UNIT 14 EMERGING TRENDS IN SOFTWARE ENGINEERING

Structure

14.0 INTRODUCTION

The field of Software Engineering is rapidly evolving. Fast paced changes, rapid innovations, market demands and ever increasing user demands result in continuous changes and improvements in the software engineering field. Innovations and changes happen in the software engineering tools, software engineering process, programming languages, hosting/delivery platforms and other areas. It is imperative of software engineers to track the industry changes and keep oneself up to-date with the changes. The key drivers behind the changes are productivity improvement, quality improvement, and quick time to market, cost optimization, high performance, high availability and high scalability.
In this unit we shall examine the key emerging trends in the field of software engineering

14.1 OBJECTIVES

After going through this unit, you should be able to

- understand key emerging trends of software engineering,
- know the high level details of low-code and no-code development,
- know the high level details of Artificial Intelligence (AI),
- know the high level details of Blockchain,
- know the high level details of Internet of Things (IoT),
- know the high level details of Augmented Reality (AR), Virtual Reality (VR),
- know the high level details of continuous delivery,

- know the high level details of containerization,
- know the high level details of Cloud Delivery Model, and
- look at various delivery approaches such as mobile-first, cloud-first, and offline first approach.

14.2 DRIVERS FOR INNOVATION

The key drivers for the software engineering innovations that lead to the emerging trends are given below:

- **Productivity Improvement**: Software engineering methods (such as low-code/no code, containerization) and delivery models (such as cloud delivery model) aim to improve the overall productivity of the developers thereby reducing the time to market.
- **Quality Improvement**: Process innovations such as continuous improvement, agile delivery enhances the overall delivery quality reducing the risk.
- **User Experience Improvement and User engagement**: Innovations such as AR, VR, AI, blockchain and machine learning improve the end user experience and provide the relevant, contextual information in quick time.
- **Automation**: AI and Machine learning are the key enablers for driving the automation.

We will look at the each of the trends in next sections

14.3 KEY EMERGING TRENDS IN SOFTWARE ENGINEERING

The key emerging trends in software engineering are as follows:

- Low Code/No Code Development wherein the tools and platforms enable developers and business stakeholders to develop the solutions with minimal code.
- Artificial Intelligence (AI) and machine learning methods enable developers to analyze huge quantity of data, detect patterns, predict trends and forecast values.
- Blockchain technologies a secured distributed record handling capabilities
- Internet of Things (IoT) platform provide methods, tools and technologies to track and monitor the devices
- Continuous delivery is a set of processes, tools and technologies that provide iterative and agile delivery of the solution with incremental features.
- Cloud Platforms has redefined the way software is built, deployed and delivered.
- Containerization provide self-contained and portable deployment model
- BigData technologies handle massive volume of data with high performance and high availability
- Augmented Reality enhances the real world objects by adding digital objects.
- Mobile-first, cloud-first, offline-first are some of the emerging delivery methods.

- Other trends include serverless functions, conversational applications, analytics, computer vision, service orchestration, Software as Service (SaaS), cross platform development

Figure 14.1 provides the key trends in software engineering.

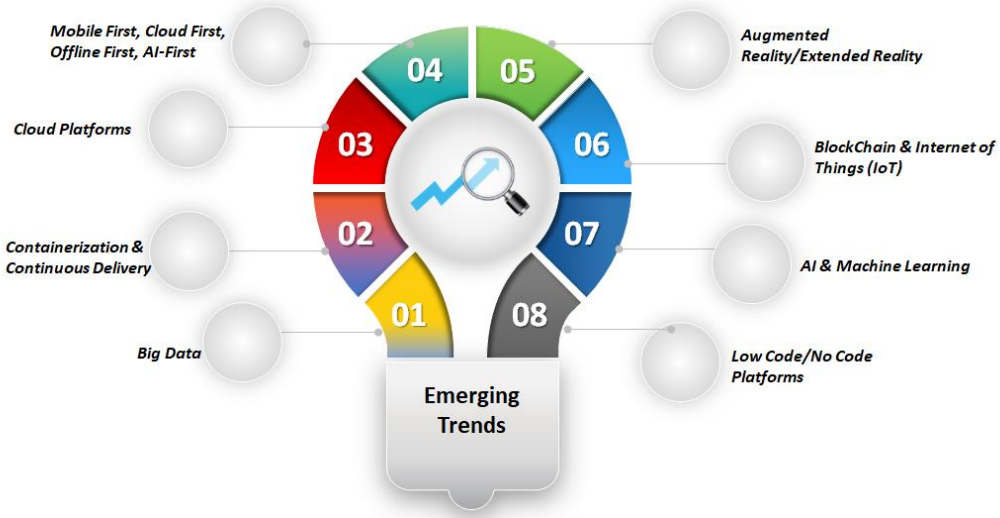

Figure 14.1 : Emerging Trends in Software Engineering

14.4 ARCHITECTURE BRIEF DETAILS OF EMERGING TRENDS

In this section we look at the details of emerging trends. For each of the trends, we shall look at the motivation, key concepts, tools, technologies involved as a part of the trend.

14.4.1 Low Code and No Code Platforms

The low code and no code platforms (LCNC) allow the users to rapidly build the user interfaces (UI), solution components, integrations with zero or minimal code. While enterprises demand rapid application development, on the other hand there is a shortage of the skilled developers; LCNC platforms are designed to fill this gap. LCNC platforms provide visual interfaces, wizards, drag and drop features that users can leverage to rapidly develop the solution components. LCNC is the new avatar of the Rapid Application Development (RAD) tools. LCNC goes a step ahead and provide pre-built integrators, reusable UI templates, solution components and configurable modules to ease the development. Due to the minimal custom coding involved, the testing effort, maintenance effort is also reduced.
LCNC platforms reduce the hand coding effort, automate the code generation process by abstracting the finer details of the software development. LCNC platforms heavily use automated code generation, visual programming paradigm and model based design.

The salient features of LCNC platforms are as follows:

- Visual programming model through which citizen developers can develop the solution
- Pre-built integrators to retrieve and persist data faster
- Drag and drop features to rapidly build the application.
- Model driven approach for building solutions
- Reusable Pre-built components, vertical solution accelerators to speed up development

- Configurable solution components that can be extended for the business needs.

The key advantages of LCNC platforms are as follows:

- Faster time to market
- Improved developer productivity
- Enablement of business team with minimal coding experience
- Rapid development and deployment
- Increased quality of the solution
- Scalable application with reusable components
- Enable quicker integration with enterprise systems.
- Leverage reusable components and in built user experience.
- Provides business self-service model
- Enable enterprises to become more agile and responsive to market dynamics
- Innovate fast with increased productivity.

Given below are some of the examples of the LCNC Platforms:

- Pega software provide the visual tools for modeling the enterprise business process and to build the corresponding screens.
- Salesforce Lightning Platform provides automation tools for modeling and developing flows through process builder. The platform also provides tools to build mobile apps with high security with minimal code.
- Microsoft Power Platform provides features to build app by using pre-defined templates, easy to use connections and cross-platform applications
- Appian platforms provide drag-and-drop features to model the complex business process.

14.4.2 Artificial Intelligence (AI)

We are living in an era where most of the tasks, processes and day-to-day activities are getting increasingly automated by machines. Automation brings in productivity, convenience, time savings, cost savings that allow humans to invest their time and energy in more valuable and complex tasks. Machine-led automation is revolutionizing the way we live, communicate, work and do business. AI-led systems are becoming ubiquitous, impacting modern human civilization in numerous forms and re-defining the daily tasks in our lives. Due to the wide impact of AI technology, we have discussed it in detail in this section. We shall look at various disciplines used in AI, applications and trends within AI.

Artificial Intelligence (AI) is the guiding force behind the automation revolution. AI helps machines “learn”, “understand” like the way humans do. AI is an interdisciplinary science that uses various methods such as natural language processing (NLP), machine learning (ML), knowledge processing, reasoning, predicting and such.

In simple terms AI includes methods and systems to make the machine perform intelligent and cognitive tasks that humans are good at performing. Tasks such as game playing, language translation, recognition patterns, identifying images, coming up with a rationale decision, problem solving, reasoning and such.

AI and Machine learning are redefining the ways people interact with machines, the ways enterprises analyze data and offer many features such as learning, prediction, forecasting, trend identification and such.

AI is an interdisciplinary field that has borrowed various methods, concepts, theories from various fields. We have given the list of fields that has contributed to the AI. We have depicted the fields of AI in figure 14.2.

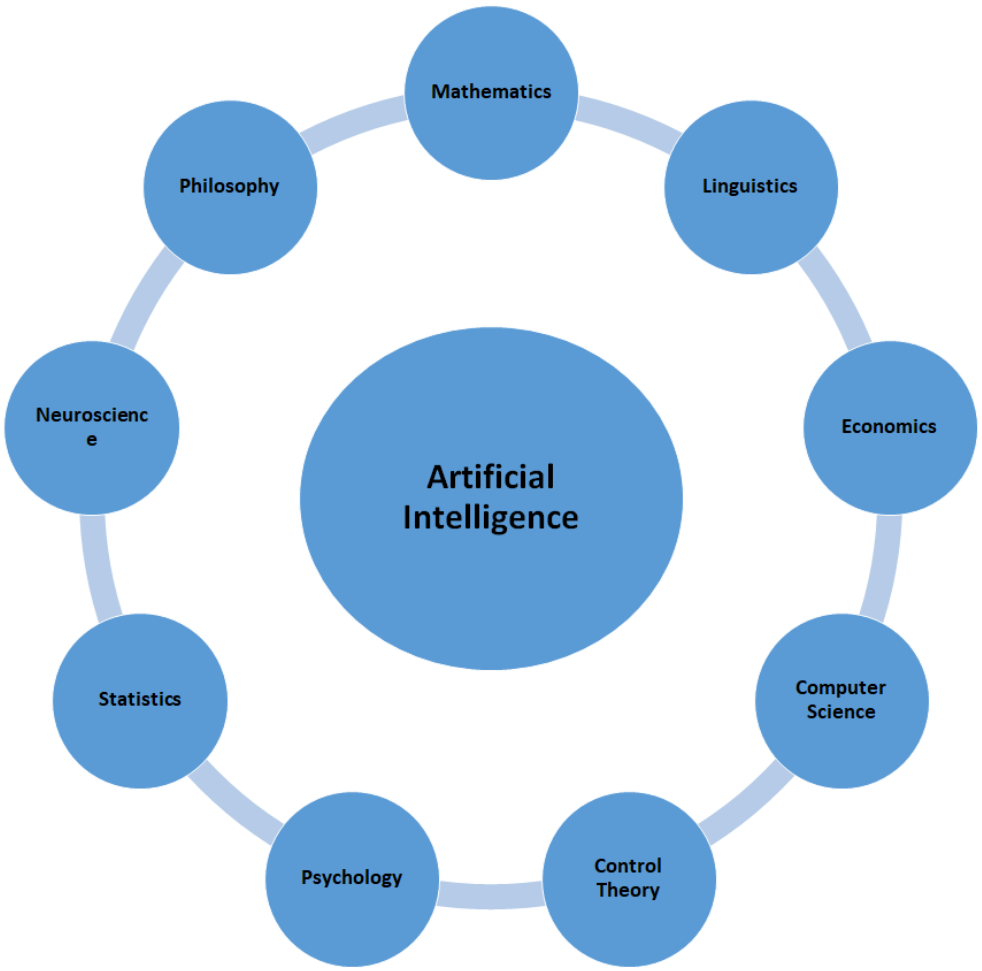

Figure 14.1 : Fields of AI

Philosophy

Concepts such as logical reasoning and theory of rationality, theory of language, reasoning are part of the philosophy. Laws of rationality define the laws and rules that govern the mind and dualism (describing dual forms of reality material/physical and immaterial/spiritual and mind and body are separate from each other), materialism (mind and body and other entities in the world are adhering to physical laws), principle of Induction (rules are based on association sensory exposure to the elements) and others. The key ideas of philosophy that has influenced the Artificial intelligence are as follows:

- Logic and methods of reasoning
- Mind as physical system
- Foundations of learning
- Language
- Rationality

Mathematics

Concepts such as Probability, Logic (such as propositional logic and predicate logic), algorithms, decidability and Formal representation and proof algorithms, automated reasoning, Formal Logic and knowledge representation. Historically the concepts such as intractability (time for solving the problem exponentially increases with the input size such as NP complete problems), reduction (transformation of one class of problems to another class with known solution), probability theory (Probability contributes the "degree of belief" to handle uncertainty in AI), *Decision theory* combines *probability theory* and *utility theory*

Economics

Concepts such as the following influence the field of AI:

- Game theory
- Formal theory of rational decisions
- Combination of decision theory and probability theory for decision making under uncertainty
- Markov decision processes

Linguistics

Concepts such as grammar, natural language processing, and knowledge representation are key influences to the AI field along with the below given topics:

- Understanding natural languages through different approaches.
- Formal languages
- Syntactic and semantic analysis
- Knowledge representation
- Relationship between language and thought process

Statistics

Topics such as regression models, learning from data, modeling uncertainty are used in artificial intelligence.

Neuroscience

The key ideas influenced by neuroscience are:

- Neurons as information processing units used in artificial neural networks.
- Study of brain functioning

Psychology

Concepts related to behaviorism and cognitive psychology (the study of information processing by brain) are areas of interest in psychology. The key factors of psychology influencing the artificial intelligence are:

- Phenomena of perception and motor control
- Human adaptation analysis
- Human behavior analysis, (how people think and act)
- The study of human reasoning and acting
- How do humans learn and process knowledge
- Study of learning, memory and thinking
- Provides reasoning models for AI
- Human brain as an information processing machine.

Computer Science

Most of the core concepts of the computer science such as programming, algorithms, design patterns, parallel computing, data structure, large scale computing, Machine learning, pattern detection, grid computing and such.

Control Theory

The main concepts influenced by control theory are as follows:

- Stability of systems
- Simple optimal agent design (systems that maximize objective function over time)
- How can artifacts operate under their own control?
- Optimal agents receiving feedback from the environment.
- Adaptation of the artifacts and their actions to:
    - Do better for the environment over time
    - Based on an objective function and feedback from the environment

Given below are some of the key AI related applications

- Autonomous vehicles: Self-driving automobiles is a fast-emerging area that heavily involves AI methods to perform tasks such as obstacle sensing, automatic navigation, autonomous planning, real-time sensor data processing, reasoning and decision making and such.
- Conversational Interface: Chatbots, virtual assistants (such as Apple Siri, Amazon Alexa) converse with humans in natural language and can perform structured tasks (such as booking appointments, route navigation, search, recommendations, activity planning, reminders and such).
- Computer Vision: Machines can perceive the images through computer vision methods.
- Robotics: Commercial and industrial robots employ AI methods to perform well-defined and structured tasks such as car washing, floor cleaning, assembling parts, motion planning and such. Highly advanced robots are also used in complex surgeries.
- Natural Language Processing: The key methods in this area are entity extraction, part of speech (POS) identification, intent identification, language "understanding" and such. Voice bots, chat bots, voice search, virtual assistants heavily use natural language processing. Other tasks such as machine translation, sentiment, information retrieval, text mining analysis also rely upon NLP methods.
- Expert systems: These systems are used for specialized activities such as legal advisory, medical advisory, domain-specific problem diagnosis (such as financial analysis, legal analysis, medical diagnosis, financial forecasting, Spam controls, logistics planning, document summarization and fraud detection). Expert systems store, process and use the knowledge for performing the activities.
- Game playing: Machines use AI methods such as automated reasoning, decision making to identify the most optimal moves in games such as Chess, Go, Checkers, Jeopardy!. As games have well-defined and structure rules, they can be formally defined which computers can use and learn/adapt from previous mistakes.
- Theorem proving: Theorem provers are mainly used to prove the correctness of mathematical theorems.

- Vision/Perception: Computer vision agents help in object recognition, face recognition, navigation, and information extraction.
- Search engines and Question and answer systems

AI is rapidly advancing into all fields of technology. Given below are the key emerging trends:

- Deep Learning: This areas of AI uses artificial neural networks to do the complex tasks such as automatic navigation, pattern recognition, computer vision, autonomous vehicles and such.
- Autonomous vehicles: Consumer vehicles such as cars and transportation vehicles such as trucks are gaining
- Facial Recognition: Recognizing and using the face as a biometric authentication is gaining popularity.
- Edge AI: AI chips are used for faster execution of facial recognition, NLP methods, speech recognition, computer vision, autonomous vehicle and such.
- Conversational AI: Many of the user facing actions such as incident management, text search, voice search, recommendation can be automated by conversational interfaces such as chatbots.
- Analytics: AI can be used along with analytics to achieve more accuracy in predictive analytics.
- Personalized search: AI algorithms are increasingly used to learn the user interests, behavior and provide personalized and effective search results.
- Explainable AI: The AI algorithms should be able to explain the results and reasons for providing the output. This helps in auditing, governance and help in complying with any regulations.
- Cognitive computing: The term refers to emerging set of technologies led by AI to provide more contextual, interactive and personalized information.
- Reinforcement learning: Unlike supervised learning and unsupervised learning, reinforcement learning "learn" through experience and mistakes without any explicit rules and training.
- Convergence with IoT, Blockchain and other emerging technologies: The convergence is key to some of the popular applications such as autonomous vehicles.

☞ Check Your Progress 1

1. _____ is mainly used in low code no code applications.
2. Machines can perceive the images through _____
3. Conversational Interface interact with humans through _____.

14.4.3 Blockchain

Blockchain technology provides a decentralized, distributed database that provides a non-tamper able record keeping facility. Blockchain is built using peer-to-peer system and provides cryptographic security. Blockchain can be used as a ledger for transactions that provide immutable and publicly viewable record of the transactions. The blockchain technology provides a way to record the legitimate transactions in "blocks" that are chained to previous blocks. Bitcoin cryptocurrency uses blockchain technology.

Given below are the key features of blockchain:

- Blockchain provides a permanent and distributed record of all genuine transactions
- Blockchain provides a decentralized governance
- The data/record in the blockchain is immutable (that cannot be altered) and irreversible due to the chained and distributed nature of the blocks.
- The blockchains provide transparent way to track the records and transactions.
- Blockchains also provide secure way for performing the transactions. As the copies are distributed across the entire chain, any attempt to alter the block's content can be easily identified by the remaining chain of blocks.
- The data in the block can be updated only upon consensus among the participants.

Given below are the key applications of blockchain:

- Blockchain can be used to store legal contracts that cannot be tampered.
- A company's Product inventory information can be stored in Blockchain.
- The supply chain information can be stored in blockchain to track a product throughout its lifecycle.
- Cryptocurrencies can be managed using blockchains
- Medical records can be secured stored using blockchains.
- Property records can be accurately stored and managed using blockchains.

14.4.4 Internet of Things

Internet of Things (IoT) represent a network of objects (known as "things") that have embedded entities (such as sensors, software, devices etc.) so that the objects can track, monitor, collect and exchange data. By embedded a tracking sensor we can collect the information of the object such as the temperature, position (latitude/longitude), speed and such. The collected information can then be analyzed to predict, forecast and conduct preventive maintenance activities.

With the emergence of 5G technology, it would be possible for all devices to be interconnected in the IoT world.

Given below are the key components of IoT:

- Sensors: The sensors are essential to collect the information about the object. Sensors could collect the information such as light, temperature etc. from the object.
- Communication: Sensors communicate the collected information to the cloud platform
- Data Analysis: The incoming data stream is analyzed to understand the trends, patterns, insights. The analysis is further used for prediction, recommendation, forecasting, analytical reporting and such. We use various data analysis methods such as machine learning methods, big data analysis methods to make sense out of sensor data.

The figure 14.3 provides a sample IoT ecosystem wherein the sensors feed the data to the analytics software running on IoT gateway. The analyzed data is then fed to the enterprise ecosystem for further analysis and reporting.

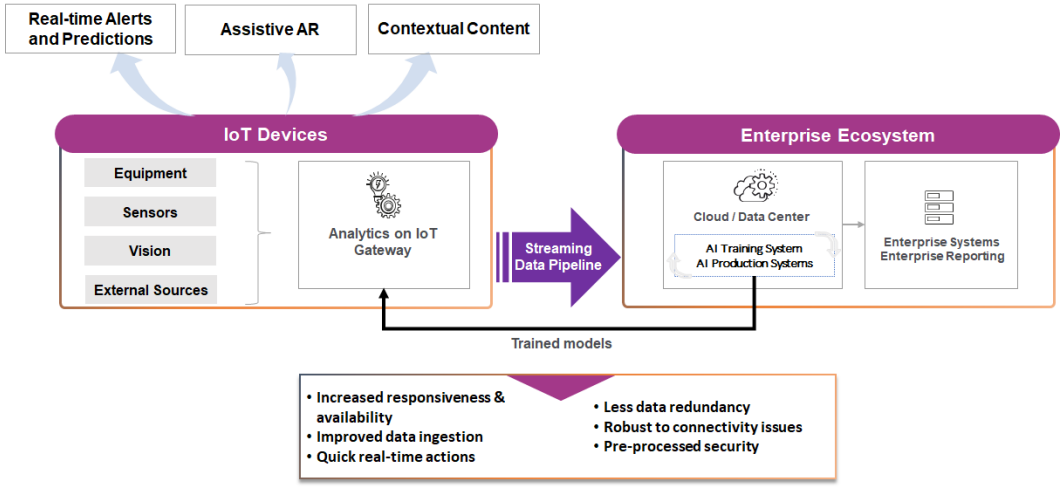

Figure 14.2 : IoT Ecosystem

Given below are the key advantages of IoT:

- Increased user experience: Through real-time tracking of the objects/things, we can provide a more accurate prediction/estimation to the end users thereby improving user experience.
- Cost Optimization: Regular monitoring of the machinery enables us to carry out preventive maintenance thereby reducing the machine downtime.
- Remote monitoring and control: IoT technologies enable us to monitor and control the devices remotely in real time.
- Advanced analytics: IoT provides us with advanced analytical information so that we can pro-actively act on the information to reduce the cost.

14.4.5 Augmented Reality/Extended Reality

Augmented Reality (AR) enhances/augments natural world objects by overlaying computer-generated information. AR uses multiple technologies such as AI, computer vision, analytics and such. AR aims to make the physical world objects more interactive by superimposing the image, video, text, and sounds onto the real world objects.

One popular AR application is that of a mobile app wherein the mobile app could overlay a new set of clothes for the user to understand how the new clothes fit. Few other AR-enabled mobile apps could virtually paint the house with various colors so that the user could choose the best suited color. Pokemon GO was one of the popular mobile games that heavily used AR wherein the Pokemon characters are overlaid onto the real world objects.

Figure 14.4 provides the key AR modules used in mobile app for adding an image to the real world. OpenCV, Google Lens, ARCore and Google ML toolkit are some of the popular tools used in the AR.

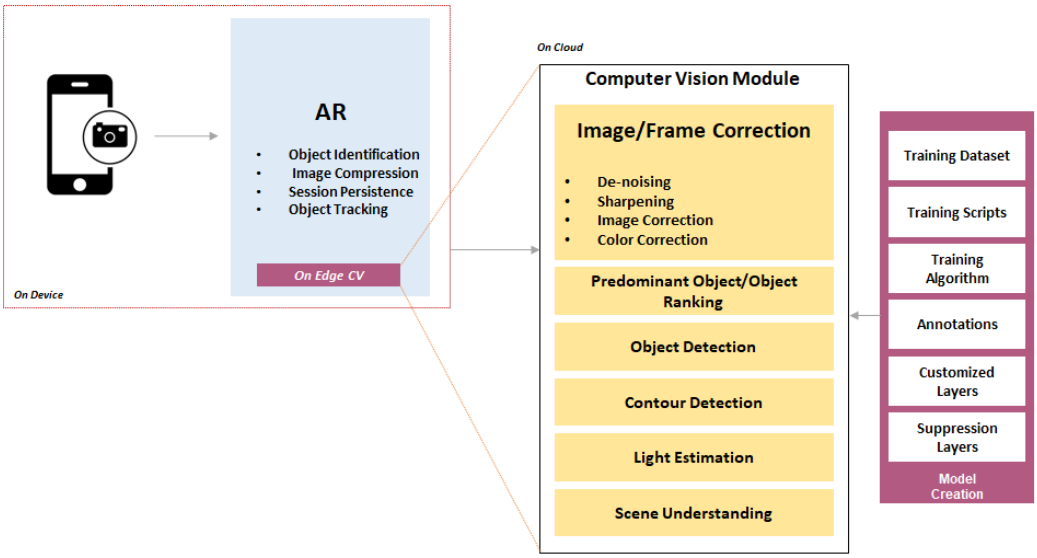

Figure 14.3 : Sample AR modules on Mobile and on Cloud

As depicted in the figure 14.4, AR Module takes environmental/mask information from CV & performs semantic interpretation. The computer vision Module performs all necessary preprocessing on the individual frames required for the AR Module to work on. This is the stage in the pipeline where data cleaning and refinement takes place. This is done on-device as well as at cloud. The ML Model Training basically feeds in the initial trained model to the CV Module. Additional layers/Suppression layers have been added to make the ML model less cumbersome for mobile devices which would perform the real-time visualization on edge.

14.4.6 Containerization

Containers are virtualized environments that provide independent, portable computing environments. With containers we could implement "write once, run anywhere" concept. Containers consist of all software needed to execute the applications including the libraries, tools, programming language, runtimes, dependencies, configurations and others. Containers abstract the application from underlying OS. Docker is one of the most popular container technologies. A docker image can be created using all the necessary binaries and dependencies needed for the application; these dependencies could include runtimes, database, application server and such. For development related activities we could also create Docker image consisting of IDE, debugging tools, browsers, SQL developer tools and others needed for development activities. Due to its flexibility, containers are the preferred choice for deploying microservices and provide elastic scalability.

Given below are key features of containerization:

- Portability: We could easily port the containers from one environment to another. Irrespective of the underlying OS (such as windows or Linux), various infrastructure methods (on-premise or cloud or virtual machine), we could easily deploy to the containers.
- Independence and self-contained: Containers are self-contained and independent platforms that
- Management and security: We could manage the computing resources such as CPU, memory and DNS name, load balancing, and sensitive confidential information easily with containers.

Given below are key advantages of containerization:

- Performance: As containers are light weight virtualization engines, they offer better performance and less overhead when compared to traditional virtual machines.
- DevOps Friendly: Container technology fits well into the modern DevOps methodology wherein we can deploy the artefacts to the Docker containers.
- Flexibility and Scalability: Container orchestration platforms such as Kubernetes provide options for elastic scalability (that is to automatically spin up new Kubernetes pods to serve the increased load based on configured memory and CPU thresholds).
- Fault isolation: If any of the containers goes down, it does not impact other containers sharing the OS. Container orchestration engines can isolate the faulty container and restart or spin up a new container.
- Agility and speed: Container ecosystem provides tools and technologies to easily configure, start or spin up a new container on demand.
- Efficiency: Being lightweight, containers are lot more efficient than other virtualization platforms. Containers are also better at scaling, ease management, enable faster roll out of new updates, enable logging, enable monitoring, and provide security.

Figure 14.5 provides various components of container based solution.

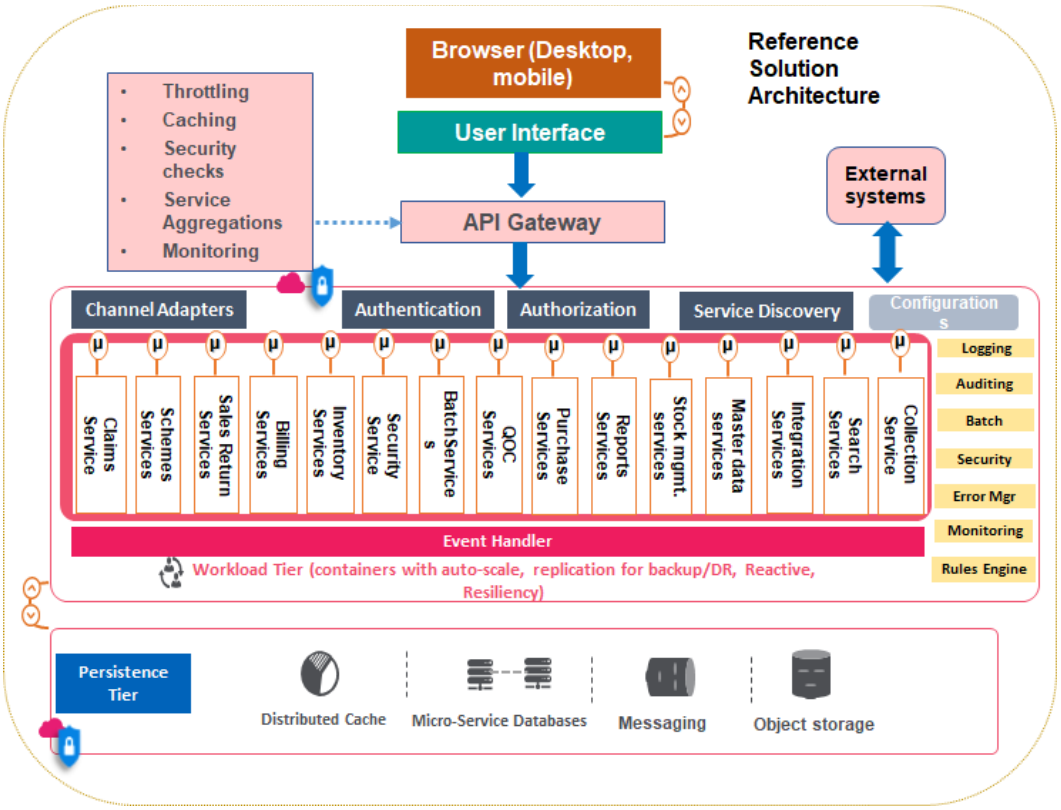

Figure 14.4 : Sample Container Based Solution

14.4.7 Continuous Delivery

The traditional waterfall development and deployment model needs higher time to market and is prone to delivery and quality risks. With the increasing user demand, market expectations and business changes, it is imperative to roll out the new release iteratively and frequently. Agile delivery implements the best practices of continuous delivery model that delivers the solution in a 2-week sprint cycles. With each delivery an incremental update is pushed to the production. Through continuous deployment, we deploy the updates automatically to the production on periodic basis. Continuous delivery model makes the enterprises responsive to changes, implements the feedback quickly, provides the features/fixes faster and reduces the delivery risk.

Continuous Integration (CI) is closely associated with continuous delivery (CD) wherein the application is integrated frequently and iteratively to reduce the integration risks. We can implement the CICD through popular tools such as Jenkins or Azure DevOps.

Figure 14.6 depicts a sample Jenkins based CICD pipeline. In the development stage, the GitHub is used for code merge and code review activities. During testing we could configure SonarQube based static code analysis and Junit based unit testing as part of Jenkins jobs. Fully tested artifacts are pushed to S3 for packaging. Maven can be used for building artifacts automatically. Finally during the deploy stage, the artifacts are deployed to the environment. We could configure AWS CloudWatch to monitor the application.

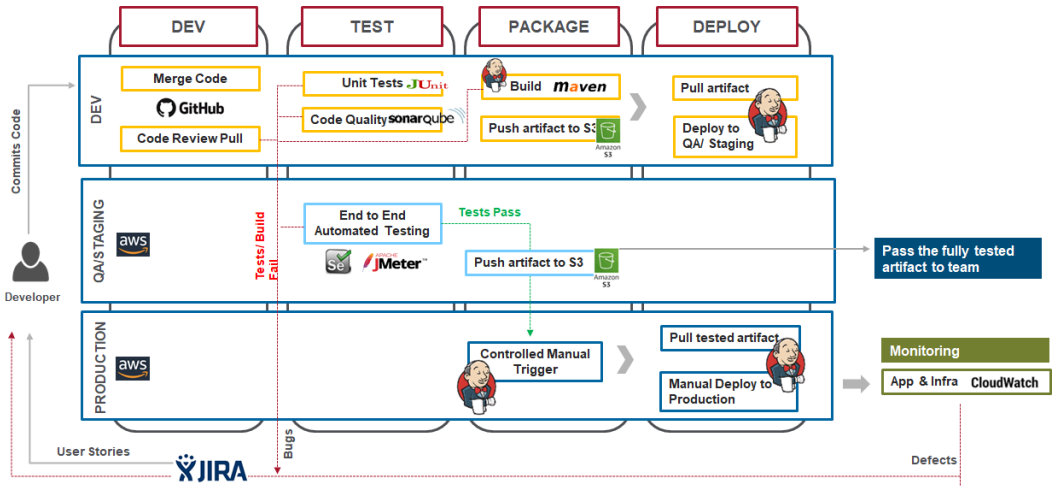

Figure 14.5 : Sample Jenkins based CICD Pipeline

The key metrics during agile delivery are given below:

- Defect Leakage: Defects that are found outside of a sprint through Acceptance, Integration, Performance, and Usability (AIPUS) testing
- Code Complexity: Typically, an automated test done with tools like SONAR that looks at coding standards and Cyclomatic complexity
- Burnup Charts: A look at project progress. The average delivery timeline is compared to the actual delivery progress
- Commit to Complete: The ratio of committed stories to completed stories
- Code Coverage: The percentage of unit test cases written
- Velocity: The number of story points that are completed in a Sprint

We have depicted various activities in a 2-week sprint in Figure 14.7.

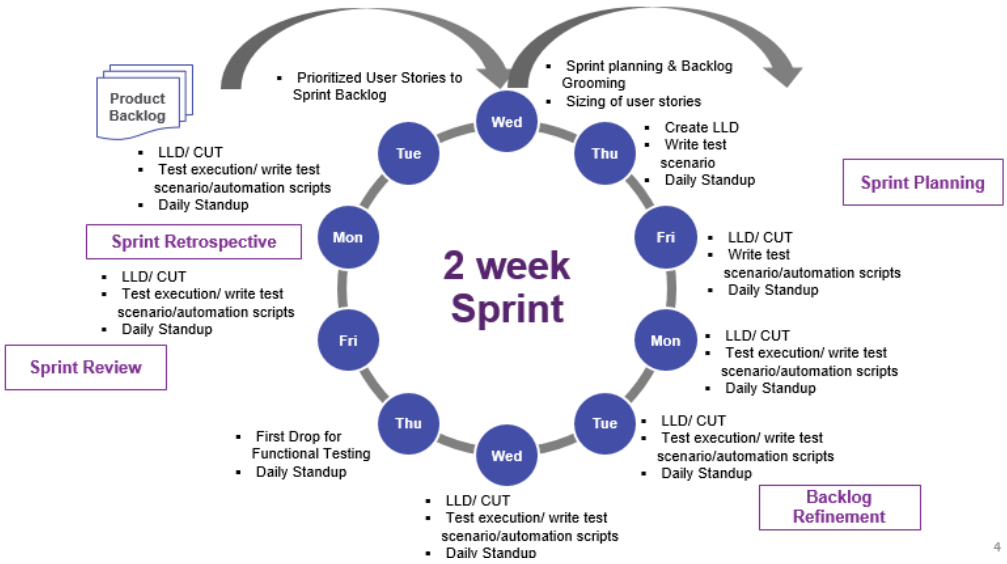

Figure 14.6 : Sample 2 Week Sprint

We have depicted a typical 2-week sprint flow and various activities, owners and metrics in Figure 14.8.

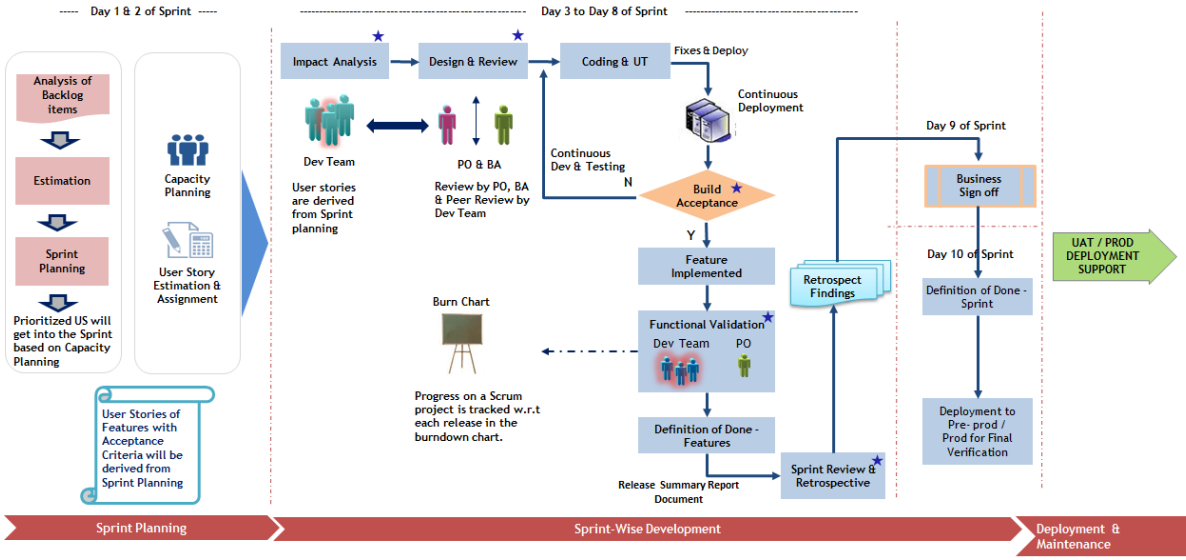

Figure 14.8 : Sprint in Action

14.4.8 Cloud Platforms

Cloud computing has redefined the way software applications are designed, built, deployed and monitored. Cloud platforms provide the computing resources such as servers, databases, network, storage on demand offering "pay-as-you-go" model. Enterprises can innovate faster, reduce the IT costs and build agile models using the cloud platforms. Microsoft Azure, Amazon Web Services, Google Cloud are the popular cloud platforms. Enterprises can use public cloud (owned by third party cloud providers), private cloud (enterprise-owned computing resources) or hybrid cloud (data shared between public cloud and private cloud)

Given below are the main types of cloud services:

- Infrastructure as Service (IaaS): Cloud platforms provide infrastructure components such as virtual machines, servers, database, operating systems and such.
- Platform as Service (PaaS): Cloud platforms provide an end to end environment for development, testing and deployment of software.

Developers can build their applications using the provided platform. PaaS platforms typically include operating systems, development tools along with the underlying infrastructure components.

- Software as Service (SaaS): In this model, the software applications are available over the cloud typically on subscription basis. The SaaS providers manage the security, infrastructure and maintenance of the software.

Given below are the key advantages of cloud services:

- Cost: Due to the metered billing of cloud platforms, enterprises will only pay for what is used and can avoid the upfront IT cost.
- Scalability: Cloud platforms provide elastic scalability based on the demand and load
- Performance: The cloud platforms offer state of the art computing infrastructure that are continuously patched and upgraded to ensure high performance.
- Availability: The cloud services offer very high availability due to the distributed nature of the computing resources and redundancy.
- Security: Most of the cloud platforms provide inbuilt methods, tools to safeguard against the security attacks.

We have depicted a sample cloud solution in the Figure 14.9.

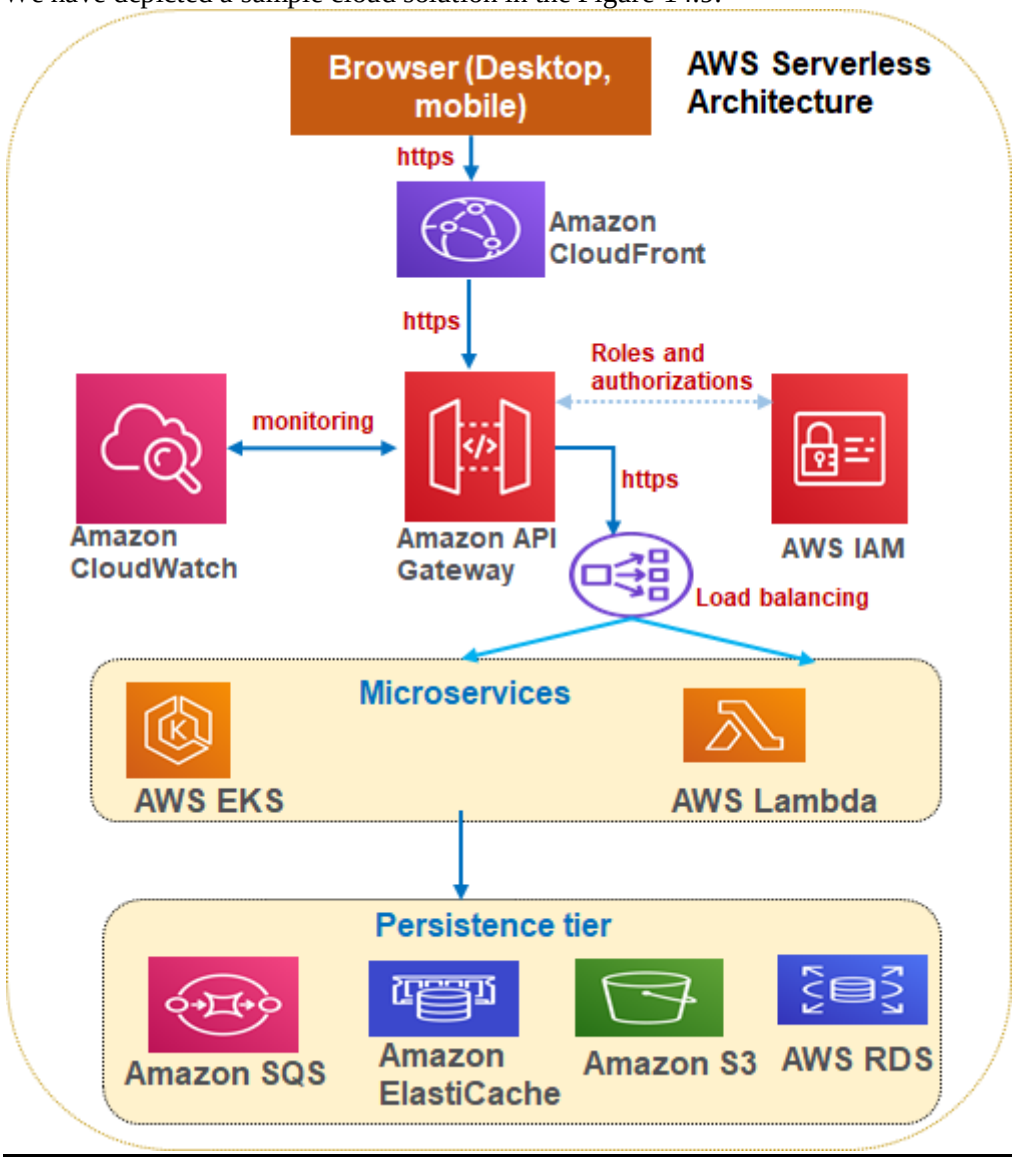

Figure 14.9 : Sample Cloud Solution

14.4.9 Big Data

The field of Big Data involves management, analysis and reporting of massive amount of data that cannot be handled by traditional data management software. With each growing data, we are generating and consuming huge volumes of data through social media posts, comments, pictures, videos and such. Storing, retrieving, managing and searching this data needs a different way of managing the data. Big Data systems are eventually consistency as per CAP (Consistency, Availability, Partition) theorem.

The sensor data and social media data are few examples of the big data. Big data technologies handle the ingestion of large volume of data, sharing the data, searching the data, updating the data, making the copies of data, reporting of data and such. Big data applications include product recommendation, consumer behavior analysis, sales forecasting, predictive analytics and such.

The three key attributes of Big Data are:

- Volume indicating the massive amount of data generated to qualify as Big Data. Though the definition of Big Data is changing with time, at this point we consider anything above 1 Terabyte as big data.
- Velocity indicates the speed at which the data gets generated
- Variety indicates the format of the data that gets generated. This includes structured data, semi-structured data, and unstructured data.

Due to semi-structured and unstructured nature, Big Data is managed in NoSQL databases such as DynamoDB, MongoDB. The NoSQL databases aim for eventual consistency instead of strict consistency.

Apache Hadoop, MongoDB, Apache Mahout, Apache Spark are some of the most popular technologies used for managing Big Data.

Given below are key scenarios for Big Data:

- Manage and process sensor data coming from IoT devices
- Store and search the social media data or user generated data
- Manage unstructured (such as text or images or video) data that needs flexible schema.
- Capture and manage customer behavioural data from various sources such as social media, CRM system and others.
- Capture and manage user transaction data for recommendation engines.
- Data needed for providing personalized and contextual web-scale search.

Besides these scenarios, there are numerous use cases that need Big Data systems such as data needed for predicting customer churn, fraud detection data, risk assessment data,

14.4.10 Software Development Methodologies

Various development methodologies are used to develop and deploy the modern applications. We have given the most popular ones below:

- Cloud first approach in which we develop the applications using cloud native technologies. The applications are developed, tested and deployed on cloud platforms.
- Mobile first approach in which the applications are built for mobile devices primarily. This includes the mobile apps or web applications using responsive web design (RWD) methodologies
- AI First approach in which the AI methods and machine learning is adopted to gain insights from data in all the service offerings.

- Offline first approach in which the applications are built for handling network unavailability issues using local storage mechanisms. Progressive web applications (PWA) provide offline capabilities.

Check Your Progress 2

1. Blockchain provides a _____ governance
2. The key components of IoT are sensors, communication and _____
3. _____ abstract the application from underlying OS
4. Normally Agile delivery involves _____ sprint cycles
5. The cloud service type that provides provide infrastructure components such as virtual machines, servers is called _____

14.4.11 Other Emerging Trends

We have compiled few other emerging trends below:

Serverless Computing

Developers can quickly develop and deploy the business functions without bothering about the underlying server, deployment, capacity and others. AWS Lambda, Azure Functions are some of the examples of serverless computing.

Cross Platform Development

In cross platform development, we could develop the code only once and then reuse the code for various mobile platforms such as Android, IoS, Windows, and Linux etc. Figure 14.10 provides a sample architecture of Xamarin based cross-platform solution. Many cross platforms provide inbuilt widgets, API integrations and portability features. Xamarin and Google Flutter are popular cross platform development technologies. We have depicted a sample Xamarin cross platform solution in figure 14.10

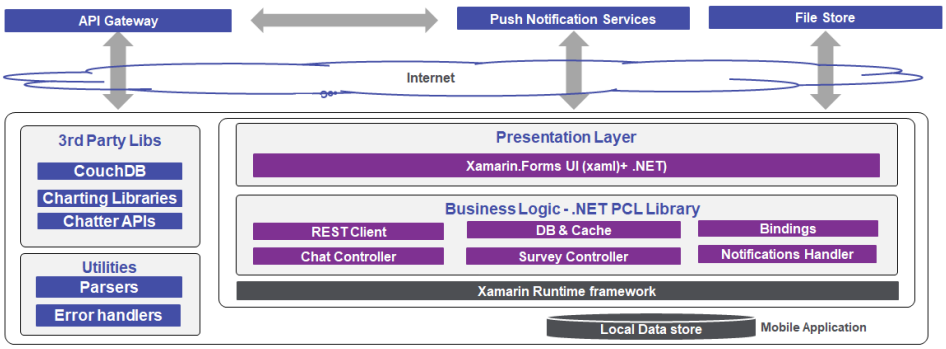

Figure 14.7 : Xamarin based Cross Platform Solution

Conversational Interfaces

AI-powered chatbots provide capabilities to understand and respond to natural language queries. Conversational interfaces can be customized to handle the functional domain specific data. Conversational interfaces are handling the first-level queries in many sectors such as banking, retail and e-commerce domains. We have depicted the high level components of a conversational interface in the figure 14.11.

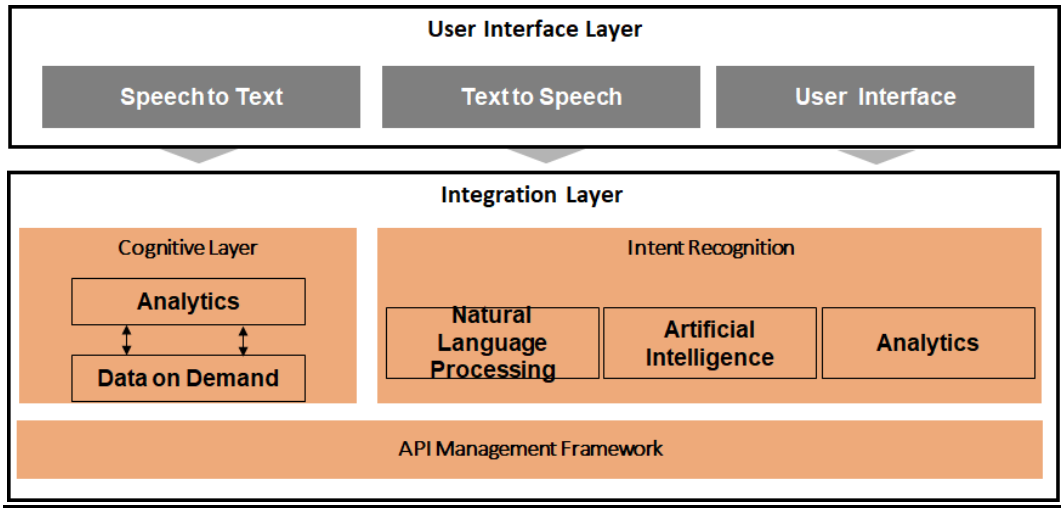

Figure 14.8 : Conversational Interface

14.5 SUMMARY

In this unit, we started discussing the main drivers of innovation. After briefly discussing the key trends in software engineering, we discussed the low code and no code platforms that provide visual tools for rapid application development. AI and machine learning methods are adopted in almost all areas of software development to provide automation and data analysis. We looked at blockchain technology for distributed data handling. IoT ecosystem provide real time continuous monitoring of the devices and make them smart. AR technology augments the real world with digital objects. Containerization provide portable technology for application development and deployment. Continuous Delivery provides an iterative and continuous development and deployment. Big data technologies are designed to handle huge volume of data.

14.6 SOLUTIONS/ANSWERS

Check Your Progress 1

1. visual programming.
2. computer vision.
3. natural language processing.

Check Your Progress 2

1. decentralized.
2. data analysis
3. Containers
4. 2 week
5. Infrastructure as Service

14.7 FURTHER READINGS

References

https://azure.microsoft.com/en-in/overview/what-is-cloud-computing/#benefits

https://en.wikipedia.org/wiki/Big_data