Collaborative processes involve more than one organization.

Figure 24.2: Business Processes Interaction with Business Functions
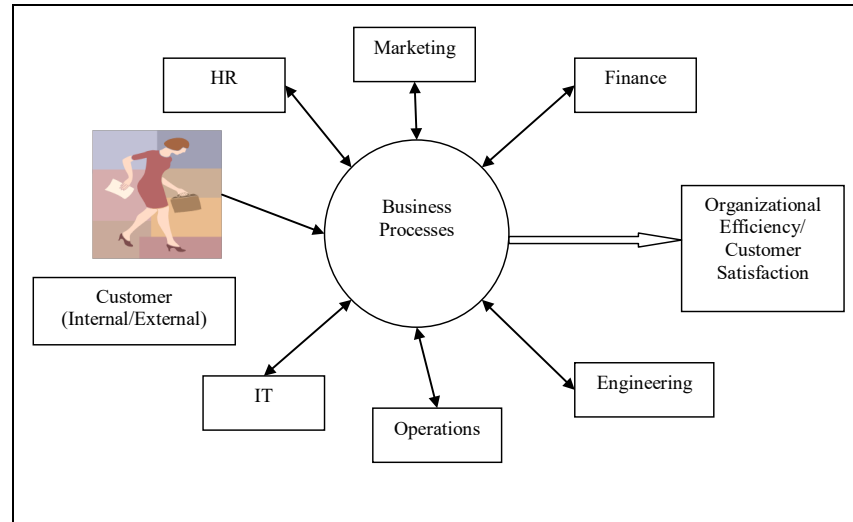
For example, an organizational goal is to increase profits by 10%. For this the business processes to be managed or reengineered are to be identified. It is possible with following steps:

- How to achieve this target? ANS: by increasing sales and by reducing costs

- Who can increase sales? ANS: Marketing and Sales departments

- Who can reduce costs? ANS: Finance Department

- What are the activities of Marketing & Sales department? ANS: Advertising and selling

- What are the activities of Finance Department? ANS: Cost structure

Thus *advertising process, selling process,* and *costing process* in the organization are to be reengineered or managed in the organization to reach the goal. Like this further sub-processes can also be identified.
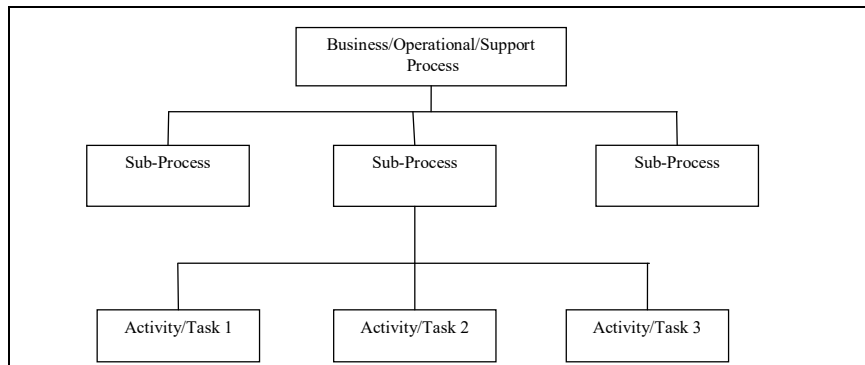
24.5.   Process Design

Once process is defined, it has to be split into sub-processes and activities/tasks as shown in Figure 24.3. Each process is divided into sub-processes and sub-process is further divided into activities or tasks. (as we do in work breakdown structures in case of software projects). The sub-processes and tasks or activities are then implemented using IT systems. In some cases, entire automation may not be possible. It may require human intervention. It is best practice to have an owner for each process. The main objective of process design is to remove waste and time consuming activities in the organization. The process design in the organization is affected by entry of new technologies, new products,

mergers and acquisitions, regulatory changes and changing market conditions. Process design can be done in *structural* (Figure 24.3) and *behavioral or flow design*. The design has to be represented in a pictorial form using BPMN (Business Process Model and Notation). The flow design shows the sub-processes or sequence of activities that take place in the process based on certain decisions.

Figure 24.3: Business Process Design (Structural)

<div style="border:1px solid">

Example: Process Design of Leadership Process in an Organization

Leadership is the core process in an organization. This process consists of the sub-processes such as

Developing vision and mission; developing core values; managing organizational structure; process management; managing change; developing and managing internal relationships; developing and managing external relationships; creating excellence culture; developing leadership profile; and managing and monitoring key performance measures.

The sub-process of developing vision and mission can further be divided into activities such as know stakeholder expectations; work with senior management in devising vision; use stakeholder expectations in deciding mission; identify values for the organization; finalize vision, mission and value statements; communicate the same to the stakeholders; train the employees in vision, mission and values; identify performance measures; and review and audit the vision, mission and values at regular intervals. Thus, each major process in the organization can be divided into sub-processes, and sub-process can be divided into activities to be implemented.

</div>

24.5.1 Business Process Reengineering

Business Process Reengineering is about modifying or changing existing processes, adding or removing processes in order to gain improved

organizational performance using IT. Avoiding the wastage and removing redundancies are part of it. Reengineering also applies to changing organizational structures and changing the way business is going on currently. It requires first inspection of existing processes. The target to be achieved is to be set. Then try to find out the alternative ways to reach the target by modifying or adjusting the business processes. Implement the modified processes. Evaluate the performance outcomes and compare them with desired results. Business process reengineering is part of organizational reengineering movement started widely in the early 1990s. Many multinational organizations benefited from business process reengineering by reducing headcounts, costs and increasing profits.

Check Your Progress-6

1. Business process management includes _____.
   a. Process definition
   b. Process design
   c. Process implementation
   d. Process deployment
   e. All of the above

2. Process is a sequence of activities executed to provide value to customer.   [TRUE/FLASE]

3. A business process can be _____.
   a. Internal process
   b. Collaborative process
   c. Waste process
   d. Either a or b
   e. None of the above

4. _____ is the first step in business process management.
   a. Process deployment
   b. Process definition
   c. Process design
   d. Process implementation
   e. None of the above

5. BPR stands for _____.
   a. Backup processor
   b. Bank records

    c.   Business Process Reengineering

    d.   All of the above

    e.   None of the above

24.6. Process Models

The *behavioral* or *interaction* or *flow design* of the business process is represented using business process model. Business process model is represented using Business Process Diagram (BPD). These diagrams are similar to flow charts of traditional information systems. OMG (Object Management Group) has given a standard for business process modeling known as Business Process Model and Notation (BPMN). BPMN 2.0 is the current version in the market. There are many commercially available tools which support BPMN. BPMN is also known as *Business Process Modeling Notation*.

For example, a customer is checking out his goods in a retail store. He wants to pay the bill amount and take his goods. For this process, that is, *checkout process,* the process model is shown in Figure 24.4. In the Figure, *rectangle* with curved edges represents *activity* and arrows show the sequence of activities. The First *circle* represents beginning of the business process and the last circle (bold) represents the end of the business process. *Diamond* is used to specify a decision (as is done in flow charts). There are also other business process modeling languages. However, BPMN is a standard and widely used in the industry.

Organizations those want to stay competitive need to enter 2021 with a focus on efficiency, adaptability and speed. Business process management (BPM) technology lets achieve these goals. This is possible because the components that underpin BPM are becoming more efficient and adaptable.

Exhibit 24.1: Business process management in2021

The four key trends in BPM in 2021 are: robotic automation, adaptive case management, low-code development and data unification. These shorten process cycles, reduce the need for manual intervention, speed time-to-development and create seamless customer and employee experiences.

Contd. .....

---

1. Robotic process automation: With robotic automation, the rules-based tasks are managed by a software "robot." Robotic automation manages tasks faster than humans, does no data entry mistakes, and thus reduces the cycle time of that business process while reducing costs. June 2020 survey reported that more than 90% of companies planned to implement robotic process automation by the end of the year.

2. Adaptive case management leverages machine learning for smarter automated workflows: Intelligent case management, is evolving into adaptive case management, which is data centric and can use machine-learning algorithms.

3. Low-code development platforms shorten time-to-results: Adaptive case management implementation contributes to the low-code environment. Low-code platforms allow developers to drag and drop the elements they need to create an application in a few hours or days, instead of the time taken to write, test and refine code for an application.

4. Combining these elements of BPM unifies data, increases efficiency and reduces costs: The result of leveraging robotic process automation, adaptive case management and low-code/no-code development is the power to unify business applications, go to market faster and deliver a seamless experience for the customer. BPM now has the capacity to orchestrate and continuously optimize multi-system integrations.

Source: https://aithority.com/technology/analytics/business-intelligence/business-process-management-is-evolving-fast-how-is-your-business-keeping-up-in-2021/

Activity: Business Process Modeling

An insurance company is facing a challenge of unauthorized insurance claims. The CEO would like to stream line their business processes. He asked the business analyst to come up with a claims process which avoids unauthorized claims processing. That is, he wants a more secure process. Help the analyst and model the business process using BPMN.

Answer:

Figure 24.4: Business Process Model for a Checkout Process in a Retail Store
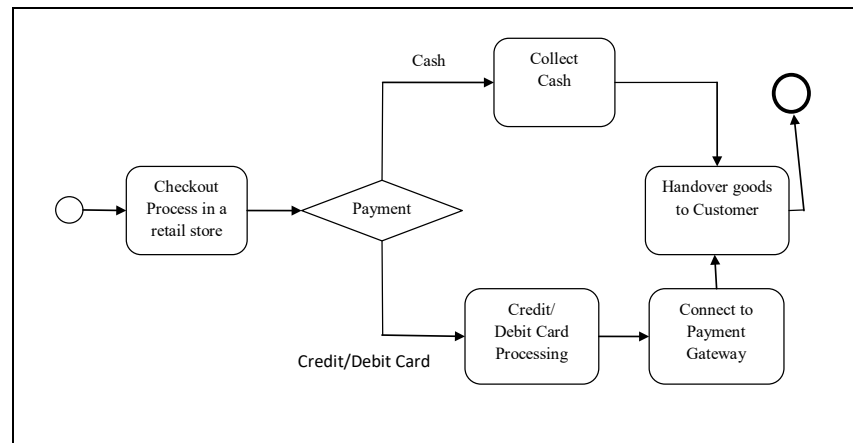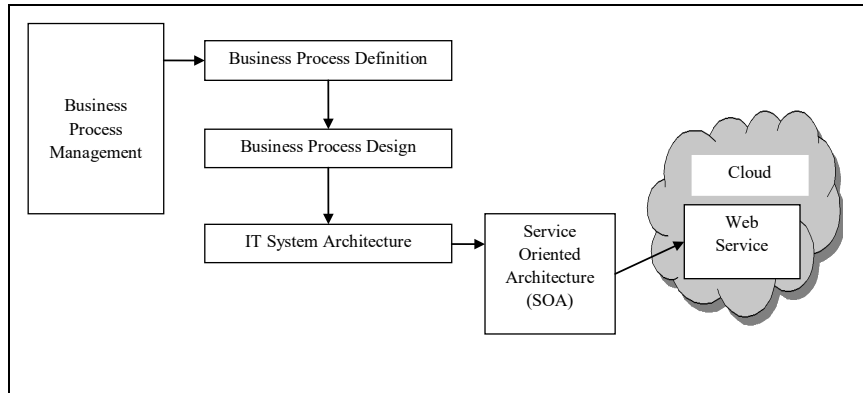

24.7. IT and Business Process Management

Many of the organizations are using Service Oriented Architecture (SOA) in implementing business processes (Figure 24.5). This is because it saves lot of time and money for the organizations. Some of the readymade business processes are available as web services in the clouds on the Internet. After business process design and during process implementation, processes are implemented in IT systems as software applications and workflows. This involves analysis and design of IT systems. For designing IT systems, service oriented architecture which is also object-oriented and easy to maintain and extend is used. SOA based architectures implemented using distributed web services over the cloud are scalable, available and reliable. Also, the organizations are using Web 2.0, Enterprise 2.0 and social technologies for business process implementation in IT systems. Once IT system design and implementation is over, it is deployed in the organization in the respective department. Once IT systems enter into operations, process monitoring and controlling starts in the organization.

Some of the enterprise systems available in the market such as ERP, CRM and SCM systems have predefined processes. Modifying or customizing these processes is required for some of the organizations. Some organizations may have to create new processes. This is time consuming and expensive process for the organizations. In these cases, organizations are going to implement their own Business Process Management Systems (BPMS) by reusing existing applications and source code in the organization.

One has to understand that Business Process Management is not just ERP, or BPR. It is not the traditional Enterprise Application Integration (EAI). It is also now Six Sigma, which works on just process excellence.

Figure 24.5: IT and Business Process Management

24.8. MIS and Business Process Reengineering

The business processes in an organization are implemented as commercially available products such as ERP, CRM, and SCM or through their own Business Process Management System (BPMS). BPMS components include a process engine, process administration, process development and business activity monitoring. Both external and internal customers use the business process management system. It interacts with the organization's other IT systems, packaged applications, legacy systems and databases (Figure 24.6). It uses the enterprise's underlying infrastructure. Separate BPMS is required if the business processes are very much mutable, and the organization needs different versions of the business processes. Organizations can make use of existing applications while developing their own BPMS. BPMS interacts with all the other enterprise systems in its day to day work in order to deliver value to customer.

The organizational MIS consists of the enterprise systems shown in Figure 24.6. In fulfilling both internal and external customers, BPMS makes use of the organizational enterprise systems.

> **Activity:** Business Process Management System
>
> A startup online e-commerce store cannot afford an enterprise level ERP system. However the CEO is very particular about having an automated streamlined business process in the organization. The CEO wants these business processes to be available to both internal and
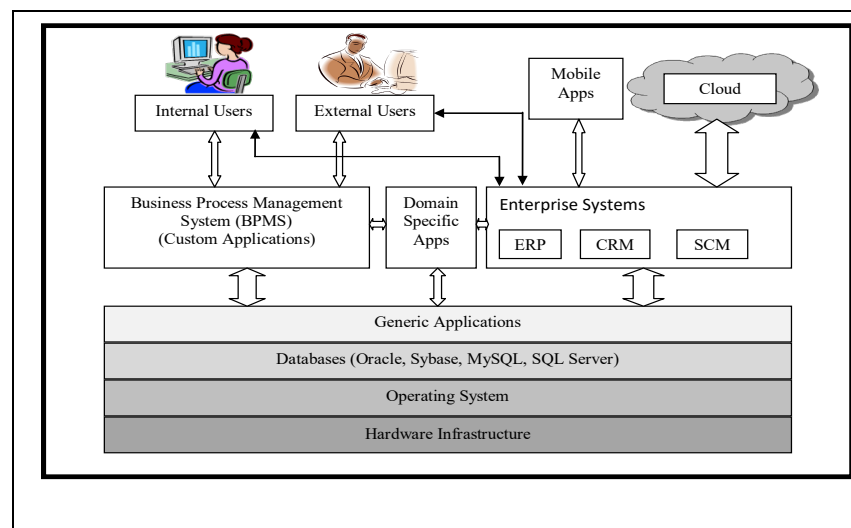>
> *Contd. .....*

| external customer from anywhere using Internet. Suggest a technology for the organization to implement their business process management system. |
| :--- |
| **Answer:** |
| |
| |
| |
| |

Figure 24.6: Business Process Management System Interaction

24.9. Communications Enabled Business Processes

Communication Enabled Business Processes (CEBP) integrate the business processes with organizational communications infrastructure in order to provide agility in service delivery and reduce the human latency. This is also known as *Unified Communication.* For example, a healthcare portal, integrates the patient communication with healthcare provider, healthcare payer and coordinator. These CEBP processes are beneficial to both the user and the organization. As shown in Figure 24.7, CEBP interacts with enterprise IT systems, which further communicates with enterprise communications infrastructure such as PBX, IP, Instant Messaging, E-mail, Voice Mail and IVR via communications enabled applications.

Figure 24.7: Business Processes Interaction with Enterprise Communications Framework
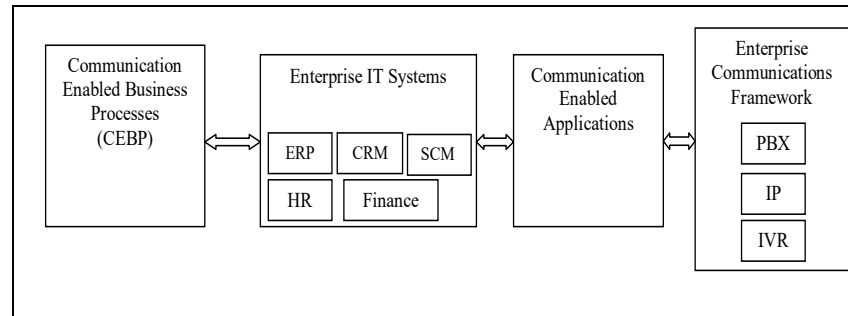
For example, in an accident insurance claim processing, as soon as the policy holder is done with his self-service on the web-site, CEBP enables him to connect with the organizational employee instantly for further processing. This is possible with CEBP. The best practice is to identify the key processes in the organization and use standard communication methods to make them communications enabled. CEBP implementation is also through service oriented architecture and web services. The challenges in implementing CEBP in the organization include lack of vision, changing technologies, changing people behavior and the ability to develop a business case.

Example: Unified Communication at Kiosk in a Retail Store

A customer enters to purchase some goods from a retail store. As soon as he enters, he sees an automated kiosk offering to help him he starts operating the kiosk. He searches for the needed product on the kiosk. The product details from organizational database and SAP system get displayed on the screen of kiosk through web services. The customer then goes through the list displayed on the screen. The customer does not find what he wants over there. He then enables the

"Talk to customer care representative" button on the kiosk. It alerts the customer care executive. He calls the customer and finds out what he wants. Then, the customer care executive using web services displays other products on to the screen in kiosk.

The customer selects the needed product on screen, swipes the credit card, generates bill and take bill print out at the kiosk itself. The customer then shows this bill at point of sale counter and picks his goods. This is an example of communications enabled business process exhibiting the unified communication.

Source: Rao, N. (2008), "Unified Communications – Communication Enabled Business Process (CEBP)", Whitepaper of Wipro, Available online at http://www.wipro.com/documents/insights/unified-communications-cebp.pdf, pp. 1-12.

24.10. Business Process Management Tools

Some of the business process management tools used in the industry includes ARIS, Intalio, BizAgi, Appian Enterprise BPM Suite and Oracle BPM Suite. ARIS platform is a complete business process management tool. It provides facilities starting from strategy definition, process design, process execution, transforming to IT system and monitoring the process. It helps in identifying organizational, technical, and structural problems in workflows. The process models developed in ARIS can be published worldwide.

Intalio supports the entire life cycle of business processes. It can support any size business process. It is based on BPMN 2.0 specification. Business processes can be modeled using Intalio. It is based on Eclipse platform. It uses J2EE and Apache. It supports human workflows and distributed transactions. It supports cloud computing and virtualization. It is 100% web based system.

BizAgi supports entire business process life cycle through its dynamic and graphic environment. Without programming, it develops web application based on the process model. It supports BPMN models. Based on BPMN model, it develops web application for process evaluation purpose.

Appian Enterprise BPM suite consists of components required for managing and modeling business processes. It supports analytics using which managers can identify the process inefficiencies. It also supports SOA and BPMN for automation and rapid development.

Oracle BPM Suite 12c, makes it really simple for business users by providing a business friendly web based composer that allows business users to model, simulate, optimize deploy and execute business processes, and provides business friendly mobile and business applications.. It can be used to develop cross department applications and end-to-end social business processes. End users can access their tasks using mobile devices or e-mail. It provides dashboard to monitor the process performance. For this it uses analytics. It is scalable, available, event-based and provides efficient case management.

Check Your Progress-7

6. BPMN stands for _____.
    a. Business Process Model and Notation
    b. Business Modeling
    c. Business Mind
    d. All of the above
    e. None of the above

7. BPMS stands for _____.
    a. Business Multiple Services
    b. Business Metals
    c. Business Process Management System
    d. All of the above
    e. None of the above

8. Communications enabled business processes interact with organizational communications infrastructure.
    [TRUE/FLASE]

9. _____ is/are example(s) of business process management tool(s).
    a. Oracle BPM Suite 11g
    b. ARIS
    c. Both a and b
    d. MS Office
    e. None of the above

10. Business process management is required _____.
    a. To remove wastage
    b. To reduce processing times
    c. To reduce costs
    d. All of the above
    e. None of the above

24.11. Summary

*   The objective of business process management is to increase the profits and reduce the wastage in the organization.

- The processes designed and implemented should meet this objective. This is possible with continuous process monitoring and controlling.
- Business process management requires planning, organizing, time and financial resources in the organization. Process reviews are to be conducted for reengineering purposes at regular intervals based on the customer feedback and organizational revenues.
- Organizations can have either commercially available enterprise systems or their own business process management system based on their requirement. Some organizations even use commercially available tools supporting BPMN for business process modeling purposes.
- Process definition, process design, process reengineering and process models are discussed. The role of IT in business process management is highlighted.
- Organizational MIS and BPMS functionality are discussed. Communications enabled business processes are discussed. Some of the commercially available business process management tools and their features are mentioned.

24.12. Glossary

Enterprise 2.0

It is the enterprise with software platforms based on social technologies. It can be a platform of one or more companies to encourage collaboration. Basically it is based on Web 2.0 technologies.

Enterprise Application Integration (EAI)

It is the early days of integration of organizational applications. The organizational applications were just integrated for data exchange. In these systems SOA was not used.

Web 2.0

It represents the second generation world wide web. It supports the more collaborative work on the Internet. Web services, wikis and blogs come under Web 2.0.

Workflow systems

These are the traditional systems to achieve the interaction between different organizational activities. They came before BPM. It achieves workflow in the organization using software.

24.13. Self-Assessment Test

1. Explain steps in business process management.

2. What is structural design and behavioral/flow design of a business process? Explain.

3. Draw a business process model diagram for ATM withdrawal using BPMN notation.

4. Can business process reengineering be possible without IT? Justify.

5. Explain key features of two business process management tools commercially available in the market.

24.14. Suggested Readings / Reference Material

1. Introduction to Information Technology, V. Rajaraman, PHI learning, 2018

2. Information Technology for Management, 2ed: Advancing Sustainable, Profitable Business Growth, Turban, Volonino, Wood, O.P. Wali, Wiley India Pvt Limited, January 2021

3. Introduction to Information Systems - 6th edition, R. Kelly Rainer; John Wiley & Sons, Inc.2016

4. Information Technology: An Introduction for Today's Digital World, Richard Fox, Chapman and Hall/CRC; 2nd edition (August 21, 2020)

5. Information Technology for Management, Efraim Turban, Carol Pollard, Gregory Wood, Wiley, 2018

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1. Critchley, L., Where Nanotechnology, the IoT, and Industry 4.0 Meet., https://www.mouser.com/blog/where-nanotechnology-the-iot-and-industry-40-meet, 2019

2. Pan India implementation of HMIS over Indian Railways, Ministry of Railways., http://railministry.com/pan-india-implementation-of-hmis-over-indian-railways/ 2020

3. Vossler, C. How Long Does It Take To Order A New BMW?

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4. Jay, A., 10 New ERP Trends & Forecasts for 2020/2021 – A Look Into What's Next. https://financesonline.com/erp-trends/2019

5. Gingiss, D., How Integrating Social Media Into The Rest Of The Business Will Increase Revenue., How Integrating Social Media Into The Rest Of The Business Will Increase Revenue (forbes.com), 2019

24.15. Answers to Check Your Progress Questions

1. **(e)** Business process management include process definition, process design, process implementation, process evaluation, process deployment and process monitoring and controlling.

2. **TRUE**. A process is a sequence of activities executed in order to provide value to customer.

3. **(d)** A business process can be either an internal process or collaborative process.

4. **(b)** Process definition is the first step in business process management.

5. **(c)** BPR stands for Business Process Reengineering.

6. **(a)** BPMN stands for Business Process Model and Notation.

7. **(c)** BPMS stands for Business Process Management System.

8. **TRUE.** Communications Enabled Business Processes (CEBP) interacts with organizational communications infrastructure.

9. **(c)** Both Oracle BPM Suite 11g and ARIS are business process management tools.

10. **(d)** Business process management is required to reduce wastage, costs and processing times.

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