FUNDAMENTAL OF COMPUTERS
&
EMERGING TECHNOLOGIES

KCA-101

Contents of Unit-5

- Emerging Technologies: Introduction
- Overview & Features of Emerging Technologies
- Limitations and Application Areas of Augmented Reality
- Virtual Reality
- Grid Computing
- Green Computing
- Big data Analytics
- Quantum Computing
- Brain Computer Interface

From Wikipedia, the free encyclopedia

Emerging Technologies are technologies whose development, practical applications, or both are still largely unrealized. These technologies are generally new but also include older technologies finding new applications. Emerging technologies are often perceived as capable of changing the status quo.

Features of Emerging Technologies:

- Radical Novelty
- Relatively fast growth
- Coherence
- Prominent impact
- Uncertainty and ambiguity.

Emerging Technologies

- Augmented Reality
- Virtual Reality
- Grid Computing
- Green Computing
- Big data Analytics
- Quantum Computing
- Brain Computer Interface

Virtual Reality (VR)

What is Virtual Reality?

Virtual reality is the use of computer technology to create simulated environments. Virtual reality places the user inside a three-dimensional experience. Instead of viewing a screen in front of them, users are immersed in and interact with 3D worlds.

What Is the Need for Virtual Reality?

- Virtual Reality allows users to create simulated, interactive and specific designed environments for specific use.
- It is designed for human interaction or for a specific reason to create experiences.
- Unlike other reality technologies like AR and MR, VR enhances the user experience to the next level with its fully immersive and interactive technology.

The three main VR categories are the following:

- Non-Immersive Virtual Reality: Non-immersive VR technology features a computer-generated virtual environment where the user simultaneously remains aware and controlled by their physical environment. Video games are a prime example of non-immersive VR.
- Semi-Immersive Virtual Reality: Semi-Immersive VR provides an experience partially based in a virtual environment. This type of VR makes sense for educational and training purposes with graphical computing and large projector systems, such as flight simulators for pilot trainees.
- Fully Immersive Virtual Reality: Fully Immersive VR generates the most realistic simulation experience, from sight to sound to sometimes even olfactory sensations. Car racing games are an example of immersive virtual reality that gives the user the sensation of speed and driving skills.

What Hardware Does Virtual Reality Use?

VR Headsets: A VR headset is a head-mounted device, such as goggles. A VR headset is a visual screen or display. Headsets often include state-of-the-art sound, eye or head motion-tracking sensors or cameras. Three types of VR Headsets:

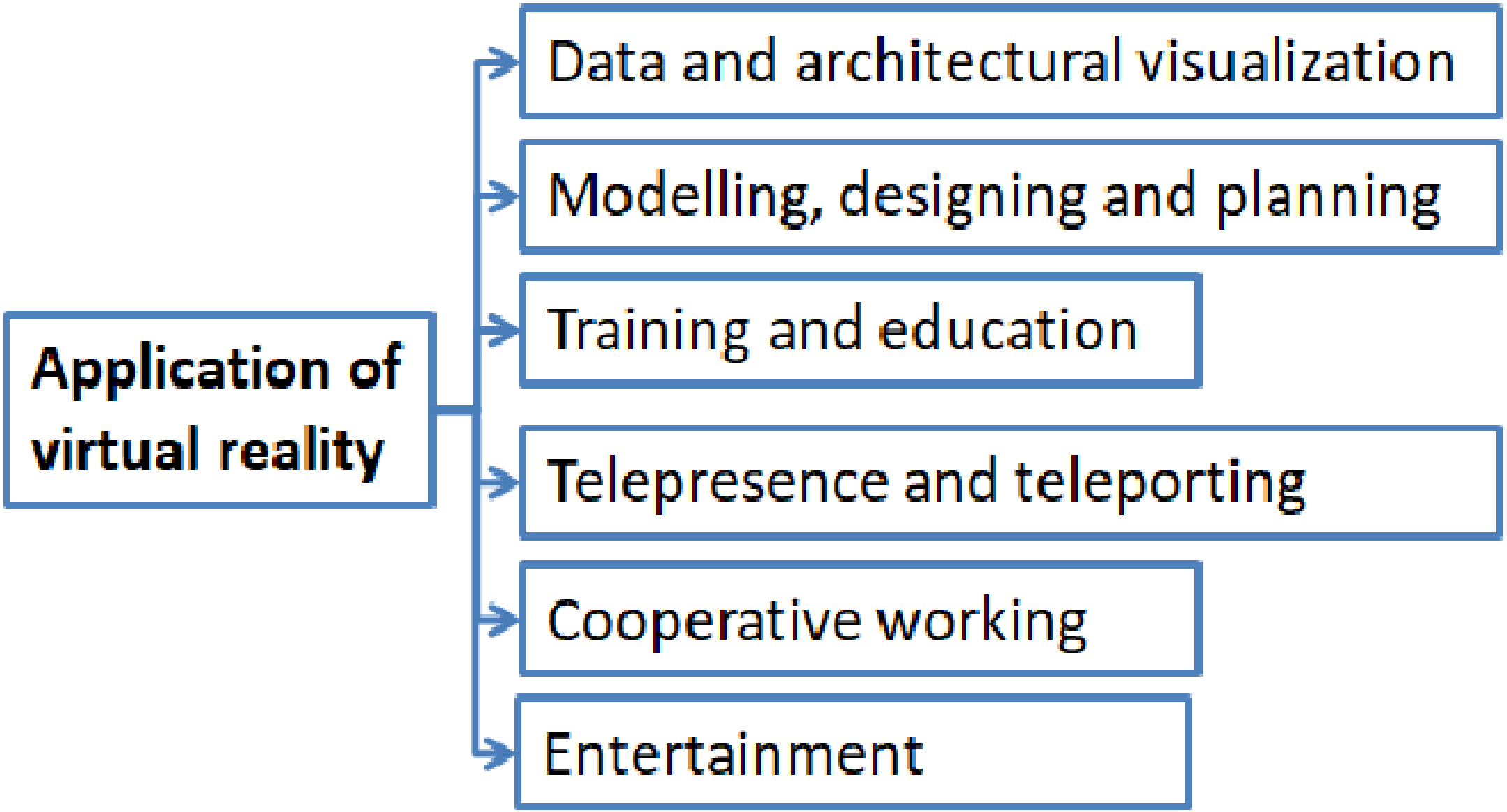
- PC-Based VR Headsets
- Standalone VR Headsets
- Mobile Headsets

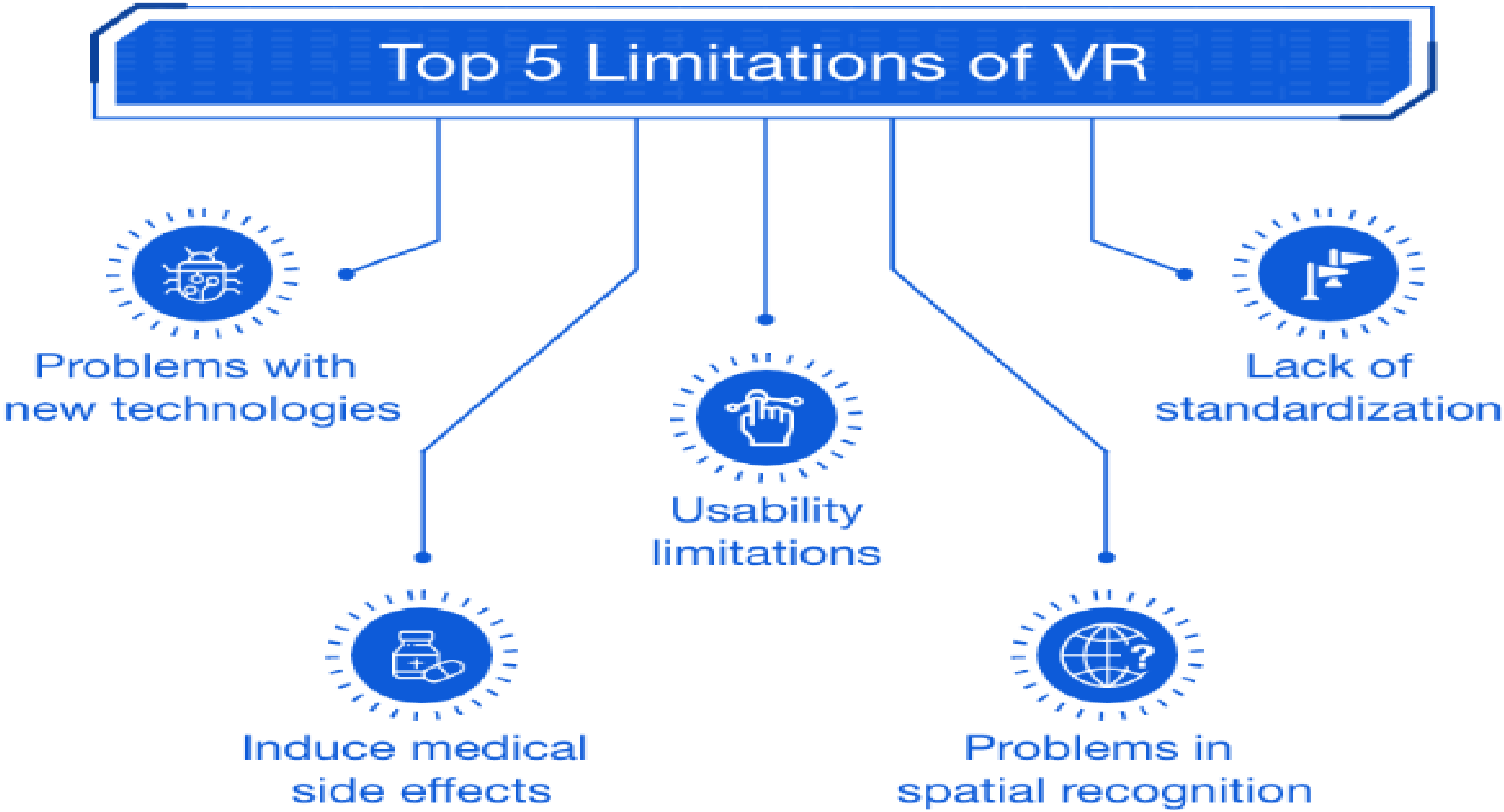
VR Accessories: VR accessories are hardware products that facilitate VR technology. New devices are always in development to improve the immersive experience. VR accessories include the 3D mouse, optical trackers, wired gloves, motion controllers, bodysuits, treadmills, and even smelling devices.

What Software Does Virtual Reality Use?

Developers use various software to build VR. They include

- VR Software Development Kit (SDK): SDKs offer a base to design, build and test VR experiences.
- VR Visualization Software: Users experience aggregated data in a virtual environment. to fully understand what data means.
- VR Content Management Systems Software: Companies use this workplace tool to collect, store and analyze VR content in a centralized location.
- VR Game Engine Software: Developers use the tools to create a VR video game experience.
- VR Social Platforms Software: Users collaborate from remote locations in VR with these tools.
- VR Training Simulator Software: This software works for almost any industry for employee training in immersive environments.


Application of virtual reality
Data and architectural visualization
Modelling, designing and planning
Training and education
Telepresence and teleporting
Cooperative working
Entertainment


Top 5 Limitations of VR
Problems with new technologies
Induce medical side effects
Usability limitations
Problems in spatial recognition
Lack of standardization

Factors	VR	AR
Virtuality	VR is completely virtual	AR uses a real-world entities enhancing digital content
Control	VR users are controlled by the system	AR users can control their presence in real world
Compatibility	VR requires compatible devices like a headset device	AR needs no specific device
Environment	VR only enhances a fictional reality	AR enhances both virtual and real-world entities
Freedom	VR is composed of cables and can be inaccessible over a specified distance.	AR is free from cables and free to move without any hindrances like distance.

References

1. What is VR: https://www.simplilearn.com/tutorials/artificial-intelligence-tutorial/what-is-virtual-reality
2. Hardware & Software used in VR: https://www.marxentlabs.com/what-is-virtual-reality/
3. Limitations of VR: https://www.appypie.com/virtual-reality-limitations
4. Applications of VR: https://www.researchgate.net/figure/Virtual-reality-applications_fig1_364962109
5. Mixed Reality (MR) combines both real and virtual entities to produce new simulated environments and visuals where physical and digital objects interact in real-time. It's a hybrid combination of augmented reality and virtual reality technology.

Augmented Reality (AR)

Advantages of green computing

- Reduced energy consumption.
- Maintaining green environment.
- Cost-effective computing.
- Conservation of resources.

Disadvantages of green computing

- Rapid change in technology.
- Initial implementation may be costly.
- Requires care from user.
- Requires deep understanding of green computing concept.

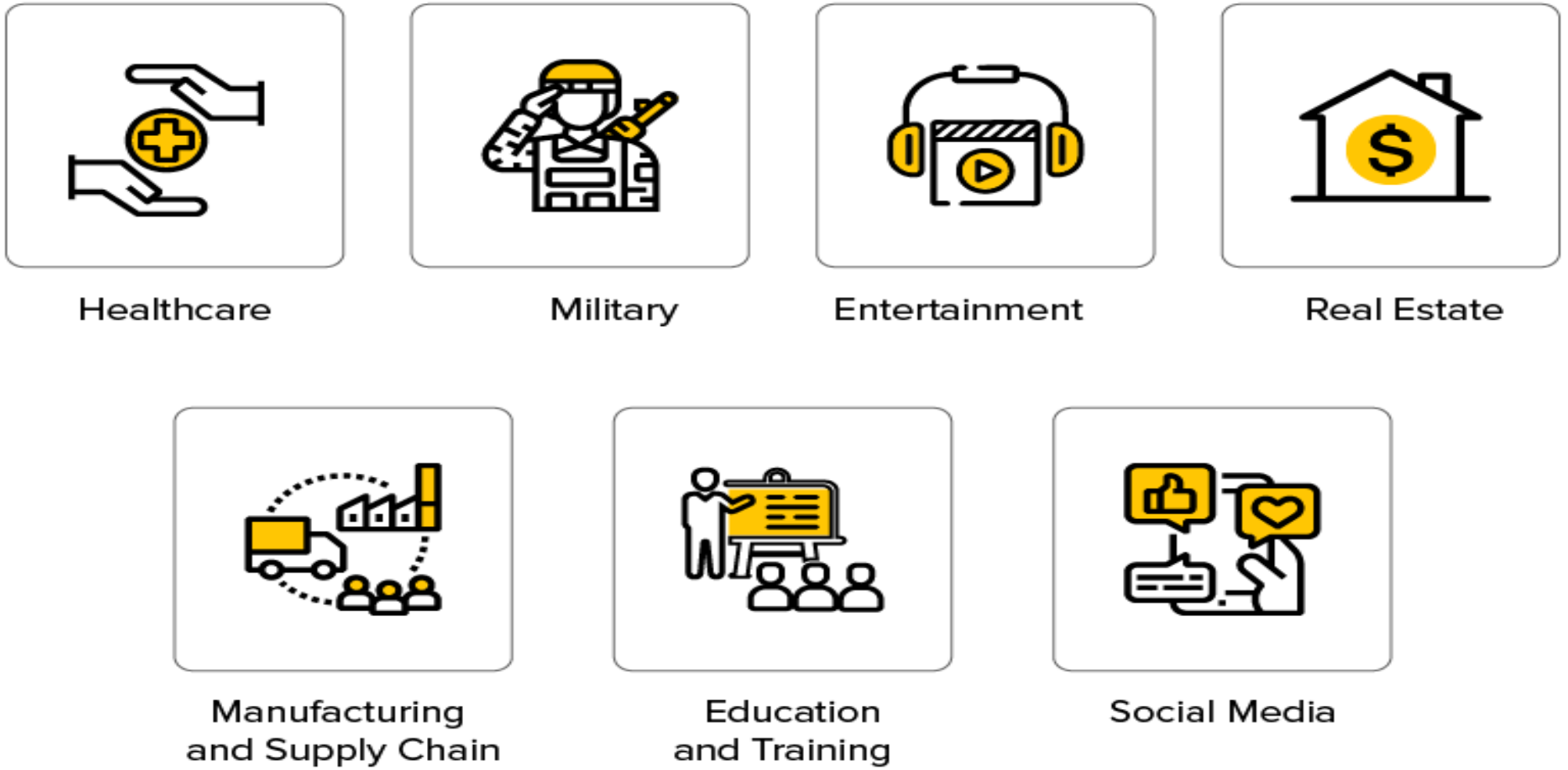
What is Augmented Reality?

Augmented reality (AR) is an interactive experience that combines the real world and computer-generated content. The content can span multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. AR can be defined as a system that incorporates three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects.

Augmented Reality process

1. An AR-enabled device with a camera such as smart glasses, a tablet, or a smartphone parses a video feed to identify a physical object or the environment around the user, such as a piece of machinery or the layout of a warehouse.
2. A digital twin – a 3D digital replica of the object in the cloud – connects the real and virtual environments. It collects information from the physical object and digital
3. The augmented reality device then downloads information about the object from the cloud. It superimposes digital information over the object using markers or trackers like GPS, accelerometers, orientation and barometric sensors, and more. This creates a part-real, part-digital 3D interface.
4. Thanks to real-time data flowing from products, the user can interact with the object or environment by moving around and sending commands to the cloud through a touchscreen, by voice, or with gestures.

Applications of Augmented Reality



Benefits of Augmented Reality

1. Customized Choices: personalization is essential for marketing and media now and AR provides it.
2. Engagement: AR offers a deep level of engagement visually and interactively. It is a must for retailers since it can provide just in time information at the point of sales and guide/ take a user to a **call for action**
3. Real Time: this is not new, but it is different in that we can combine digital and real-world content in real time.
4. Ability to Visualize Products: For retail and marketing this is essential for the future and growth of electronic content.
5. Interactivity: AR offers new choices; users can interact with digital content and the real world at the same time.
6. Tracking: AR makes it possible for objects and print media to deliver the same or even better analytics than regular apps.

Challenges/ Limitations of Augmented Reality

- Hardware issues: available AR headset is a bulky piece of hardware that may be too expensive for the masses.
- Limited content: Creating content that can promote businesses can be extremely complicated and expensive.
- Lack of regulations: There are no regulations that help businesses and consumers understand which type of AR applications can be used and how data can be processed. Public skepticism: Although augmented reality is a popular topic of discussion among tech experts, consumers are unaware of the benefits of the technology.
- Physical safety risks: Augmented reality applications can be immensely distracting and may lead to physical injuries esp. when used in potentially risky environments such as busy roads, construction sites, and medical institutions. Example: people were injured while playing Pokemon Go.

References

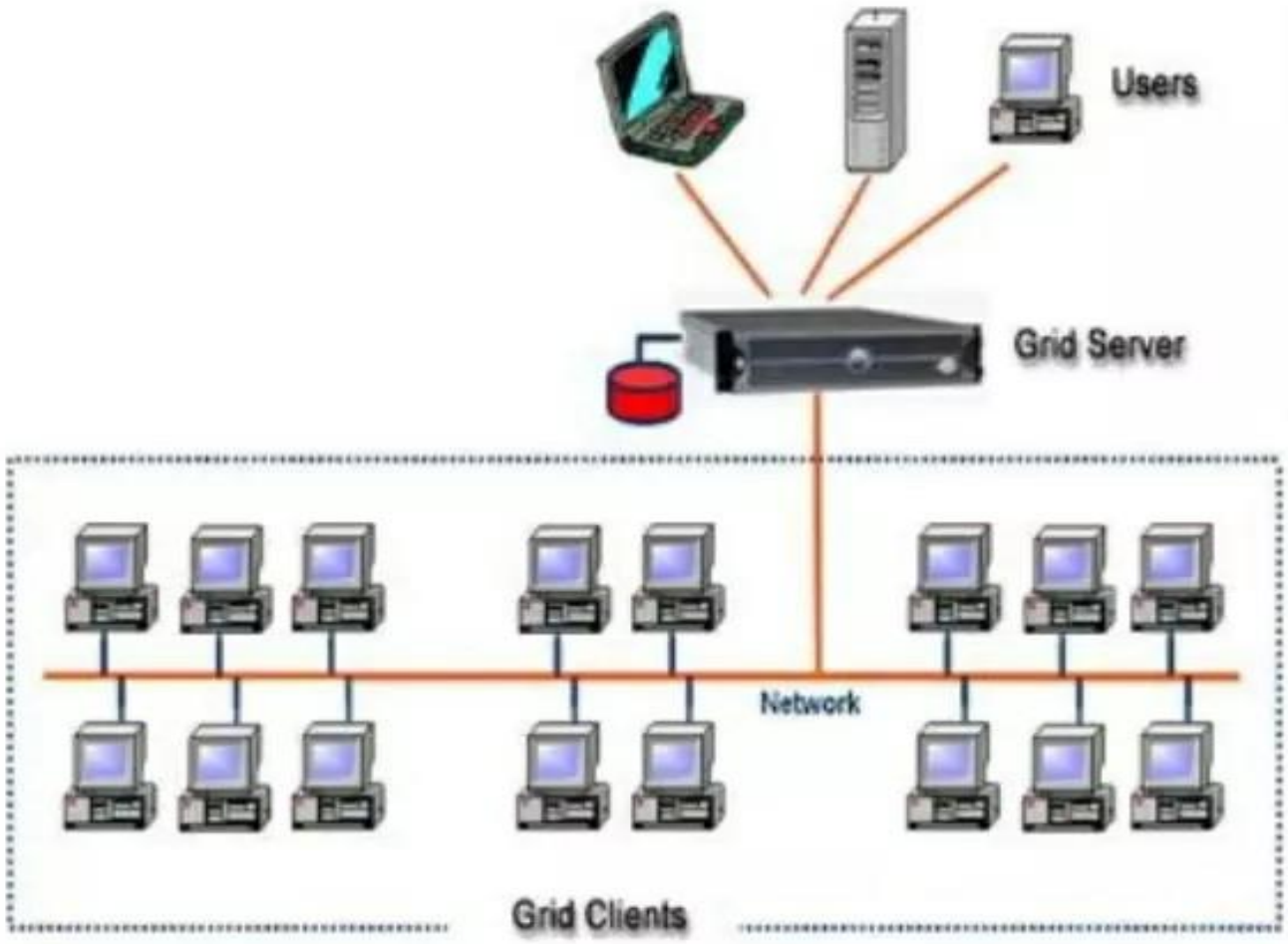
1. Applications of AR: https://appinventiv.com/blog/augmented-reality-benefits-for-businesses/
2. Benefits of AR: https://www.billnewell.com/9-key-benefits-of-ar/

Grid Computing

What is Grid Computing?

- Grid Computing can be defined as a network of computers working together to perform a task that would rather be difficult for a single machine.
- All machines on that network work under the same protocol to act like a virtual supercomputer.
- The task that they work on may include analyzing huge datasets or simulating situations which require high computing power.
- Computers on the network contribute resources like processing power and storage capacity to the network.
- Grid Computing is a subset of distributed computing, where a virtual supercomputer comprises of machines on a network connected by some bus, mostly Ethernet or sometimes the Internet.
- It can also be seen as a form of Parallel Computing where instead of many CPU cores on a single machine, it contains multiple cores spread across various locations.
- In the ideal grid computing system, every resource is shared, turning a computer network into a powerful supercomputer.

How Grid computing works ?



In general, a grid computing system requires:

- **At least one computer, usually a server, which handles all the administrative duties for the System**
- **A network of computers running special grid computing network software.**
- **A collection of computer software called middleware**

Working of Grid Computing

A Grid computing network mainly consists of these three types of machines

- Control Node: A computer, usually a server or a group of servers which administrates the whole network and keeps the account of the resources in the network pool.
- Provider: The computer which contributes its resources in the network resource pool.
- User: The computer that uses the resources on the network.

Applications of Grid Computing

- **Movie Industry-**Many films can’t be made without the use of grid computing not only because of special effects but also because grid computing enables faster production of a film.
- **Gaming Industry-**
    - In-game art internal creation
    - In-game cut scenes rendering
    - Packaging game assets for multiple platforms
    - Distribution of online program
    - Hosting of a massively multiplayer online game
- **Life Sciences-**With these rapid changes, new challenges are also being surfaced like massive amounts of data analysis, data caching, data mining, and data movement.
- **Engineering and Design**
    - Analysis of real-time data to find a particular pattern.
    - Experiment modeling to create new designs.
    - Verifying existing models for accuracy using simulation activities

Advantages of Grid Computing:

- It is not centralized, as there are no servers required, except the control node which is just used for controlling and not for processing.
- Multiple heterogeneous machines i.e., machines with different Operating Systems can use a single grid computing network.
- Tasks can be performed parallelly across various physical locations and the users don’t have to pay for them (with money).

Limitations of Grid Computing

- The software of the grid is still in the involution stage.
- A super fast interconnect between computer resources is the need of hour.
- Licensing across many servers may make it prohibitive for some applications.
- Many groups are reluctant with sharing resources.

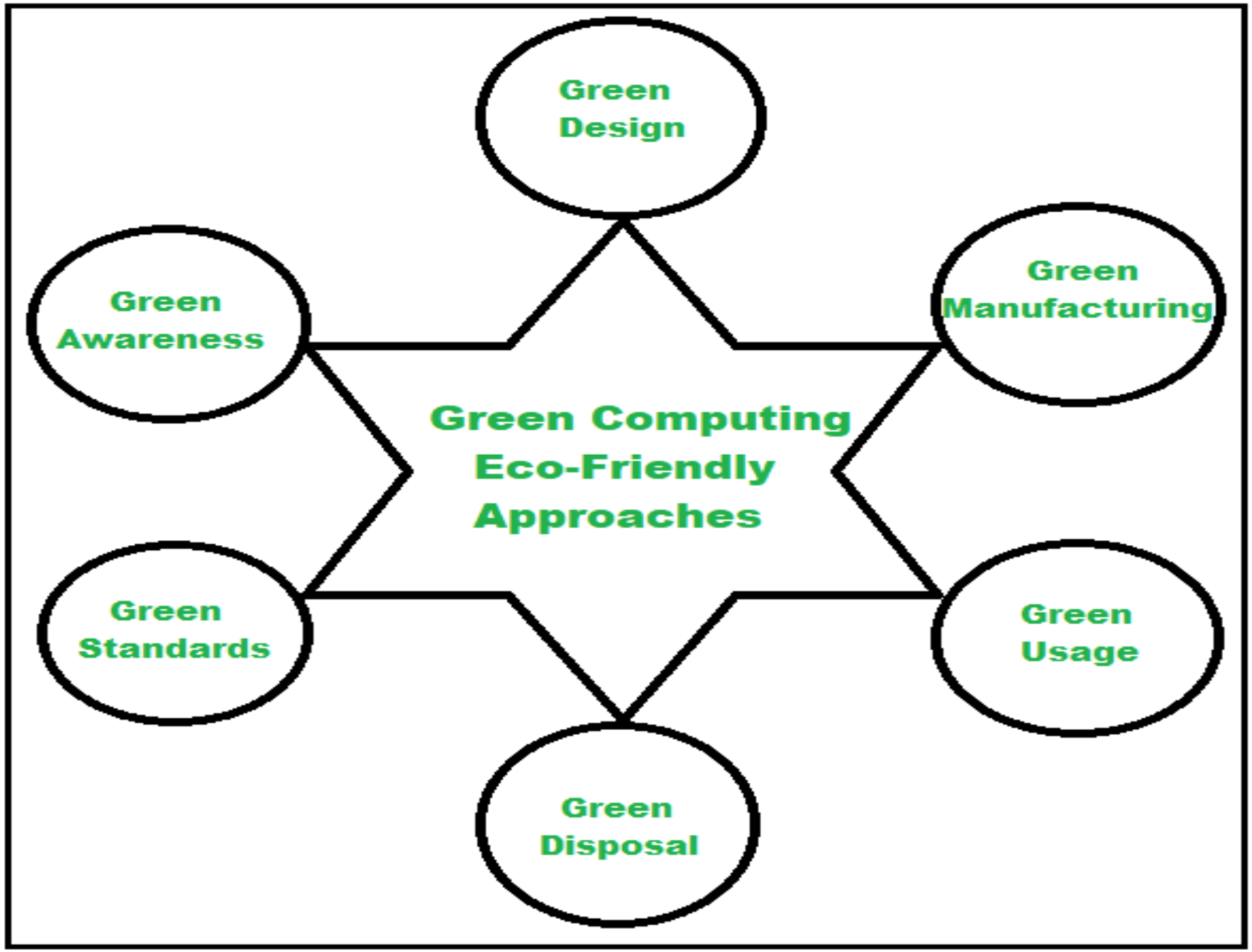
Green Computing

What is Green Computing?

Green computing, also known as green technology, is the use of computers and other computing devices and equipment in energy-efficient and eco-friendly ways. In 1992, it was originated and initially known as Energy Star, later it is known as Green Computing.

Why Green Computing?

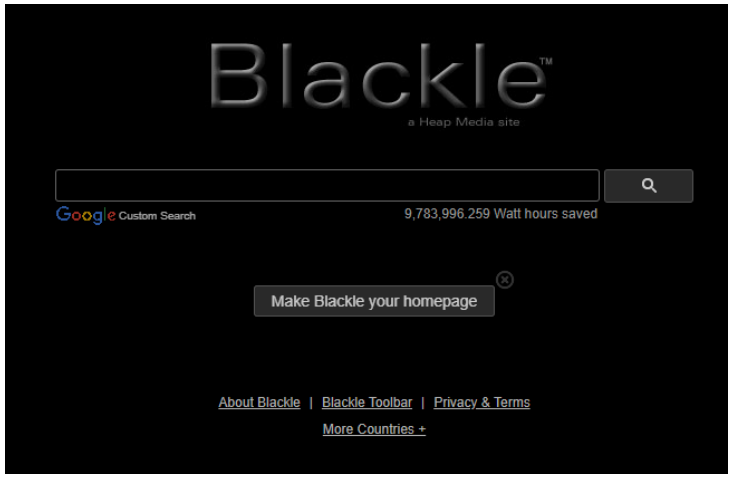
- We need green computing to limit the environmental damage caused by the electronics industry and the IT sector, and to study new technologies and practices for zero-impact computing
- With current technologies, the production of a single computer involves the emission of 227-270 kilos of Carbon dioxide.
- It takes months to make a microchip, during which a long series of cuts and finishes generate considerable waste compared to the size of the finished product
- It is not only a problem of pollution but also of energy availability: if the energy demand continues to grow at this rate , there is a risk of not being able to satisfy it, not with renewable sources alone


Green Design
Green Awareness
Green Manufacturing
Green Computing Eco-Friendly Approaches
Green Standards
Green Usage
Green Disposal

Tips

Some tips for the computer users and businesses to make computing process more green

- Power-down the computer system, and it's peripherals during completion of its usage.
- Sleep mode the systems away from system for extended periods of inactivity.
- Use notebook computers and laptops rather using desktop computers.
- Go for green packaging solutions.
- Minimize the use of paper and use e-paper also recycle the wastage papers.
- Proper disposal of electronic wastage.
- Try refurbishing an existing device instead of going for a newer one.



Google home page, your computer consumes 74W. When the screen is black it consumes only 59W.

Big Data Analytics

What is Big Data Analytics?

Big Data analytics is a process used to extract meaningful insights, such as hidden patterns, unknown correlations, market trends, and customer preferences.

Types of Big Data Analytics

- Descriptive Analytics
- Diagnostics Analytics
- Predictive Analytics
- Prescriptive Analytics

What is Big Data?

Big Data is a collection of data that is huge in volume yet growing exponentially with time. It is a data with so large size and complexity that none of traditional data management tools can store it or process it efficiently. Big data is also a data but with huge size.

Characteristics Of Big Data

- Volume
- Variety
- Velocity
- Variability

VALUE

What action should be taken?

Why did something happen?

What happened?

1

Descriptive

Based on Live Data, Tells what's happening in real time

Accurate & Handy for Operations management

Easy to Visualize

2

Diagnostic

Automated RCA – Root Cause Analysis

Explains "why" things are happening

Helps trouble shoot issues

3

Predictive

Tells What's likely to happen?

Based on historical data, and assumes a static business plans/models

Helps Business decisions to be automated using algorithms.

4

Prescriptive

Defines future actions – i.e., "What to do next?"

Based on current data analytics, predefined future plans, goals, and objectives

Advanced algorithms to test potential outcomes of each decision and recommends the best course of action

What is LIKELY to happen?

Complexity

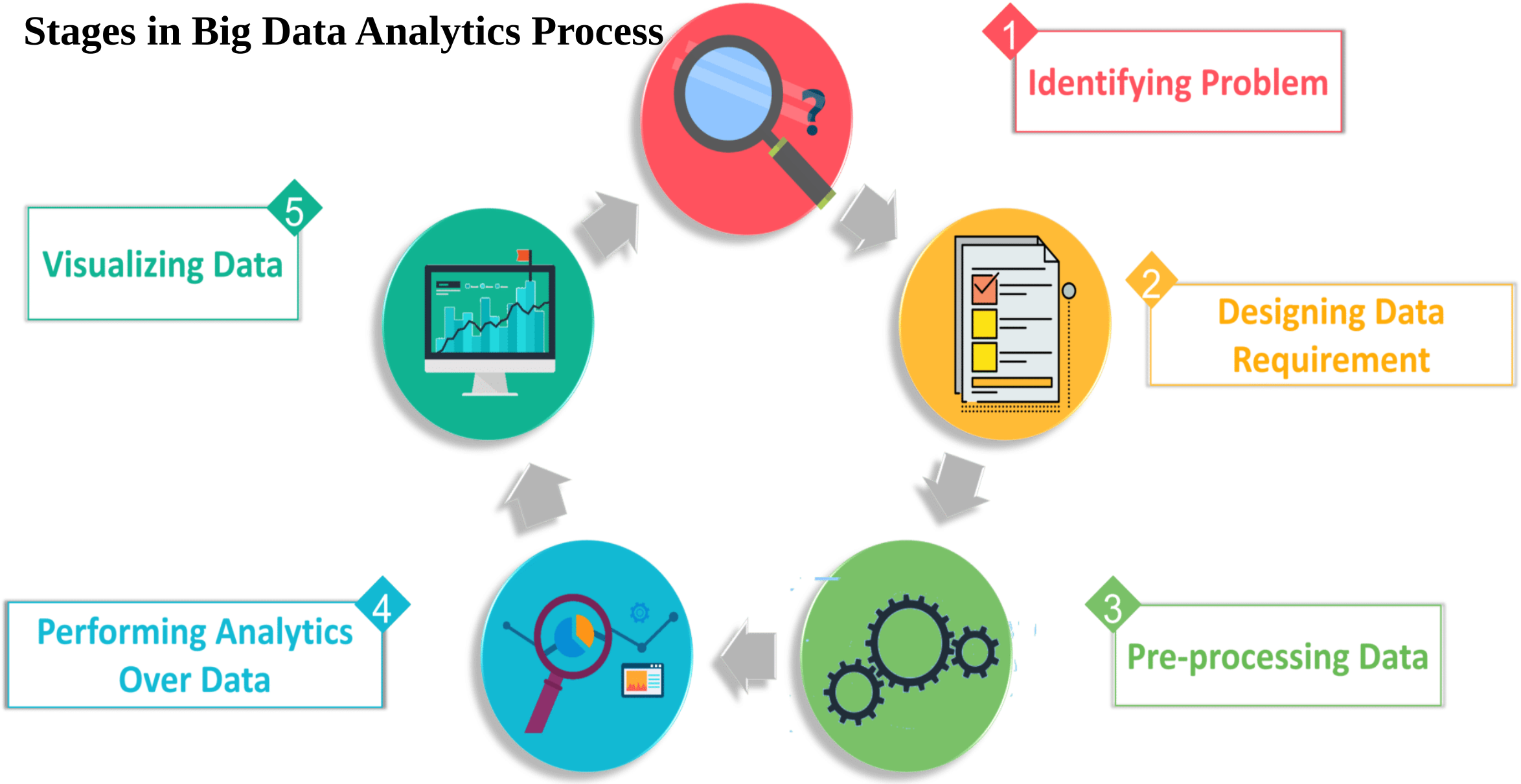
Volume – The name Big Data itself is related to a size which is enormous. Whether a particular data can actually be considered as a Big Data or not, is dependent upon the volume of data. Hence, **‘Volume’** is one characteristic which needs to be considered while dealing with Big Data solutions.

Variety – The next aspect of Big Data is its **variety**. Variety refers to heterogeneous sources and the nature of data, both structured and unstructured. Nowadays, data in the form of emails, photos, videos, monitoring devices, PDFs, audio, etc. are also being considered in the analysis applications. This variety of unstructured data poses certain issues for storage, mining and analyzing data.

Velocity – The term **‘velocity’** refers to the speed of generation of data. How fast the data is generated and processed to meet the demands, determines real potential in the data.

Variability – This refers to the inconsistency which can be shown by the data at times, thus hampering the process of being able to handle and manage the data effectively.

Stages in Big Data Analytics Process



Benefits of using Big Data Analytics

- Analysis of large volumes of data from disparate sources in a variety of forms and kinds in a timely manner
- Quickly making well-informed judgments for successful strategizing to enhance the supply chain, logistics, and other tactical decision-making sectors
- Savings due to the increased efficiency and optimization of business processes
- More informed risk management techniques based on large data sample sizes
- Greater knowledge of consumer behavior, demands, and sentiment can result in better product development data and strategic management processes

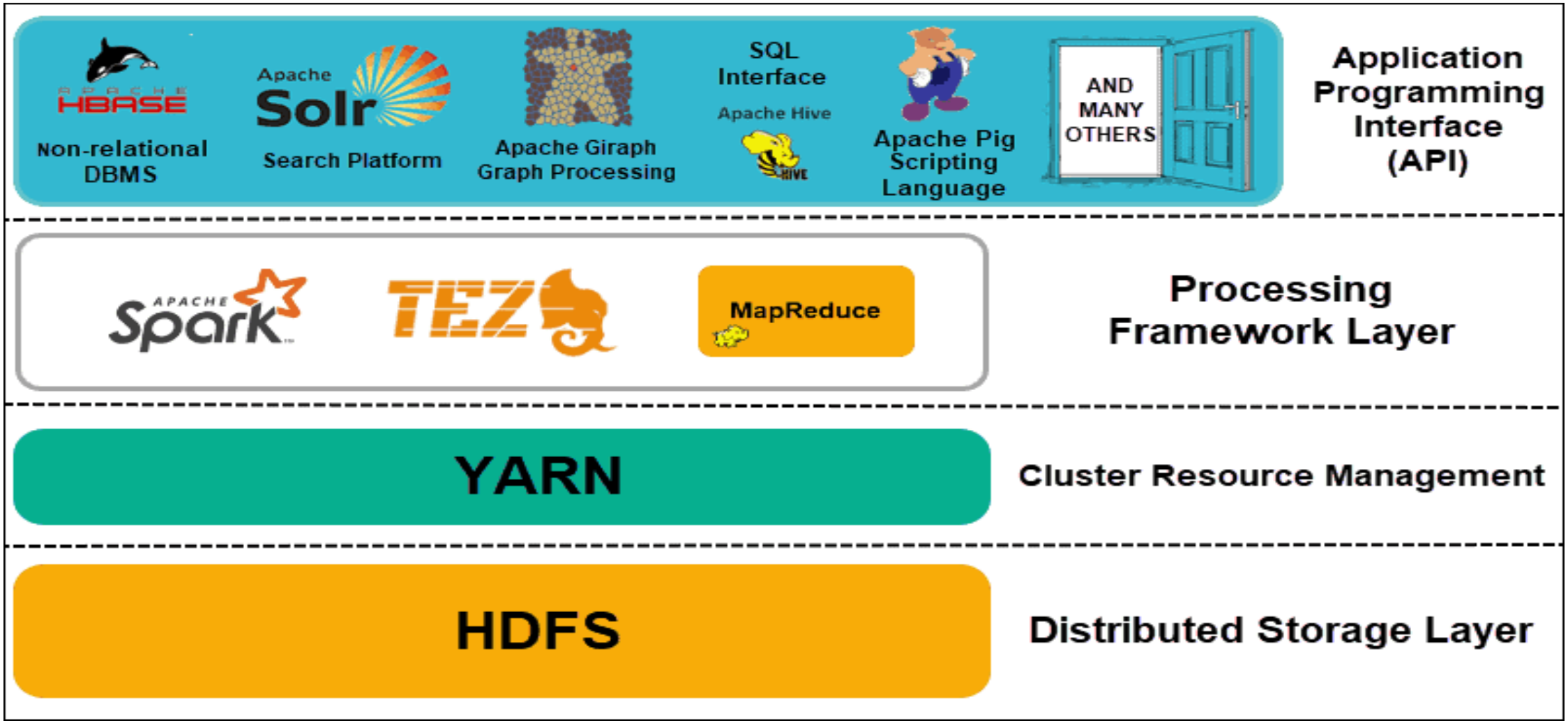
Big Data Analytics Challenges

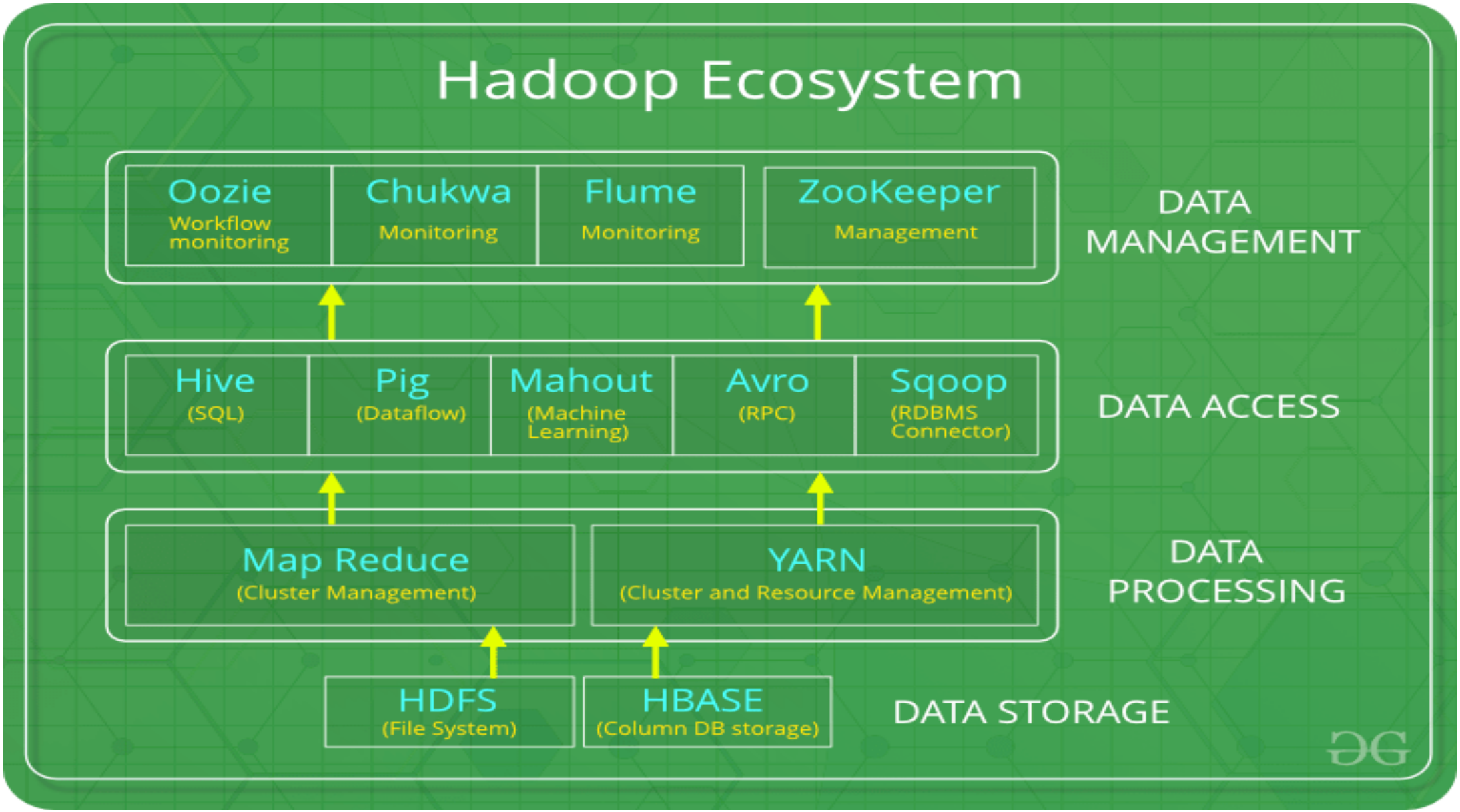
- **Accessibility of Data:** With larger volumes of data, storage and processing become a challenge. Big data should be maintained in such a way that it can be used by less-experienced data scientists and data analysts as well.
- **Data Quality Maintenance:** With high volumes of data from disparate sources and in different formats, the proper management of data quality requires considerable time, effort, and resources.
- **Data Security:** The complexity of big data systems poses unique challenges when it comes to security. It can be a complex undertaking to properly address such security concerns within complicated big data ecosystems.
- **Choosing the Right Tools:** Choosing big data analytics tools from the wide range that is available in the market can be quite confusing. One should know how to select the best tool that aligns with user requirements and organizational infrastructure.
- **Supply-demand Gap in Skills:** With a lack of data analytics skills in addition to the high cost of hiring experienced professionals, enterprises are finding it hard to meet the demand for skilled big data analytics professionals.

Big Data Industry Applications

- Ecommerce - Predicting customer trends and optimizing prices are a few of the ways e-commerce uses Big Data analytics
- Marketing - Big Data analytics helps to drive high ROI marketing campaigns, which result in improved sales
- Education - Used to develop new and improve existing courses based on market requirements
- Healthcare - With the help of a patient's medical history, Big Data analytics is used to predict how likely they are to have health issues
- Media and entertainment - Used to understand the demand of shows, movies, songs, and more to deliver a personalized recommendation list to its users
- Banking - Customer income and spending patterns help to predict the likelihood of choosing various banking offers, like loans and credit cards
- Telecommunications - Used to forecast network capacity and improve customer experience
- Government - Big Data analytics helps governments in law enforcement, among other things

Major Big Data analytics tools and services

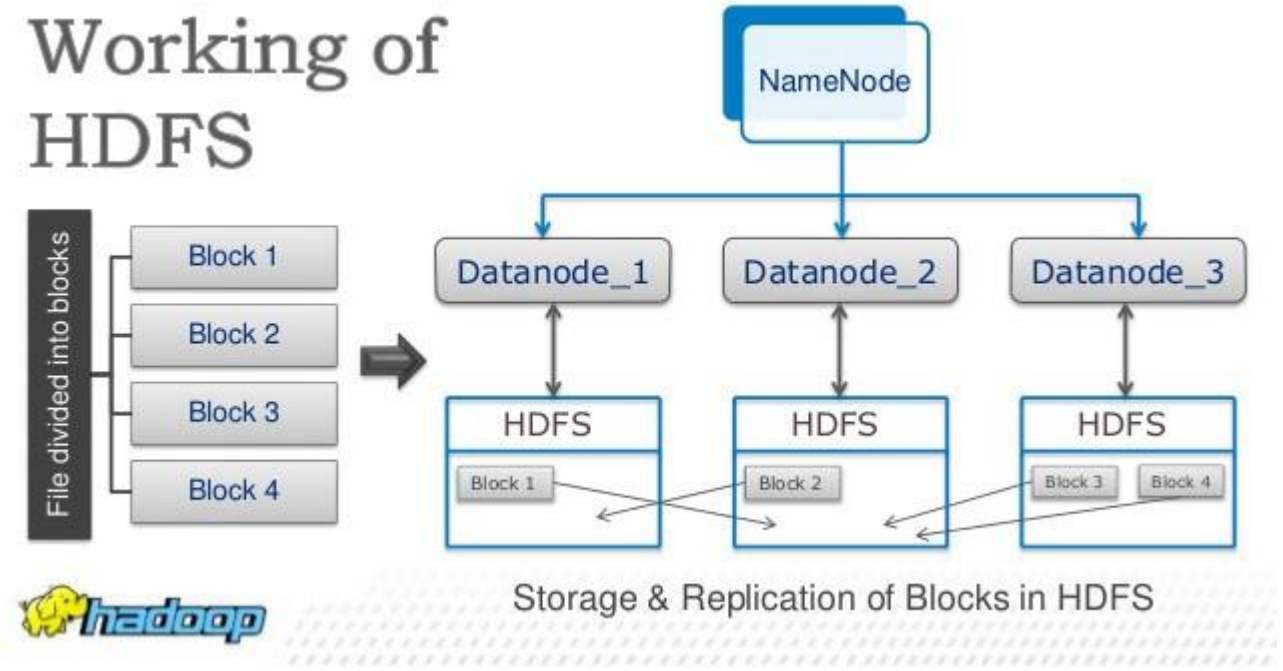



Hadoop Ecosystem
Oozie
Workflow monitoring
Chukwa
Monitoring
Flume
Monitoring
ZooKeeper
Management
DATA MANAGEMENT
Hive
(SQL)
Pig
(Dataflow)
Mahout
(Machine Learning)
Avro
(RPC)
Sqoop
(RDBMS Connector)
DATA ACCESS
Map Reduce
(Cluster Management)
YARN
(Cluster and Resource Management)
DATA PROCESSING
HDFS
(File System)
HBASE
(Column DB storage)
DATA STORAGE

Hadoop ecosystem consists of core components include:

- **HDFS** splits the data into smaller chunks (each sized 128MB by default) and stores them across different nodes in a cluster.
- The **MapReduce** processing engine is used to process the data stored in Hadoop HDFS in parallel by the means of dividing the task submitted by the user into multiple independent subtasks.
- **YARN** (Yet Another Resource Negotiator) is the Hadoop operating system that helps manage and monitor workloads.

Apache Hadoop is an open-source framework that is used to efficiently store and process large datasets ranging in size from gigabytes to petabytes of data. Instead of using one large computer to store and process the data, Hadoop allows clustering multiple computers to analyze massive datasets in parallel more quickly.



HDFS: Hadoop Distributed File System is the core component, or you can say, the backbone of Hadoop Ecosystem.

- HDFS is the one, which makes it possible to store different types of large data sets (i.e., structured, unstructured and semi structured data).
- HDFS creates a level of abstraction over the resources, from where we can see the whole HDFS as a single unit.
- It helps us in storing our data across various nodes and maintaining the log file about the stored data (metadata).
- HDFS has two core components, i.e., **NameNode and DataNode**.
  - The **NameNode** is the main node, and it doesn't store the actual data. It contains metadata, just like a log file or you can say as a table of content. Therefore, it requires less storage and high computational resources.
  - All your data is stored on the **DataNodes** and hence it requires more storage resources. These DataNodes are commodity hardware (like your laptops and desktops) in the distributed environment.

Quantum Computing

What is Quantum?

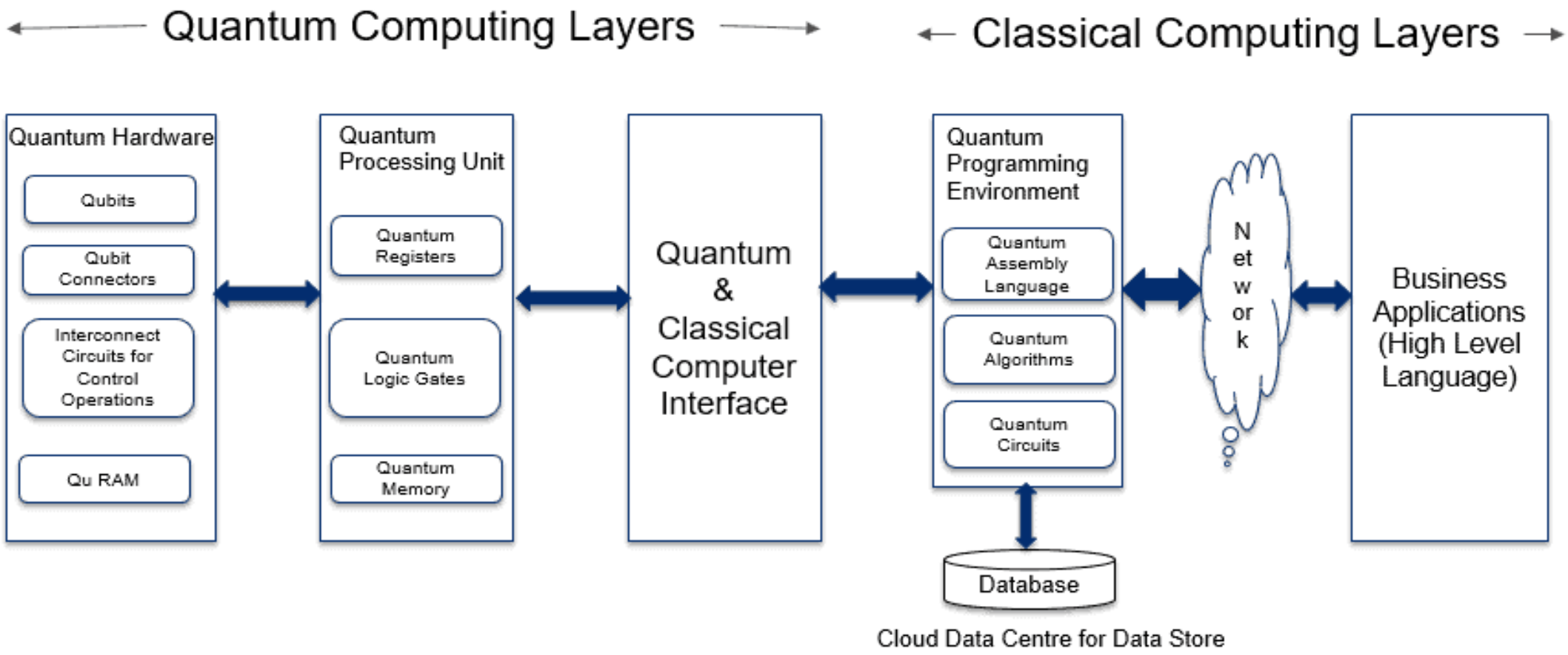
The term quantum comes from the study of quantum mechanics, which is a field of physics that explores the physical properties of nature on a small atomic and subatomic scale. It is the foundation of quantum physics.

What is Quantum Computing?

Quantum Computing is the process of using quantum-mechanics for solving complex and massive operations quickly and efficiently. Quantum Computer uses Quantum bits (called Qubits) to store the information. It is the fundamental building block of the Quantum Computer. Qubits can be carried as atoms, ions, photons, or electrons and their respective control devices that are working together to act as computer memory and a processor. One qubit is equal to two bits. For example, a 4-qubit computer register can hold 16 different numbers simultaneously. Quantum computing uses the properties of quantum states, such as entanglement and superposition, to perform computation.

Feature	Classical Computer	Quantum Computer
Measurement	Calculates with transistors, which can represent either 0 or 1	Calculates with Qubits which can represent 0 or 1 at the same time
Power	Power increases as the number of transistors increases. Linear increase	Power increases exponentially in proposition to the number of Qubits
Computing	Logical Operations	Unitary Operations Conditions of Atoms
Temperature	Operates at room temperatures and the error rate is less	Operates at very low temperatures and error rates are high
Usage	Every day processing	Optimization problems, data analysis, simulation
Computation	N bit processor = 1 Operation	N qubit processor = 2^n Operations
Storage	N bit storage holds 1 value from 0 to $2^{(n-1)}$	N qubit storage holds 2^N operations
Gates	Truth table (True/False)	Unitary Matrix Gates are Reversible
Security	Less Secure Encryption is based on Mathematical Algorithms	Much secured Encryption based on Quantum Properties

Quantum Computer Platform Architecture



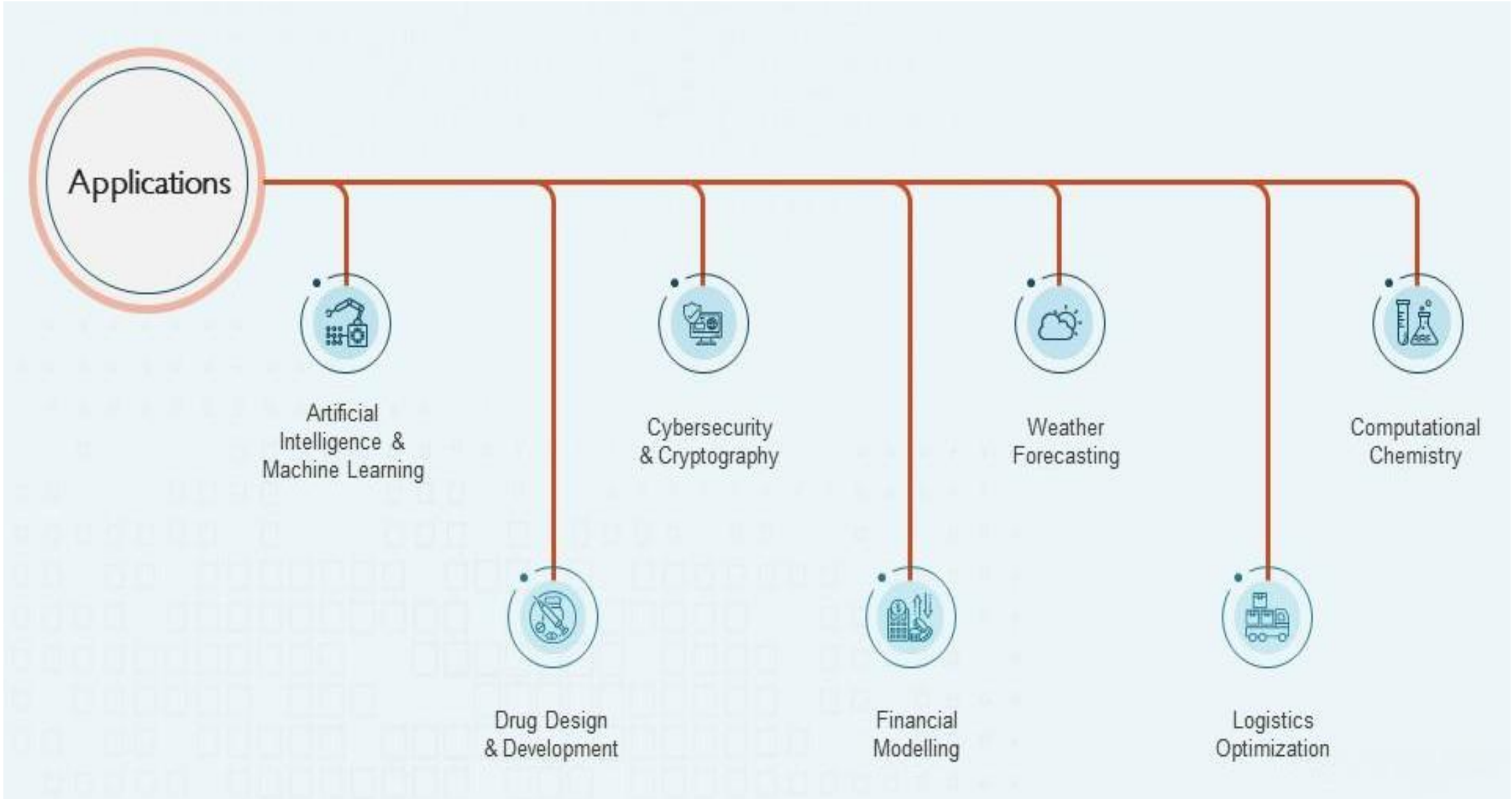
Quantum Computer Platform Architecture

Quantum Computer Platform consists of two layers namely Quantum Computing Layer and Classical Computing Layer. Quantum Computing Layer consists of Quantum Hardware, Quantum Processing Unit, and Quantum-classical interface.

- Quantum hardware covers Qubits that are surrounded by superconducting loops for the physical realization of qubits. It also consists of interconnect circuitry for control operations of Qubit.
- Quantum processing Unit (QPU) consists of Quantum registers, Quantum logic gates, and quantum Memory.
- The quantum-classical interface includes hardware and software which provides interfacing between classical computers and a QPU.

Classical Computing Layer, consists of Quantum Programming environment, Cloud data Centre and Business Applications. Quantum programming environment consisting of

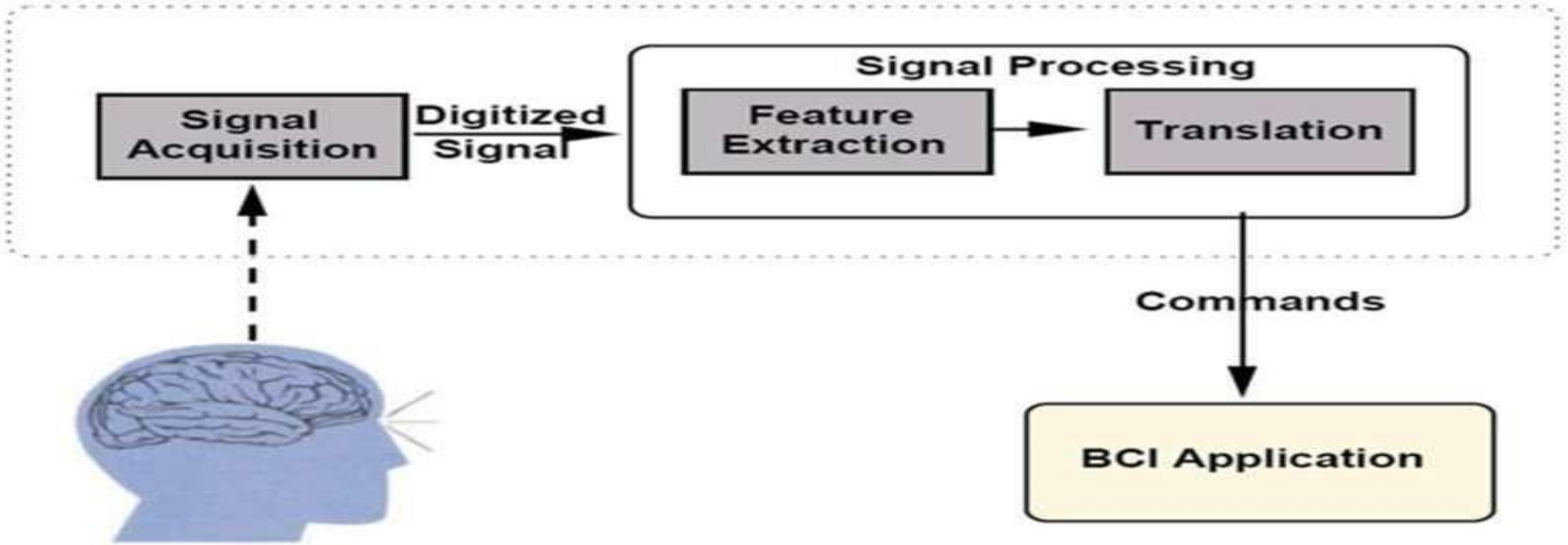
- Quantum assembly language for instructing QPU
- Quantum programs in high-level programming languages
- Quantum Algorithms for solving a variety of computing problems much faster than a classical computer
- Quantum circuits, the common models for representing quantum computation. In this model, the steps of a quantum algorithm can be expressed as a sequence of quantum logic gates. Each quantum logic gate transforms the input qubits in well-defined manner, typically expressed as operations on matrices and vectors
- High-level programming API or instructions used for composing the quantum programs


Applications
Artificial Intelligence & Machine Learning
Drug Design & Development
Cybersecurity & Cryptography
Financial Modelling
Weather Forecasting
Logistics Optimization
Computational Chemistry

Challenges in Quantum Computing Today

- Lack of good software, i.e., more QC algorithms that solve real-world problems
- Technological challenges like limited qubit connectivity, too low gate fidelities, or large amounts of qubits required for error correction. Therefore, detecting, controlling, and correcting errors becomes a major challenge.
- Lack of collaboration and exchange between industry and academia
- Quantum computers operate at temperatures close to absolute zero, colder than the vacuum of space. Maintaining such a low temperature is a big challenge.
- Current quantum computer's structure and nature of operation make it difficult that it could ever be built into a mobile device such as mobile phones

Brain Computer Interface



A brain–computer interface (BCI), sometimes called a neural control interface (NCI), mind–machine interface (MMI), direct neural interface (DNI), or brain–machine interface (BMI), is a direct communication pathway between an enhanced or wired brain and an external device. BCIs are often directed at researching, mapping, assisting, augmenting, or repairing human cognitive or sensory-motor functions.

Hans Berger (1924) was a German psychiatrist. He is best known as the inventor of electroencephalography in 1924, which is a method used for recording the electrical activity of the brain, commonly described in terms of brainwaves, and as the discoverer of the alpha wave rhythm which is a type of brainwave.

Monkey operating a robotic arm with brain–computer interfacing (Schwartz lab, University of Pittsburgh)

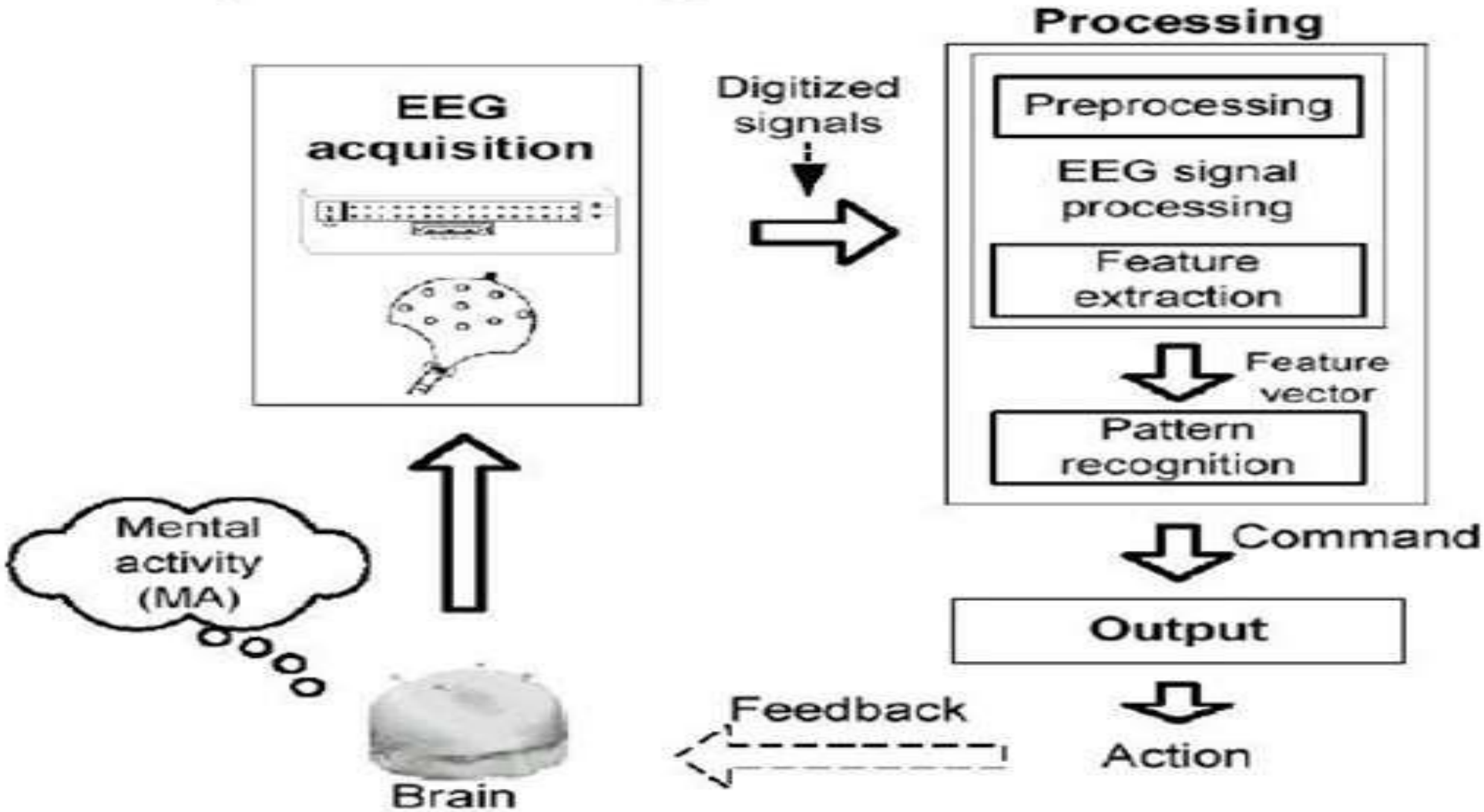
2001: Matthew Nagle (October 16, 1979 – July 24, 2007) was the first person to use a brain-computer interface to restore functionality lost due to paralysis. He was a C3 tetraplegic, paralyzed from the neck down after being stabbed.

2002, Jens Naumann was the first person to be able to see using bionic eyes after he lost his vision in both of his eyes.

How to Measure Brain Activity?

1. **Electroencephalograph (EEG):** One of the biggest difficulty faced by researchers in brain-computer interface in the present scenario is the complex mechanics of the interface itself. A group of electrodes which is a device known as an electroencephalograph (EEG) attached to the scalp is the easiest and invasive method. It is used for reading brain signals. However, significant portion of the signal emanated from our brain gets distorted as the skull blocks the electrical signals. Regardless of whatever location you place the electrodes, the basic mechanism is the same i.e. the electrodes measure minute differences in the voltage between neurons and then signal is then amplified and filtered.
2. **Magnetic Resonance Image (MRI):** An MRI machine is a complicated and massive device. Even though the images produced by the MRI are of high-resolution, we cannot use it as a part of permanent or semi-permanent. Researchers used this to get standard for certain brain activity or to depict where in the brain electrodes should be placed to measure a specific function.

BRAIN COMPUTER INTERFACE ARCHITECTURE



Hardware Components

- Brain Chip
- Connector
- Converter
- Computer

Interface

- Electroencephalograph (EEG) attached to the scalp.
- The electrodes can read brain signals.
- To get a higher resolution signal, scientists can implant electrodes directly into the gray matter of the brain itself, or on the surface of the brain, beneath the skull.

Projects/ Applications of BCI

1. **Brain controlled wheelchair:** Project can be developed for physically impaired people in their movement, all the system need is user's concentration. Users are allowed to navigate in a familiar indoor environment within a reasonable time with the help of Wheelchair.
2. **Brain Controlled Robotic ARM:** Brainwave sensor can catch your brain signals whenever you blink your eyes, when you concentrate, meditate and can be used in various applications. Brain Controlled Robotic Arm is one of the Applications of it. The Robotic Arm is moved with EEG sensor based on a parameter collected by it.
3. **Brain Keyboard (You can type with your Eye blink):** Brain keyboard make paralyzed people to communicate with their surroundings. EEG sensor reads the eye blink and accordingly, text gets displayed on the text box.
4. **Helicopter Controlled by Brain:** Helicopter can fly according to your level of concentration, and meditation so when you concentrate it flies up and when you relax it will be back, isn't it interesting.

Limitations/ /Disadvantages

- Research is still in the beginning stages.
- The current technology is crude.
- Ethical issues may prevent its development.
- Electrodes outside of the skull can detect very few electric signals from the brain.
- Electrodes placed inside the skull create scar tissue in the brain


Enjoy Studying
LEARNING